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Situational Analysis and Needs Assessment for Ethiopia

AIR POLLUTION, OCCUPATIONAL HEALTH AND SAFETY, AND CLIMATE CHANGE

FINDINGS, RESEARCH NEEDS AND POLICY IMPLICATIONS

Establishing a GEOHealth Hub for East Africa

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&

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Abera Kumie, Jonathan Samet and Kiros Berhane

Table of Contents

Background

The Addis Ababa University School of Public Health, Ethiopia, and the University of Southern California, USA were awarded paired planning grants toward the establishment of a Global Environmental and Occupational Health (GEOHealth) Hub. A key objective of the planning process was to conduct a Situational Analysis and Needs Assessment (SANA). This working document addresses limited information in three key areas: air pollution, occupational health and safety, and climate change, as well as the policy and organizational frameworks across these key thematic areas in the Ethiopian context.

The SANA process engaged national stakeholders at various stages including an initial project launch meeting, project inception meeting, and national workshop for the purpose of getting inputs and priority issues in four thematic areas. Four technical expert teams were organized with members from the Addis Ababa University School of Public Health and University of Southern California. An implementation guide was prepared after repeated consultative meetings. The guide explicitly indicated the purpose of the GEOHealth Hub planning project, deliverables, operational definitions, and the tools of primary and secondary data collection. The final SANA report was disseminated at a national workshop organized in Addis Ababa on July 25, 2014 in the presence of key national and regional stakeholders including those from the Ministry of Health, Ministry of Labour and Social Affairs, Ministry of Environmental Protection and Forestry, National Meteorological Agency, Ministry of Agriculture, Five Federal Universities, and others. The workshop included presentation of key findings as well as critique of the findings by national experts on the respective themes. The SANA report was then revised based on the feedback from national experts and key stakeholders.

The working document contains 4 sections co-authored by highly experienced experts in the respective fields. Each section is independently organized and presented in this report.

This assessment is expected to identify national priority areas for research in support of evidence-based problem-solving, management, and associated capacity building. It also provides an assessment of key stakeholders and the policy frameworks in place for addressing environmental and occupational health problems. The lessons and experiences gained from this assessment is being used to conduct similarly designed SANAs in each of the three other East African countries (Kenya, Uganda, Rwanda).

EXECUTIVE SUMMARY

Introduction

The burden of disease due to environmental and occupational health hazards and effects of global climate change are of growing concern in Ethiopia, a country already facing the ongoing challenges of malnutrition, poverty, poor maternal/child health, and infectious diseases. These challenges are also shared by other countries in East Africa. To tackle these complex and multi-faceted challenges, the School of Public Health (SPH) of Addis Ababa University (AAU) in Ethiopia and the Department of Preventive Medicine and the Institute for Global Health, University of Southern California (USC) in the US, in partnership with regional partners from Kenya, Rwanda and Burundi, are currently undertaking a two-year planning project (September 2012 – August 2014) entitled "Establishing a GEOHealth Hub for East Africa". The hub focuses on three main areas; namely, air pollution and health, occupational health and safety, and climate change and health. The project has the long-term goal of establishing a regional hub for training, research, and policy support.

As part of this planning process, a country-wide situational analysis and needs assessment (SANA) on the health impacts of environmental exposures, occupational safety and health (OSH), and climate change has been conducted for Ethiopia to assess the existing country profile and to identify the most critical gaps in these areas. The output of this assessment is expected to identify national priority areas for research in support of evidence-based problem-solving, management, and associated capacity building. It also provides an assessment of key stakeholders and the policy frameworks in place for addressing environmental and occupational health problems. The lessons and experiences gained from this assessment will be used to conduct similarly designed SANAs in each of the other three East African countries (Kenya, Uganda, Rwanda), eventually leading to the establishment of a regional GEOHealth Hub. The SANA was organized 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.

Purpose

The main purpose of the SANA was to

1. Assess the existing country situational profile on air pollution, occupational safety and health, climate change and health, and the policy-regulatory framework with regard to managing the environment;
2. Identify gaps and needs related to tracking data, research evidence, and capacity, based on the situational analysis;
3. Determine possible interventions to remedy the identified needs.

The SANA used secondary data from published articles and relevant reports. Journal articles, thesis reports from academia, government and national statistical reports were the main sources of information.

A structured data collection guideline, in line with the goals of the assessment and the overall purpose of the GEOHealth hub, was first developed taking into consideration the current practices in environmental and occupational health in Ethiopia. The content of the literature search for the four key themes was identified and approved for subsequent data gathering and review. Data collectors who are currently engaged in practices relevant to the GEOHealth Hub were carefully recruited, oriented, and involved in data collection and synthesis until the SANA draft report write-up process was completed. The progress of data collection and its management were monitored weekly through meetings of the technical teams from January through March 2013.

Two 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 second approach used collection of primary information from stakeholders with semi-structured discussion guidelines. The major stakeholders for GEOHealth -- primarily, the Ministry of Health, the Ministry of Labor and Social Affairs, and the Environmental Protection Authority -- had significant roles as sources and facilitators of data collection. The collected data were categorized into the four themes and synthesized for the write-up using a descriptive approach as described below.

Air pollution and Health

This theme distinguished between two types of air pollution: ambient or outdoor air pollution, which is caused mainly by industries and vehicles; and indoor air pollution from biomass fuel used in households. The relative contribution of indoor air pollution seemed to be greater compared to that of outdoor air pollution, although the latter is on the rise, reflecting 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 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_2, CO, and particulate matter to evaluate levels of indoor air pollution in households and refugee camps. These studies are geographically limited to Addis Ababa, Tigray, Oromia, and the Southern regions. These limited studies have found that the levels of indoor air pollution exceeded limits that have been recommended by regulatory agencies such as the USEPA and by the WHO guidelines. 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 assessment found monitoring and management of air pollution to be critical areas of concern. There exists a conducive policy structure for management and control of air pollution as mandated to the Ethiopian Environmental Protection Authority (EPA). EPA has proclamations and regulations dealing with the management of air pollution, but the capacity to evaluate and monitor the levels of urban air pollution has not resulted as yet in tangible accomplishments. Limited resources as well as limits in technical and training capacity appear to be major bottlenecks to the progress of air pollution management.

The problem of air pollution due to vehicular movement 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, the growing on-road vehicular density and the limited road infrastructure are likely indicators of potential health hazards.

In general, there is currently inadequate information on levels of air pollution in Ethiopia. Improving the national capacity to conduct effective monitoring and evaluation of indoor and outdoor air pollution and to assess the health effects of air pollution, through well-planned and targeted research and training in these domains, would be timely and is highly recommended.

Occupational Safety and Health

This theme focused on exploring the level of industrialization in the country and its impaction the health and safety of the workforce, in addition to the health effects of agricultural exposure. Ethiopia is a primarily agrarian country with only about 5%of the total employed workforce engaged in the manufacturing, construction, and mining sectors. 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. Generally, chief safety issues include accidents that result in injuries, and a wide variety of health hazards of major concern involving chemicals and physical agents. Workplace hazards are 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. Stand-alone health facilities and contract-based public health services are the two modes of provision. In most of the cases, the provisions of health services do not appear to have a strong link with the monitoring and prevention of hazards.

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 and booming 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.

The theoretical concept of hazard management through its avoidance, reduction, or isolation may be currently ineffective in Ethiopia due to such factors as the widespread use of obsolete machines, poor accountability by employers, poor knowledge of and awareness by workers of work-place risks, and limited training on safety issues. Risk management at the person level through the provision of personal protective devices is a common practice, but of little efficacy. Hazard signs are not properly identified by employees because of limited training.

There is severe shortage of properly trained OSH inspectors in Ethiopia. Close to 95% of all available OSH inspectors are found in four regions (Addis Ababa Tigray, Oromia,and Amhara). 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. Even this Bureau, however, is in dire need of assistance and further development with regard to basic professional training on the handling of existing monitoring instruments and enhancing the quality of monitoring instrumentation.

There are only handful studies for Ethiopia that assessed the type and magnitude of relevant health outcomes and respective occupational risk factors. Exposure measurements in the work place were only available in some studies and these 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. The few available studies appear to be neither comprehensive nor nationally representative.

The current organization of hazard surveillance and monitoring of accident/ injury does not appear to be systematic. A shortage of monitoring instruments and the poor quality of the existing instruments are major constraints. Lack of basic training on the operation of the instruments is a challenge in M & E activities. Capacity-building efforts in areas of research, training, policy development, regulation, and organization are greatly needed.

Climate Change and Health

Climate change currently represents one of the greatest development and health challenges in Ethiopia. The current stage of research on climate change and health in Ethiopia is rudimentary: research findings and other activities tend to appear largely fragmented and uncoordinated. As a result, there are only few spatially detailed, methodologically consistent climate impact studies available for review.

Climate change is of critical importance to Ethiopia, which has been identified as one of the world's most vulnerable countries with regard to the impact of the adverse effects of climate change. Human-induced climate change is expected to bring further warming over the next century at unprecedented rates. Climate models suggest that Ethiopia will see further warming in all seasons between 0.7°C and 2.3°C by the 2020s and between 1.4°C and 2.9°C by the 2050s.

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, agricultural failings with malnutrition, extreme temperature events (extreme heat and cold), and re-emergence of climate-sensitive diseases. 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; increasing incidence of climate-sensitive diseases such as malaria, meningitis, and diarrhea; and other adverse health impacts due to scarcity of water and natural disasters such as floods and droughts. Malaria in the highlands is likely to occur in the very near future, while soil-transmitted helminthic infections such as hookworm may increase because of warming. Diarrhea is expected to be a frequent 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 -- not only among children under five, but even among adult population -- will be a significant concern because of food shortages posed by the anomalies of climate change. While the impact of climate change on health and other related issues is recognized by various governmental stakeholders, the specific actions and responses have had very little oversight to date.

This assessment identified the lack of sufficient collaboration among organizations on the planning and execution of climate change and health activities, and the lack of trained professionals who can independently perform climate change and health-related research and activities at various levels. The SANA also revealed lack of a well-organized structure in the various organizations and poor inter-sectoral collaboration; poor coordination and communication among different stakeholders; lack of policies and programs among those who independently target climate change and health; inability of the existing policies to consider the gender- and community-related dimensions of climate change; and weak monitoring and evaluation efforts on climate change and health activities at the various organizations.

Policy, Regulatory and Organizational Framework

This theme addressed the foundation of policy and organizational contexts that play roles in the management and control of health impacts of air pollution exposure, occupational safety, and climate change.

Results of the SANA showed that there are a number of major constraints in addressing the public health challenges arising from air pollution exposure, occupational safety, and climate change.

While many policies and regulatory provisions are already in place, in the majority of cases a lack of persistence is evident in implementing the policies/strategies and enforcing the regulatory provisions.

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 of the stakeholders appear to be suffering from an acute shortage of professionals and poor retention mechanisms.

Research activities in the health impacts of air pollution exposure, occupational safety, and climate change currently appear to be at the minimal level. Consequently, evidence-based decision making and monitoring and evaluation are hampered.

The findings from the SANA on all of the three themes discussed above are characterized by the complexity of the challenges and by their multi-sectoral nature. However, mechanisms for coordination and integration are mostly on paper and not practically functional. Lack of such mechanisms reduces the engagement of the different stakeholders mandated by the government.

The linkage between universities and concerned ministries indicates a mismatch between what the training institutions are producing and the specific skills required by the ministries. It also 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 compounded by poor documentation. The need to build training and research capacity, develop clear implementation guidelines, and build effective inter-ministerial coordination mechanisms should be highlighted as some of the most important findings from this assessment. The development of a full GeoHealth Hub would be of great benefit to Ethiopia.

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Section I

Situational Analysis and Needs Assessment:

AIR POLLUTION IN ETHIOPIA

Establishing a GEOHealth Hub for East Africa

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Summary

Background

The Global Environmental and Occupational Health (GEOHealth) program of the National Institutes of Health (NIH) - Fogarty International Center (FIC) awarded paired planning grants to AAU and USC for a project entitled “Establishing GEOHealth Platform of Research and Training for East Africa” for a period of two years (starting from September 2012). This project focused on three areas: Air pollution and health; Occupational health; and Climate change and health. One of the main objectives of the planning process was to conduct a Situational Analysis and Needs Assessment (SANA) on four thematic areas including the three focus areas mentioned above, as well as policy-related issues as a fourth cross-cutting theme. This report summarizes the findings on the theme of air pollution and health from the SANA that was conducted in Ethiopia. The intent is to appraise the air pollution status of the country and, based on SANA – Ethiopia, to conduct planning of a full GEOHealth HUB for Ethiopia. In year two of the planning period, a similarly designed SANA - with three focus themes and a fourth cross-cutting policy-related theme – is being conducted in each of the three other partner countries in East Africa.

According to the SANA conducted in 2010 on Health and Environment across Sub-Saharan Africa, air pollution was identified as one of the high-risk environmental problems that affect human health in Ethiopia. Moreover, during the pre-inception assessment of the GEOHealth hub, a set of questions was completed by a group of 14 experts working on the theme of Environment and Public Health to rank environmental risk factors/problems using Likert scales. The result showed that the issue of air pollution received the experts' averaged high score of 74% for indoor air pollution and 69% for ambient air pollution (which was identical to the score for occupational health). By contrast, the experts’ scores reflected relatively higher scores for liquid waste and water pollution (each 84%), solid waste (82%), climate change (81%), sanitation and food safety (each 79%), and drinking water supply (76%). Therefore, based on public health significance and feasibility, we found a consensus across the board on the importance of air pollution as a focus area for the GEOHealth hub.

Aims

The main objective of the SANA on air pollution was to investigate the available body of evidence in this area to identify gaps and needs that should be addressed to mitigate and reduce air pollution in Ethiopia. The findings from the SANA will then be used as input to the application for planning the full GEOHealth hub platform of research and training for East Africa.

Methods

A review of published peer-reviewed articles, reports from government and multilateral organizations, official statistics, and unpublished gray literature was conducted using Pubmed, Google search, and hard copy reports to assess the scope of air pollution in Ethiopia. In-depth interviews were conducted with experts from the Ministry of Health (MoH), Environmental Protection Authority (EPA (now, Ministry of Environmental Protection and Forests)), Ministry of Water and Energy (MoWE), and the National

Meteorological Services Agency (NMSA) of Ethiopia to reaffirm the findings of the situational analysis and to identify the constraints/gaps and needs on issues including policy and legal provisions for enforcement, organizational framework, research capacity, training, and institutional capacity, as well as monitoring and evaluation.

Findings

The limited available evidence shows that air pollution is a pressing problem in the country. The health impacts of air pollution, especially those due to indoor air pollution, pose a significant burden to public health. The evidence, however, especially on ambient air pollution, is not extensive and lacks adequate attention. The policy situation is favorable to the environment in general and pollution prevention in particular, including air pollution. The legal frameworks that are currently in place are solely based on a limited number of local small-scale studies, and not founded on solid scientific evidence due to paucity of information in this area. The framework for the enforcement of the laws is mainly intended for ambient air quality management and is mandated to EPA (now MOEPF). However, the laws are not adequately implemented to date due to constraints in human and technological capacity. Monitoring and enforcement are severely hampered by the lack of proper training and experience among the limited skilled manpower, as well as by the lack of laboratory facilities to measure and characterize air pollution exposures. The control of indoor air quality is undertaken by the MoH as well as MoWE, though no surveillance is currently in place. In addition, the SANA revealed that the issue of air pollution and its impact on health is not given sufficient priority by concerned major stakeholders. Without an implementation framework formulated by a consensus among the various stakeholders, the lack of coordination among the various governmental bodies is not surprising.

Conclusion and Recommendation

There seems to be favorable and detailed policy, as well as legal provisions, on air pollution in the country. However, there is very limited human and physical capacity to implement and enforce the existing laws and guidelines.

Very little peer-reviewed research on air quality and its health impacts has been carried out, making it difficult to quantify the magnitude and health effects of air pollution in Ethiopia. In addition to the paucity of high caliber research on air quality, the monitoring and evaluation framework is almost nonexistent due to the relatively low priority accorded to issues related to air pollution by governmental bodies, and to the lack of necessary monitoring facilities.

Therefore, air quality must be given higher priority to enable adequate surveillance for indoor and outdoor air quality; to train the required skilled manpower to conduct relevant high quality research; to promote good practices by the populace to improve air quality (e.g., through better promotion of ventilation in living quarters and use of clean fuel sources); and to promote better coordination among key stakeholders through an agreed-upon implementation framework. It is recommended that concrete steps be taken to improve the technical capacity through training, and to establish air quality management

‘districts’ with the necessary sampling equipment and reference laboratory facilities at regional levels and in large cities.

Abbreviations

AP	Air pollution
AQMD	Ambient Quality Management District
ARI	Acute Respiratory Infection
COPD	Chronic Obstructive Pulmonary Disease
CRGE	Climate Resilient Green Economy
EC	Elemental Carbon
EFY	Ethiopian Fiscal Year
EPA	Environmental Protection Authority
ERA	Ethiopian Road Authority
ETA	Ethiopian Transport Authority
GEOHealth	Global Environmental and Occupational Health
GERD	Grand Energy Renaissance Dam
GO	Government Organization
GTP	Growth and Transformation Plan
IAP	Indoor Air Pollution
MoA	Minsitry of Agriculture
MOEPF	Ministry of Environmental Protection and Forestry
MOFED	Ministry of Finance and Economic Development
MoH	Ministry of Health
MoI	Ministry of Industry
MoT	Ministry of Trade
MoWE	Ministry of Water and Energy
NGO	Non-Governmental Organization
NIOSH	National Institute of Occupational Safety and Health
NMA	National Meteorology Agency
OC	Organic Carbon
PAN	Polyaromatic Hydrocarbon
PM	Particulate Matter
RSP	Respirable Suspended Particles
SCS	Self Contained System
TSP	Total Suspended Particulate
USEPA	United States Environmental Protection Agency
WASH	Water Sanitation and Hygiene
WIF	WASH Implementation Framework

Introduction

The topic of Air Pollution (AP) is one of the four core themes of the situational analysis and needs assessment (SANA) that is intended to make an inventory of existing data/information regarding key

environmental health challenges facing Ethiopia, and to conduct a thorough needs assessment to fill existing gaps in research, capacity, and policy. A variety of data resources were explored on AP covering sources and the magnitudes of exposure, determinant factors, health consequences, exposed and vulnerable populations, and cross-cutting issues such as gender.

The search for data/information was undertaken through a systematic collection and evaluation of the literature; this was carried out using web search tools including PubMed and Google Scholar and a review of the websites of relevant offices. Additionally, personal interviews were conducted with key informants working in the field. The resulting compilation included national and international reports, peer-reviewed journal articles, and government documents, along with the information obtained through interviews. The SANA also reviewed policy frameworks, legal provisions, and resource allocation; it also identified the needs for capacity development related to training, research, implementation, policy and legal framework, and organizational structure.

The review of qualitative and quantitative data considered both past and current situations related to AP. It involved a careful appraisal of all relevant sources, summarized into text form; this was followed by extraction of data using Excel spreadsheets which were later transferred to the GEOHealth database. The GEOHealth database was adopted to fit the objectives of SANA from the HELDS database originally developed by WHO/UNEP for an earlier continent-wide SANA on Health and Environment for Africa. The GEOHealth database has a Microsoft Access platform and is specifically designed for our purposes. The collected information was then synthesized to form the basis for the structured content of this report which is organized by sub-themes of AP.

This SANA report has the goal of providing baseline information on indoor and outdoor AP and health for Ethiopia. The identified gaps and prioritized needs will likely help researchers, policy makers, practitioners, and other partners in the field to set the future research agenda and design interventions that would help to reduce exposure, save energy, and mitigate the effects of AP and climate change on human health through responsible and sustainable synchronized activities for the development of the country. The findings will also be used as input for the design of the envisaged full GEOHealth Hub Platform of Research and Training for East Africa.

Is Air Pollution a Major Problem in Ethiopia? A General Perspective

Air quality, both indoors and outdoors, is a fundamental determinant of health and quality of life. The detrimental effects of living in an environment with polluted air on human, animal, and plant life are immense. Air pollution in Ethiopia, although not well studied, has always been considered until recent years as “low” and inconsequential, based on very little information from some pilot-scale studies (1).

A report released by the Ethiopian Environmental Protection Authority (EPA) (now, Ministry of Environmental Protection and Forest (MOEPF)) indicated that the problem of air pollution manifests locally in large urban areas such as Addis Ababa due to mobile (vehicular) and stationary (industries and

houses) sources. However, the report recognized that the contribution from industrial sources to air pollution was not measured and had yet not been studied (1).

However, recent studies conducted in different parts of the country including the capital city - Addis Ababa - show that air pollution is increasingly becoming a health concern due to high concentrations of indoor as well as traffic-related and other ambient air pollutants (2-6). Moreover, a recent national situational analysis and needs assessment report on the inter-linkage between health and the environment showed a weak relationship, while also identifying air pollution as one of the important policy priorities in Ethiopia (7).

The majority of the diseases and deaths worldwide due to indoor air pollution are believed to occur in sub-Saharan African countries (8). Children and women comprise the most vulnerable segments of the population affected, as they spend significant portions of their days at home where cooking takes place in a very confined and poorly ventilated environment; hence, they are exposed to toxic pollutants contained in smoke from indoor combustion of biomass fuels.

The recent World Health Organization (WHO) report on the global burden of disease and mortality shows that the burden of disease and death attributed to the use of unclean fuel and unvented stoves in the developing world occurs due to acute respiratory infections (ARI) and chronic obstructive pulmonary disease (COPD) among children under the age of five and adult women aged greater than 25 years, respectively (9, 10).

For outdoor air pollution, the major sources are of mobile (vehicular) and stationary (industries) origin. Given the limited capacity for strict regulation and enforcement of technical efficiency and import of used cars, many cars in low to middle income countries, such as Ethiopia, operate for long periods of time, mostly well beyond their mechanical limits, without adequate and regular maintenance. This is believed to contribute significantly to ambient air pollution in urban areas due to incomplete combustion of diesel fuel. Regarding non-mobile sources of air pollution, with the exception of localized problems of air pollution observed near some industries in large urban settings such as Addis Ababa, very little effort has been expended to quantify the contribution of this sector to poor outdoor air quality (1).

Nonetheless, the opportunity presented by the increased public awareness of the effects of climate change and the consequently increased political commitment to the issue during the past decade has encouraged Ethiopia and other nations to anticipate the future and move towards greener economic models. In this regard, some regulatory efforts have been initiated in resource poor nations of sub-Saharan Africa, an indicator of progress.

The ban by the Ethiopian government on importing used cars with old manufacturing dates and the recent efforts towards the use of renewable energy sources such as ethanol mixed with benzene for automobiles, along with efforts to boost power production from other renewable sources like hydro- and wind-power are encouraging signs. These activities are likely to lead to some progress towards achieving

the envisioned climate resilient green economy (CRGE) designed to make Ethiopia a carbon neutral country by 2025.

Although air pollution exposures are likely increasing both indoors and at the ambient outdoor level, there are only a few pilot-scale studies quantifying the concentrations of air pollutants and very little epidemiologic evidence on the health effects of exposure to these pollutants. Hence, one of the main objectives of the planning activities under this proposed GEOHealth Hub platform is to examine the available evidence on the magnitude and determinants of air pollution exposures to identify gaps and areas for future research and to prioritize the needs for capacity building and environmental health policy in Ethiopia. This approach is also designed to be applicable to other countries.

This SANA on the theme of air pollution and health was conducted to systematically review all available evidence on the state of indoor and outdoor air pollution in Ethiopia and associated health effects, and to identify critical gaps to the needs and priorities for research, training and capacity, building in the field of air pollution and health in Ethiopia. The methods and results of the situational analysis are presented in the sections below, followed by a discussion on the identified needs and priorities.

Description of the Methods

Based on a systematic literature search, a total of nine scientific papers were identified and reviewed; these articles were either published in peer-reviewed journals or were based on research conducted with adequate scientific rigor (See Annex 7.1), even if the sources were unpublished. Adverse health effects from exposure to indoor air pollution were assessed in a few studies (2, 5, 6, 11), although primarily using indirect methods. Study designs ranged from longitudinal (two) to experimental (two) and cross-sectional (four). One study did not report the type of study design that was used (12). Seven of the studies measured indoor air pollutants at the household level in urban and rural areas of Ethiopia. The remaining two studies assessed indoor air pollution using proxy factors such as type of fuel source used for cooking.

The studies on indoor air pollution were mostly conducted in an urban setting, with four of the studies undertaken in the city of Addis Ababa, while the rest were conducted in rural parts of Ethiopia including two in central southern, one in northern, and one in southwestern Ethiopia. One additional study was conducted in eastern Ethiopia in a refugee setting.

Although our main interest was on the US EPA's Criteria Pollutants, we included other pollutants in our review such as polyaromatic hydrocarbons (PAHs) and total suspended particles (TSP) that were considered in some of the reviewed articles. The two longitudinal studies with larger sample sizes focused on NO_2, with one looking at concentrations and the other examining the sources of variation. The experimental, exposure assessment and cross-sectional studies focused mostly on carbon monoxide and particulate matter of less than 2.5 micron aerodynamic diameter ($PM_{2.5}$).

The reviewed literature revealed that outdoor ambient and traffic-related air pollution has not been well-studied in Ethiopia. Even fewer studies have been conducted in the outdoor environment on air pollution and its health effects, compared to the limited work on indoor air pollution.

Assessment Findings: Situational Analysis on Air Pollution

Indoor Air Pollution

Overview

Indoor air pollution was documented in several published articles and unpublished research, according to our literature search. The magnitude of indoor air pollution was studied in various parts of the country, both in urban and rural households. These included studies conducted in Tigray (North Ethiopia, Tigray Regional State), Jimma and West Wollega (Oromia Regional State, Western parts of Ethiopia), Kebribeyah (Somali Regional State, Eastern Ethiopia), Butajira (SNNPR, Central Southern part of Ethiopia), and Addis Ababa (Federal Capital, Central Ethiopia). With the notable exception of the *Butajira* study which was longitudinal, all of the other studies were conducted using cross-sectional study designs. The study in the *Kebribeyah* refugee camp used a design resembling an experimental design, but it was not published. One pilot-scale study was conducted on risks associated with occupational-related exposure occurring with traditional coffee ceremonies. A similar cross-sectional study with a relatively larger number of households was conducted in the *Shiromeda* area of Addis Ababa to examine indoor air pollution caused by cooking as measured by particulate matter and carbon monoxide.

Magnitude of Exposure to Indoor Air Pollutants

There are very few studies conducted in Ethiopia that attempt to quantify the concentration of indoor air pollutant and the exposure of subjects to toxic smoke. This section shows the magnitude of exposure as reported in these studies, categorized by pollutants.

Nitrogen Dioxide (NO_2)

Nitrogen dioxide (NO_2) was measured in a longitudinal study in rural homes of the *Butajira* area in south central Ethiopia. This study was conducted from March 2000 to April 2002 and measured NO_2 concentrations for 24-hour periods in about 3300 homes at three-month intervals. Homes with children under five years of age were the targets of this study (11).

The study found the mean (SD) 24-hour concentration of NO_2 in rural *Butajira* to be 97 $\mu g/m^3$ (91.4 $\mu g/m^3$). This concentration was more than double the current WHO guideline values, indicating that the indoor air pollution levels of NO_2 were high in rural Ethiopian homes (13). There are no other published studies reporting indoor NO_2 levels in households in rural or urban areas of Ethiopia.

Particulate Matter and PAH

A 2012 community based cross-sectional study was conducted in Addis Ababa measuring fine particulate matter ($PM_{2.5}$) in 60 households using particle monitors from the University of California – Berkley. Out of 422 households surveyed using questionnaires, only 60 households were selected for particle monitoring due to limited resources (i.e., limited equipment, funds, and time). Respiratory

symptoms of ARI among children under five years of age were assessed using the mothers' survey responses, and the prevalence and risk factors for ARI were determined (6).

Study results showed that the indoor concentration of $PM_{2.5}$varied based on the type of fuel used for cooking and baking (6). Those households using solid biomass fuels had the highest indoor concentrations (2904 μg/m^3), followed by those using kerosene (1446 μg/m^3), and clean fuel (i.e., electricity and LPG) (483 μg/m^3). Surprisingly, the concentration of particulate matter among households mainly using electricity and LPG exceeded the WHO guideline value (14). This might be due to the use of multiple types of fuel in a given household and the arrangement of the town houses that allows smoke to migrate indoors from neighboring homes.

A study in the *Shero-Meda* area of Addis Ababa monitored 84 households to determine the level of women's exposure to indoor air pollutants emitted from biomass burning for cooking as measured by PM and CO over a 24-hour period. The study used a hybrid approach that included in-depth interviews and focus group discussions with the community to gather information concerning issues about fuel use, fuel preference, economics, and social empowerment (15).

This study revealed a high level of indoor air pollution in the *Shero-Meda* area due to biomass fuel used for cooking. The 24-hour average $PM_{2.5}$ levels emitted from the kitchens of 69 of the monitored homes (those with accurate measurements) was 1580 μg/m^3 (Range: 136 - 12,737 μg/m^3). Hence, all monitored households in this study exceeded the USEPA standard of 35 μg/m^3 by threefold or more (15). The remaining 15 homes were not included in the analysis due to inaccurate measurements.

From October 1999 to February 2000, another cross-sectional study was conducted on 382 households in 13 localities (*Kebele*s) of the rural *Jimma* Zone of the *Oromia* region to assess the type of domestic fuel used, identify environmental factors contributing to indoor air pollution, and determine the type of pollutants. Accordingly, information on housing and energy use, including the type of houses, fuel type used, location and type of stove, and time spent in cooking meals were collected using a questionnaire. Smoke was monitored in kitchens with measurements taken near the stove and the surrounding area within breathing distance during cooking. Carbon monoxide, TSP, and PAH levels were also monitored (16). However, this study did not attempt to carry out a bivariate or multivariate analysis.

The concentration of TSP measured in rural *Jimma* homes was found to exceed the 1987 WHO guideline value. The findings for CO and PAH concentrations were similarly found to exceed those recommended in the guidelines. The presence of hydrocarbon molecules (BaP) was identified, although the study was not able to quantify the amount. More than 61% of the sampled (18 sets) households showed pollutant levels greater than the recommended level of 0.15 mg/m^3. Female cooks were exposed to smoke for an average of 4 hours a day, whereas the maximum time recommended for cooks to be exposed to more than 28.8 mg/m^3 is only one hour (16).

Indoor air pollution was studied by Usinger in rural Tigray, Northern Ethiopia (12). The aim of the research was to test, monitor, and document indoor air quality in the kitchens of rural Tigray. Eleven kitchens, built with stone walls and straw, mud, or stone roofs, with an average area of 5 sq. m, were selected for the study. The kitchens contained stoves made by women for baking *injera* (flat bread made of tef – "grass seed") and a small stove connected to the main stove with a tunnel to cook 'watt' – the traditional sauce. The kitchens were separated from the main house and they were typically ventilated through two outlets in the roof for smoke and a door that usually remained open during cooking. The article provided no further details about the methods. The summary report states that the study was initiated jointly by WHO and the Ministry of Health of Ethiopia.

Air quality in the rural Tigray study was measured while Injera is baked, with focus on carbon monoxide (CO), total suspended particles (TSP), and poly-aromatic hydrocarbons (PAH). Consequently, this study reported maximum indoor TSP concentrations that ranged from 83 to 175 mg/m^3, while average concentrations were typically around 20 mg/m^3. Relatively low concentrations of TSP were observed in kitchens with chimneys. Measurements of PAH in the particulate samples taken near the stove showed relatively high carbon concentrations (i.e., up to 417 mg C/m^3), compared to the WHO standard (0.15-1 mg C/ m^3) with large tar spots, while starting the fire. The average value of PAH concentrations was 47 mg C/m^3 (12).

A pilot study was conducted in *Gimbi*e, West *Wollega* in the western part of Ethiopia to assess airborne particulate matter concentrations in homes that use biomass fuels (biomass homes) for cooking. Respirable suspended particulate matter was measured in both biomass and non-biomass homes in the study areas in several households. The NIOSH method 0600 was used to measure RSP indoors (3).

The *Gimbie* indoor air pollution study found that the concentrations of RSP were as high as 130 times greater than air quality standards (3), suggesting that in-home burning of biomass fuels is a major risk factor for maternal and child health effects.

Another pilot study was carried out in 10 homes of Addis Ababa (2) to determine whether cooks and participants of traditional coffee ceremonies were exposed to excessive indoor smoke levels and if this exposure was potentially hazardous to the health to those present. Although the households were not randomized, the authors included a variety of housing structures intended to account for nonrandom sampling. Carbon monoxide, total particulates, and respirable particulate matter (PM_4) were measured using standard instruments, after proper calibration and conditioning of the PM filters in a US-based lab for relative humidity and temperature.

In this study, both personal and area-level exposure measurements were collected from coffee preparers and coffee ceremony participants. The coffee preparers were asked a set of questions before the ceremony began about their attitude towards the smoke produced during the ceremony and about preferences for heating methods. The ventilation conditions in the rooms were ascertained and the volume of the room was measured (2).

Measurements of PM_4 and CO for both personal (coffee preparers) and area level (coffee ceremony participants) exposure were collected for a short period in each home (range: 60-85 min., median: 71 min.).The results showed that the geometric mean of particulate matter concentration was more than 1000 $\mu g/m^3$. The 24-hour 2005 WHO guideline value was exceeded in 7 out of 10 sites, and the median and mean concentrations were above the same guideline value (2).

Carbon Monoxide

In a study of CO monitored among 54 homes in the Shiro-Meda area of Addis Ababa, the 8-hour average concentration was 16.08 ppm (range: 0.66 ppm - 69 ppm). The US EPA's 8-hour average CO level of 9 ppm was exceeded in 26 households (48%) (15).

The maximum CO concentrations in the rural Tigray study ranged from 310 to 600 ppm, although the average CO concentrations were found to be low (only 44 ppm), and very low concentrations (only 5 ppm) were observed in households with chimneys. However, the concentrations tended to increase when the wind blew into the chimney. Due to the poor combustion efficiency of dung, the CO content of the exhaust fumes could exceed 4000 ppm, showing the highly polluting potential of the stoves when used with dung (12).

The results of CO from the coffee ceremony smoke exposure study in Addis Ababa homes showed that in at least one sample of CO measurements, the WHO guideline value was exceeded in nine out of the 10 sites (90%)(2).

The authors of the same study in the Addis Ababa pilot study found that the contribution of respirable particulate matter (PM_4) from coffee ceremonies during a 24-hr period was estimated to have median values of 57 $\mu g/m^3$ and 72 $\mu g/m^3$ and geometric means of 58 $\mu g/m^3$ and 72 $\mu g/m^3$, for cooks and participants, respectively, with a minimum of 8 $\mu g/m^3$ for both groups and maximum concentration of 359 $\mu g/m^3$ and 496 $\mu g/m^3$, respectively (2).

Household Energy Use Pattern, Sources of IAP, and Stove/Fuel Efficiency

In households, the type of energy source, cooking habits, and ventilation conditions are important factors that determine the level of pollutant concentration indoors and consequently the health of the family, especially children and women.

The most recent national survey indicated that biomass fuel is used by nearly all Ethiopian households (95%), with the vast majority (85%) using firewood for cooking. The household fuel use pattern is mixed, in that more than one type of fuel can be used in a household. With respect to the main source of energy, however, the pattern varies between rural and urban settings. For instance, firewood is used by nine out of ten rural households as the main fuel source for cooking, while slightly more than half (54%) of urban household dwellers use wood (17).

Charcoal is the second most frequently used type of fuel (18%) in urban areas, although it is used infrequently (0.2%) as fuel in rural areas, with the remainder of rural households (8.4%) using leaves/dung cakes. The use of relatively cleaner energy sources such as kerosene, LPG, and electricity for cooking is almost non-existent in rural settings, whereas in urban areas kerosene (5%) and gas/electricity (7.7%) are used in small proportions. Kerosene is used, however, for lighting in urban (88%) and rural (64.4%) households (17). In addition to the nationwide survey on patterns of energy use, pocket studies (5,6,13,16) were also conducted in several parts of the country, reporting a varied pattern of household fuel use. A summary of the results is presented in Table 1 below.

Table 1 Percentage Distribution of Household Energy Use Pattern for Cooking by Country, Rural and Urban Settings of Ethiopia

Citations: Author & Year Type of Fuel Used for Cooking (%)	WMS, 2011*			Kumie, A. 2009	Desalegn, B. 2012	Faris, K. 2008	Senbeta, H. 2012
	Country, %	Urban, %	Rural, %	Rural, SNNPR, Butajira, %	Rural, SNNPR, Shebedino, %	Rural, Jimma, %	Urban, Addis Ababa, %
Wood	85	63.3	90.8	52.1	97.3	86	21.1
Leaves/Crop residue/ Animal dung	7.2	2.7	8.4	47.8	2	14	4.7
Charcoal	3.9	17.5	0.2	0.1	0.7	-	34.4
Solid fuel	95	87.4	99.6	99.9	100	100	60.2
Kerosene	1.2	4.9	0.2	0	-	-	18
LPG/ Electricity	1.9	7.7	0.2	0	-	-	21.8
Total	100	100	100	100	100	100	100

*This is a national survey; while the rest are pocket-area surveys representing limited geographic locations with varying survey periods.

Table 1 shows that wood is the dominant source of household fuel, ranging from 52% in the Butajira study (13) to 97% in the Shebedino district (5), with both studies conducted in the SNNP Region (Southern Ethiopia). The use of wood for cooking is relatively low in Addis Ababa (6), where only 21% of the surveyed households use wood for cooking. Instead, charcoal is used by more than a third (34.4%) of the households in Addis Ababa, followed by electricity (19.4%) and kerosene (18%).

Nationally, nearly all households in rural areas and a great majority of those in urban areas (87.4%) use solid biomass fuel for cooking. Cleaner fuel sources are used for cooking by less than 2% in the country, while their use is almost nonexistent (0.2%) in rural areas. Charcoal is used in Addis Ababa for the same purpose at twice the country's urban average rate of use. Nearly half of the households in a study in rural Butajira (13) use crop residues and animal dung for cooking, which is similar to the proportion using wood for the same purpose. The study in Addis Ababa shows that urban dwellers use nearly three times more clean energy fuel than the national average. In the *Jimma* area study (16), it was shown that cow dung is not a widely used type of biomass fuel among rural communities, but rather that wood, leaves, crop residue, sawdust, and oil cake are more commonly used. Wood (86%) was the preferred choice, followed by animal dung (14.1%) (Table 1).

Mixed use of fuel types for cooking is a common practice in both urban and rural areas of Ethiopia. A household often uses more than one source of energy for cooking, including mixing of clean with unclean fuel types, especially in urban areas (6,13). Consequently, the variation in pollutant concentration could very well be due to the type of material burnt and its pattern of mixing.

The burning of cooking fuel is not necessarily the only source of indoor air pollution, although it is considered the major source. Other sources include pollutants generated from unclean fuel sources used for indoor space heating and lighting (5,13,17). As previously stated, more than half of the population in Ethiopia (52.3%) uses kerosene for lighting, while among the rural population nearly two-thirds (64.4%) use it for the same purpose (17). The disparity in terms of access to electricity for lighting is very high when comparing households in urban areas (87.4%) to their rural counterparts (4.9%), leading to a national average of 22.5% for coverage of electricity.

A traditional coffee ceremony, which involves the process of roasting coffee beans using charcoal and the use of incense, is a common ritual in both rural and urban households in Ethiopia. The ceremony may be undertaken up to 3 times a day on some occasions. This process releases particles and toxic gases into the air that could potentially harm the health of those exposed (2).

Therefore, the higher concentration of fine indoor particles observed among surveyed households in Addis Ababa (6) that exceeded the recommended WHO guideline values might be due to additional sources of pollution from lighting, indoor space heating, and activities such as coffee ceremonies. Moreover, the migration of smoke from one townhouse to others nearby and to those that are interconnected could contribute to the spread of the indoor pollutants.

Two studies -- one with a pre-post intervention design in homes in Addis Ababa City, Central Ethiopia, and the other in Kebribeyah refugee camps, Somali region, in the eastern part of Ethiopia – were conducted to measure indoor air quality resulting from solid biomass fuel burning. The two studies were independently conducted by the Gaia Association (18,19). The researchers measured the concentrations of CO and $PM_{2.5}$ emitted from combustion sources in the kitchen during the pre-intervention phase, and then measured the corresponding post-intervention levels after replacing those unclean stoves that burn crude fuels with clean cook stoves that use ethanol as fuel.

The Gaia Addis study was conducted in the kitchens of nine homes in the *Yeka* sub-city of Addis Ababa. CO and PM were measured using instruments that were pre-calibrated against “gold standards”. The households in this study were selected using set criteria among similarly structured households made of metal, wood, and mud, and their inhabitants were members to the Good Shepherd Sisters Charities and the Former Fuel Wood Carriers Associations.

CO and PM were measured for continuous 48-hour periods using a protocol that specified where to place the monitoring equipment in the kitchen. A pre-monitoring questionnaire was used to determine the structure of the cooking areas, while a post-monitoring questionnaire was used to interview the main cook of each household to determine what the cooking environment looked like throughout the monitoring period. This was intended to help explain variations in pollution levels that may occur as a result of diverse cooking activities (18).

The Gaia *Kebribeya*h study was similarly conducted in 11 homes at the *Kebribeyah* refugee camp in the Somali region (19) where CO and $PM_{2.5}$ were measured using similar instruments and methods. A unique characteristic of this study was the uniformity of the housing units, which were characterized by their poor ventilation as they had no windows or doors; instead, they were covered by cloth flaps in both the living quarters and the cooking shelters. This unique characteristic offered an exceptional testing environment that was likely to yield high concentrations of combustion pollutants.

The results of the 9 homes in *Yeka* area (Addis Ababa) study (18) showed a significant reduction while using wood and charcoal stoves (before) compared to using clean stoves (after), with $PM_{2.5}$ concentrations of average (Range: 0.64 -0.23 mg/m^3), maximum (Range: 27.66 -11.88 mg/m^3), and highest 15-min average (Range: 13.03 -4.23 mg/m^3) by 64%, 57% and 68%, respectively. Likewise, a 76% significant reduction was found in the mean HOBO CO concentration after clean cook stoves were installed (5.9 ppm), compared to before (24.6 ppm). However, a non-significant 49% reduction was also observed in the maximum CO HOBO concentration which dropped from 158.1 ppm to 80.8 ppm during before-and-after interventions, respectively. Improvement in indoor air quality was evident in $PM_{2.5}$ concentrations (i.e., 640 -230 ug/m^3), despite secondary sources such as kerosene still being used, compared to the WHO guideline of 2005 (i.e., 75 or 25 ug/m^3). However, the average CO concentration dropped significantly from 28.2 mg/m^3 (before charcoal and kerosene use) to 6.8 mg/m^3, compared to WHO 2000 air quality guidelines (i.e., 10 mg/m^3).

The findings from the *Kebribeyah* study (19) showed a statistically significant (P=0.004) 94% reduction in average $PM_{2.5}$ concentration after the intervention (i.e., clean cook stoves) (0.13 mg/m^3) (Range: 0.06 – 11.2 mg/m^3), compared to before (2.17 mg/m^3) (Range: (0.04 - 70.11 mg/m^3) (i.e., traditional wood and charcoal stoves). Similarly, the highest 15-minute average concentration showed a 91% reduction from 42.72 – 3.64 mg/m^3. For the mean HOBO concentration of CO, a 79% reduction was observed after the intervention (14.6 ppm) versus before (70.5 ppm). A similar reduction (72%) was seen in the CO (maximum, HOBO) concentration of 509.3 ppm before versus 140.5 ppm after; and CO (mean, tubes) concentration of > 37.2 ppm and > 12.7 ppm for before and after the intervention, respectively. Despite limitations and assumptions based on experimental designs, the use of clean cook stoves rather than stoves that use solid fuel has shown a significant reduction in PM and CO pollutants.

In general, the findings from the two independent studies described above demonstrate that the use of clean cook stoves alone at different settings (rural, urban, or refugee camp) could dramatically improve indoor air quality, reduce exposure to toxic gases, and improve the health of the family.

Determinant Factors for Indoor Air Pollution (IAP)

There are various factors that affect the exposure to indoor pollution levels including fuel type, energy efficiency of cooking stoves, ventilation, weather conditions, and season of the year. This section describes the factors that are found to be major determinants of indoor air pollution in Ethiopian homes based on the evidence from the few available studies.

The study in *Shiro-Meda* homes in Addis Ababa differs from other studies in that measurements were taken on days when the flat bread'injera' was baked. This activity could contribute to the high levels of indoor pollution as leaves and tree branches are typically used for baking. Factors such as maximum temperature recorded during cooking (which might be an indicator for poor ventilation and closed windows) and kitchen volume were observed to have significant effects on CO levels. As the monitoring data were collected during the rainy season (June-July), the weather might have made a significant contribution to the high levels of indoor air pollution (15).

Factors such as altitude, vegetation, season, type of fuel, frequency of fire events, and number of foods cooked per day help to explain the sources of variation of indoor levels of nitrogen dioxide (NO_2) in the rural Butajira study. Living in a household located in a highland setting, wet season, use of crop residues, having a fire event, frequency of food items, and interaction between ecology and season were found to be statistically significant predictors of NO_2 concentrations indoors (13).

In the rural *Jimma* study, more than 90% of the households had one or two rooms. Few households were reported to keep windows and doors open at all times (8%), while a similar proportion of the study homes possessed a proper chimney (11.5%) for ventilation. Thus, lack of a separate kitchen (72.5%) and lack of windows for ventilation (92%) were identified as risk factors contributing to high indoor air pollution levels in the surveyed households (16). The results from the same study also showed that concentrations of pollutants exceeding the WHO recommended guideline values were recorded for some fuel types, especially when wood was used alone or in combination with other fuel types. Similar to the rural *Jimma* study, the study in rural Tigray showed that households with chimneys recorded the lowest concentrations of TSP (12).

For children living in homes using biomass fuel, the likelihood of suffering from ARI was 3 times greater than for those living in homes using clean fuel [OR=2.96, 95% CI: 1.38-3.87], after adjusting for confounding factors such as cigarette smoking, sex of head of household, ventilation, and carrying a child on the back during cooking. Based on a range of the identified risk factors, study authors recommended implementing concrete public health actions including improving fuel and cooking technology and housing and ventilation conditions, and keeping children away from sources of smoke (6). A similar finding in an earlier study in *Shebedino*, Southern Ethiopia, also showed that child-carrying position at home can be a risk factor for ARI (5).

Health Consequences of indoor Air Pollution

The levels of fine particulate matter are very much linked to respiratory symptoms, especially ALRI among children (WHO 2007). The 2011 Ethiopian Demographic and Health Survey reported a country-wide prevalence of 7% for acute respiratory infections (ARI) among children under 5 years old. An urban-based pocket survey (6) found a prevalence of 23.9% for ARI's among children under 5 years in surveyed homes of Addis Ababa during January to February 2012. An earlier study reported an ARI

prevalence of 21% during January to February 2006 among children in the *Shebedino* district, S*idama* Zone, Southern Ethiopia (5).

While a relatively lower prevalence was reported for the national average, the higher prevalence in the two urban and rural area-based pocket surveys suggests that the surveys were conducted in areas where more vulnerable populations reside, and hence, underlying risk factors such as malnutrition among young children might have had an impact.

Particulate matter from biomass and cleaner fuel such as kerosene is known to contain a large number of chemicals and compounds ranging from toxic metals such as lead to carcinogenic hydrocarbons. Aerodynamic size is also critical as smaller particles, specifically the fine and ultrafine, can penetrate into the small airways and alveoli. Very few studies have attempted to determine the dose-response relationships for indoor air pollutants in Ethiopia. Efforts were made to assess the association between proxy indicators of pollution such as fuel type used (5) with the respiratory health condition of young children. The average PAH concentration of 47 mg C/m^3 reported in the rural *Tigra*y study indicated the presence of carcinogenic substances in the particles measured (12). The study in rural *Jimma* (16) also showed the presence of BaP in the burning biomass fuel; the report, however, did not quantify the concentration.

At-Risk Populations and Analysis of Gender Equity

The long-term exposure to indoor smoke could cause health hazards to women and other vulnerable populations. The global toll of the problem is grave with regard to ALRI and COPD among children and women (8).

Globally, studies conducted in numerous developing countries show that the use of unimproved stoves and solid fuel sources has a greater impact on the health of young children, often in the form of acute lower respiratory infections (ALRI) and in adults, affecting mostly women, with chronic obstructive pulmonary disease (COPD) (20).

In Ethiopia, women who are engaged in cooking in poorly ventilated kitchens using biomass fuels and unimproved stoves (15) could be at high risk of exposure to indoor air pollution and the associated health problems (2). Also at high risk are those who are engaged in coffee brewing -- including coffee ceremony participants-- in homes with similar conditions.

The mother is the most exposed family member in most households. The study in rural *Jimma* revealed that mothers (91%) were the main cooks, followed by daughters (8%). Most mothers in the study claimed to have spent 1 to 3 hours for cooking, and a few claimed to spend 4 or more hours cooking (16).

In addition, younger children (under 5 years of age) are also vulnerable to respiratory illnesses and other related diseases caused by exposures in households with conditions favorable to poor indoor air quality. The position of young children while cooking (5, 6) was found to be a determining factor, especially in

rural homes where indoor air pollution levels are aggravated by lack of windows or a ventilation system, overcrowded conditions, and sharing space with domestic animals (21).

Urban Outdoor/ Ambient Air Pollution

Overview

Based on the literature review, only a few studies have been published on outdoor/traffic-related/ambient air pollution in Ethiopia. The most recent --and the only longitudinal study in Addis Ababa -- was conducted on traffic-related air pollution as measured by carbon monoxide (CO) at 40 roadside sampling locations on 20 major road networks in the city. The sampling took place during July 2007 (wet season) and January 2008 (dry season) on the roadsides and March/April 2008 (dry season) using on-road sampling on weekdays, plus Saturday from 7:00am to 6:00pm. This study is unique for addressing seasonal variation and for its relatively large sample size and number of sampling sites; it used only CO, however, as an indicator of traffic-related air pollution (4).

A pilot study in Addis Ababa during the dry season (January-February 2004) was conducted at 12 sites using 21 samples. This study looked at ambient air quality by measuring particulate matter, with an aerodynamic diameter of less than 10 micrometer (PM_{10}), CO, and ozone (O_3). The study also analyzed the concentrations of 40 elements in the sampled particles. Study sites were divided into two geographic areas -- urban and sub-urban --, allowing for comparison of air quality in different settings, which also helped to differentiate the sources. The sampling may not represent the annual air quality level, however, as a cross-sectional study design was used but during one season only (22).

One study conducted an experimental assessment on the spatial and temporal aspects of total suspended particulate (TSP) and PM_{10} during February to April 2008 and from June to July 2008. Sixty-six samples were collected from seven distinct sampling sites. The mass of each particulate matter sample was measured using gravimetric methods; the chemical composition of the particulates in PM_{10} samples was also analyzed. Strengths of the study included sampling in urban as well as peri-urban locations within 5km and at a 10km distance from the city center, respectively, and sampling during two seasons (dry and wet). The number of sampling sites was limited, however, and the study did not include surrogate indicators for traffic-related pollution as its focus was on metals, not gases. The composition of the particulate aerosols was documented in this study (23).

Based on the literature review we conducted and to the best of our knowledge, there is no published research available until now that was conducted on the magnitude and composition of ambient air pollution levels in regional cities, large or small towns, or in rural areas of Ethiopia, with the exception of Addis Ababa. Moreover, almost no research has been conducted on the health effects of traffic-related air pollution in urban and sub-urban areas of Ethiopia. Our literature search identified only one study conducted in Jimma town, which is located in Southwestern Ethiopia (24).

The *Jimma* town study used a proximity model to explore the effects of traffic-source air pollution on allergic symptoms and diseases. The investigation addressed the effects of exposure to traffic-related pollution on the risk of wheeze in an Ethiopian population using the proximal factor of distance from paved roads to home addresses for 7609 individuals in *Jimma*. Data previously collected on respiratory symptoms, allergic sensitization, and numerous lifestyle and demographic factors were used. Additionally, the households were retraced in 2003, and the shortest distance to the nearest paved road and traffic flow on these roads were measured (24).

Magnitude of Traffic-Related/Ambient Air Pollution

Carbon Monoxide

The study in Addis Ababa found that the 15 minute mean concentrations of CO during the wet and dry seasons were 2.1 ppm (GM=1.3) and 2.8 ppm (GM=2.2), respectively. The variation in concentration between the two seasons was statistically significant. However, a similar profile was observed temporally and spatially between the two seasons. The mean CO concentration of all on-road collected samples was 5.4 ppm (GM=5.3). The 8-hour CO WHO guideline value was not exceeded, however; and CO concentration in 15% of the samples collected on the roadside and all (100%) on-road samples were measured at greater than 50% of the 8-hour CO WHO guideline value. Daily maxima of CO concentration were observed in early mornings and late afternoons during the study periods (4).

Particulate Matter, Ozone and Lead:

A study in Addis Ababa found that the PM_{10} mass concentrations measured at urban sites during the dry months (January/February) were higher (<100 $\mu g/m^3$) than those in sub-urban areas (40 $\mu g/m^3$) of the city. PM_{10} lead (Pb) concentrations present in all samples collected were found to be < 0.1 $\mu g/m^3$. The authors underscored the importance of this finding, coming a few months after the government stopped importing leaded gas into the country and anticipated that the stocks would be depleted by the end of 2003. One-third to nearly two-thirds (i.e., 34%-66%) of the total mass of PM_{10} reconstructed chemical composition was derived from geological materials, which probably resulted from unpaved roads and road shoulders (22).

The contributions of carbon compounds (i.e., elemental carbon (EC) and organic carbon (OC)) to the measured PM_{10} at sub-urban sites (EC vs. OC: 24% vs. 26%) are generally less than that of the urban sites (EC vs. OC: 31% vs. 60%). The difference between the sub-urban and urban areas, however, especially with regard to the proportion OC, is more than double in urban sites. The urban sites showed only a 7% increase in EC PM_{10} composition, compared to sub-urban sites.

The same study noted that the peak hour for PM_{10} and CO pollution levels was 7:00AM, followed by secondary peaks during late afternoon and evening. The authors postulated that the timing for the observed peaks might be due to the high pollution arising from high motor vehicle traffic and cooking/heating activities during those periods. They also suggested that the condition may have been magnified by the temperature inversion phenomenon during cold nights (22).

The ozone (O_3) concentrations measured near mid-day were all <45ppb. The non-volatile particulate nitrate (NO_3), which is a lower limit for atmospheric NO_3, measured <5% and 7% for PM_{10} at urban and sub-urban sites, respectively (22).

Chemical Composition of PM:

Another study found that TSP concentration in Addis Ababa ranged from 17 to 556 μg/m^3. PM_{10} concentration was within the range of 17 to 285 μg/m^3. The highest peak values for TSP and PM_{10} were observed at two sites during the dry season sampling (February 2008), while the lowest values of TSP and PM_{10} were observed during the wet season (June and July 2008) at two sites. The mean TSP concentration exceeded the WHO safe guideline value of 150 μg/m^3. The maximum TSP concentration exceeds the WHO safe guideline value by nearly threefold (270%) Seventy-nine percent of the PM_{10} values were found to be below the WHO guideline value. The ratio of PM_{10} to TSP was in the range of 0.26-0.59; by mass, PM_{10} contributed 39% to the TSP. The average element concentrations in the PM_{10} filter sample was in the order of Fe<S<Mg<V<Al<B<Sb<Zn<K<Na<Ca. All the chemicals analyzed contributed 0.1% of PM_{10} mass; according to results from the SEM-EDAX analysis of PM_{10} samples, Si, Al, Na, Zn, Ba, K and C were the predominant species. C and Cu represented 5-24% of the crustal materials, which contributed to 76-95% of the filter mass (23).

The Health Effects and Exposure to Outdoor/ Traffic-Related Pollutants

As described earlier, the *Jimma* study (24) investigated the effects of living close to traffic- bearing roads on the risk of wheezing. The study did not take any direct measurement of pollutants, however. Proxy factors such as traffic volume and distance of household location from the nearest paved roads were used in the model, in addition to respiratory symptoms, allergic sensitization, demographics (age, sex), socio-economic status (based on goods ownership), and lifestyle factors (smoking status). This proximity model, compared to more recent predictive models, lacks additional environmental variables such as wind direction and speed, relative humidity, temperature, exposure to indoor air pollutant factors due to household activities such as cooking behavior, ventilation system, and type of fuel used, although use of kerosene and smoking status were included. Although the daytime traffic density in *Jimma* (median of 653 vehicles) is relatively low, ranging up to only about 2500 vehicles per 12 daytime hours, the high pollution and consequently elevated asthma prevalence perhaps may be attributed to the old age and poor maintenance of the vehicles (24, 25).

The long time span -- from 1996 when the first study on which symptoms of respiratory diseases and asthma allergy sensitization were measured to 2003 with the measuring of traffic flow and houses' proximity to the road -- limits interpretation of the results. It is likely that the flow and network of roads might have changed over time, even though the authors assumed no significant changes have occurred (25). Moreover, the target population was not specifically the more vulnerable population groups:

younger children and women, who spent most of their time at home potentially exposed to high levels of indoor air pollution from combustion sources arising from indoors and/or the outdoor environment.

Other findings from the same study revealed that for 7609 (80%) of the households where location data were collected, no statistically significant difference in the overall prevalence of wheeze was evident between individuals living in households located within 150 m from road traffic and those living further away (i.e., 3.9% v. 3.7%). A significant linear relation was observed, however, among the 3592 individuals living within a 150 m distance from the road (adjusted odds ratio=1.17 per 30 m proximity, 95% CI: 1.01 - 1.36 m), showing increased risk in the prevalence of wheeze. The relationship in the prevalence of wheeze between persons living within 150 m from the road and those living further than 150 m away was stronger, although the difference becomes less significant for roads with traffic flow above the median. This might be due to excessive exposure and consequent adaptation to the allergic sources. Based on the data, the authors concluded that living in close proximity to road vehicle traffic is significantly linked with an increased risk of wheeze. They did not rule out the potential importance of other environmental factors, however, as inputs for improving future modeling (24, 25).

Outdoor air pollution levels are generally considered to be lower in non-industrialized developing nations such as Ethiopia compared to those of the Western world; however, the results in *Jimma* suggest the adverse effects of living in close proximity to road traffic on asthma risk, even with significantly lower traffic flow. The prevalence of wheeze in those living farther than 150 m from roads was not as low as expected, suggesting the importance of other environmental factors not considered in this study population.

Policy, Legal and Organizational Framework

Policy and Legal Framework on AP

A potentially favorable policy environment for air quality is provided in the FDRE Constitution in Article 44/1, granting the right for all persons to have a clean and healthy environment as a fundamental environmental health right. Moreover, it implies the obligation that the government has to ensure the citizens' right to live in a healthy environment and to ensure that the design and implementation of projects and programs will not damage or destroy the environment. These provisions are stated in Articles 92/1 and 92/2, respectively.

Based on the Constitution, the environmental policy of the country was issued reflecting the duties to prevent pollution of land, air, and water in cost-effective ways; to recognize the importance of water resources to meet the energy demand of the country; and to promote training and to improve the working conditions of researchers under the specific objective of preventing pollution under the Sub-Articles 2/2/f, 3/5/g, and 4/8/b, respectively.

The FDRE health policy contains statements about the prevention of environmental pollution from hazardous chemical wastes under Article 5/3.

Regarding the legal frameworks affecting air pollution, Proclamation No. 300/2002 issued on Environmental Pollution Control, under sub-article 6/1/b, outlines the provisions covering environmental policy on air quality standards (especially ambient air quality) and on the need for decisions on cut-off points to provide allowable amounts of emission for both stationary and mobile air pollution sources.

Institutional Arrangements to Control Air Pollution

To implement the policy effectively, organs that can promote a healthy environment, draw effective strategies and issue guidelines, and conduct enforcement duties through enabling an organizational framework equipped with technical and other relevant capacities, need to be in place. To this effect, the Environmental Protection Authority was established following the provision of the Environmental Organs Establishment Proclamation (Proclamation No. 295/2002). The proclamation vested the Federal EPA (now MOEPF) to be an autonomous organ that can function through its regional and subsequent line offices. It provides the right granted by the Constitution of Ethiopia to regional governments to be autonomous and hence to establish an independent regional environmental agency, or designate an existing environmental agency to manage the environment.

Therefore, from the above mentioned legal provisions and policy frameworks, the issue of environmental protection in general, and prevention and control of ambient air pollution in particular, is given to EPA/MOEPF. Based on these provisions, EPA/MOEPF is responsible for issuing guidelines on air quality standards for the ambient environment. The Ambient Environmental Quality Standards are set on these premises with a goal of protecting the environment and safeguarding public health.

Capacity to Monitor Ambient Air Quality

EPA/MOEPF issued guideline values to regulate emissions by point sources such as industries. With the exception of the CRGE strategy issued to adapt and mitigate climate change, few strategy documents are available on air pollution to date that could implement the stated policies, legal provisions, regulations, or environmental standards/guidelines. The Environmental Inspectorate was vested with the power to enforce the standards as constituted under Article 7 of the Environmental Pollution Control proclamation (no. 295/2002). Moreover, article 7 sub-article (b) states that environmental inspectors may ‘without prejudice to sub article 3 and 6, enter any land or premise at any time which seems appropriate to them without prior notice or court order’. However, it seems that the current focus of the federal EPA/MOEPF is the control of large state development industries/factories, although regional EPA/MOEPF line offices are also delegated to undertake the rest of the activities. Even so, the human and institutional capacities of the federal EPA//MOEPF and its line offices at the regional level prevents it from discharging its responsibilities according to the guidelines. The availability of well-equipped laboratories and technical expertise to measure and analyze samples is also very limited. The regional Environmental Protection Agencies and designated bodies also face similar problems to discharge their

responsibilities properly. The fact that the regional annexes of EPA//MOEPF are autonomous (exercising decentralized power) might also have prevented the federal agency from implementing strategies in a smooth, systematic, and coordinated manner.

Implementation and Coordination Capacity on AP

EPA/ /MOEPF is mandated to enable line ministries to open offices that link its mandated activities with respect to environmental protection and pollution control, and to coordinate their efforts through monitoring and evaluation, training, and capacity building. In this regard, the Ministries of Agriculture, Mines, Water and Energy, Trade, and Industry are coordinating efforts with the federal EPA/MOEPF to fill key positions and open coordination offices. These institutions are also delegated to perform environmental audits and impact assessments using their own experts and to report to EPA/MOEPF. The MoH, however, has not been able to do so for reasons that are not immediately clear.

It is worth noting that the MoH does not have a dedicated Environmental Health directorate or department due to the recent restructuring in the ministry. Rather, environmental health activities seemed diluted into different directorates and agencies under its jurisdiction, though most recently hygiene and environmental health was reorganized as a case team structure. Under this scenario, environmental health activities apparently seem visible only at the community or Kebele level through the activities of the Health Extension Workers. Air pollution in general and indoor air pollution in particular, therefore, need a concerted effort among concerned stakeholders such as MoH, MoA, MoWE, and Civil Societies to receive much needed attention. However, no such effort exists among these stakeholders who are charged with working for the common goal of safeguarding public health and protecting the environment. In this regard, the WASH Implementation Framework (WIF) agreement signed between MoH, MoE, and MoWE to implement WASH projects in a collaborative manner is a good start that can set an example for similar inter-ministerial coordination of activities with shared goals.

The qualitative findings from the situational analysis and needs assessment suggest little coordination between EPA /MOEPF, NMA and MOH, as one agency points towards another when asked about its role with regard to air pollution, with the issue of monitoring ambient air pollution as an example. There is a general understanding, however, among the ministries that EPA/MOEPF is mandated to monitor and enforce standards on ambient air pollution, while NMA is responsible for generating data on climate and air quality. While NMA reports to MoA, there is no as-such working relationship or coordination with EPA/MOEPF, except in CRGE implementation-related activities. A communication gap seems to exist between the two governmental bodies.

Currently, NMA plans to install air quality monitoring and surveillance equipment in Addis Ababa. There is no doubt about the need for a systematic ambient air quality management activity, especially in Addis Ababa. However, it is not clear if EPA/MOEPF needs to monitor ambient air, which it is not currently doing, to issue guidelines and enforce them. From the perspective of resource utilization, avoiding duplication of efforts is critical, and it is vital to create a working relationship among these concerned

parties to utilize the generated data and affect policy. It is worth mentioning, however, that the efforts by EPA/MOEPF and the Ethiopian Transport Authority to study automobile tailpipe emissions and set standards are exemplary.

Indoor Air Monitoring and Surveillance

To date, the monitoring of indoor air pollution seems to be an activity left to no particular organizational body. MoH promotes healthy housing conditions through HEWs, and MoWE/MoA encourages households to use clean, fuel- efficient stoves. However, the efforts "on the ground" appear less coordinated. Thus, there is uncertainty as to the agency holding responsibility to monitor indoor air pollution. Experience from developed countries shows better coordination and systematic efforts for measurement and evaluation. For instance, in the United States, there is a federal EPA with several air quality management districts (AQMD) located in different states. AQMD monitors ambient air continuously and point stationary sources periodically to ensure that emissions to ambient air do not exceed the national standards. However, in Ethiopia, no research activities are currently funded or conducted by EPA/MOEPF and/or MoH on air pollution control and prevention.

Does Air Pollution Affect Public Health and the Healthy Environment?

The major environmental problems in Ethiopia, according to EPA/MOEPF, are natural resource degradation, pollution, and climate change.

The fact that air pollution and its associated health effects receive low priority from both EPA/MOEPF and MoH, leads to limited allocation of resources in the institutional budgets. Arguably, though, the reverse could also be true. For instance, the total budget for the country in general and for specific sectors such as EPA/MOEPF is quite small in resource-limited countries like Ethiopia. Hence, even if AP is among their top priorities, the total budget that can be allocated is subsequently very limited and may not have the capacity to afford, for example, the continuous monitoring of air pollutants.

The problem of air pollution, both indoor and outdoor, is much greater than generally perceived. The available evidence shows that traffic-related air pollution --though not well studied -- and indoor air pollution are important sources of pollution exposure. Moreover, experts agree that the burning of solid waste in urban centers contributes significant air pollution to the ambient environment. Some of the pressing evidence on the magnitude of the problem on health impacts linked to exposure to air pollution is described below.

The burden of disease attributed to indoor air pollution from the burning of solid fuels is very high in developing countries in general. National estimates on the burden of diseases for the year 2002 due to indoor air pollution shows that in Ethiopia, where over 95% of the population uses solid fuels for cooking, the lives of 50,320 children under five years of age were lost due to ALRI, and 6410 adults greater than

or equal to 30 years old died due to COPD from solid fuel use. The total estimated DALYs is 1,790,800 and the national burden of disease attributed to air pollution from solid fuel use is estimated to be 4.9% of the total (8).

Respiratory diseases are linked with poor air quality and lack of proper ventilation. According to a MoH report on the top ten causes of morbidity in Ethiopia, 1,262,908 (5%) cases of acute upper respiratory infections occurred during the EFY 2003 (2010/11 G.C), which might be linked to air pollution, among other factors. A similar number of pneumonia cases (5%) were also reported during the same period, accounting for 7% of hospital admissions. Moreover, 2% of admissions were due to tuberculosis (26).

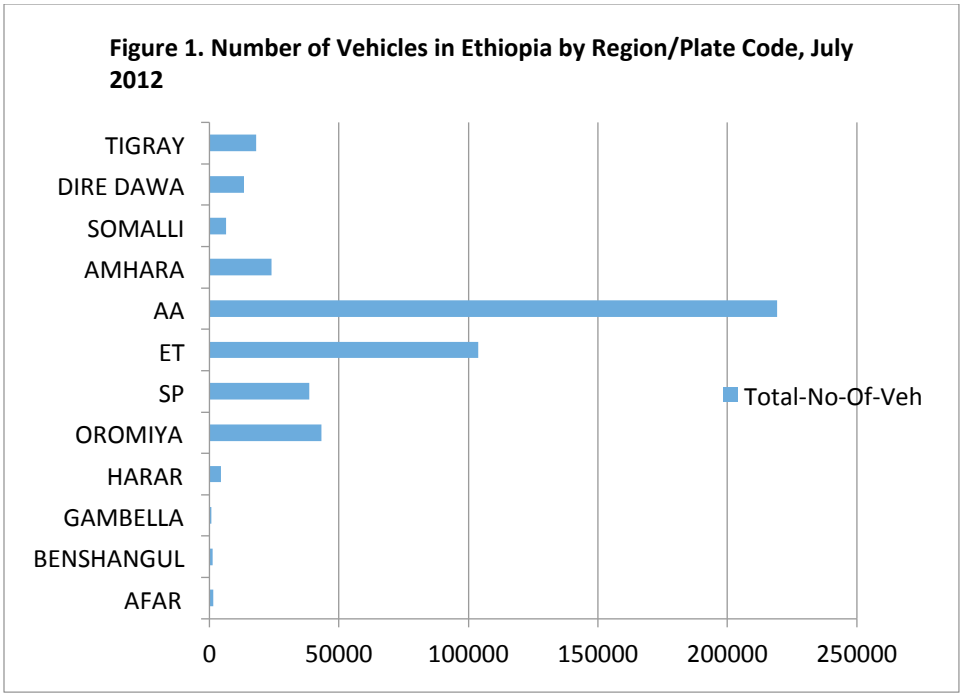
The toll of outpatient cases and hospital admissions due to respiratory diseases, however, is very high among children under 5 years of age. The MoH report shows that pneumonia stands as the first leading cause of hospital admissions and the second cause of morbidity, accounting for 23% and 13%, respectively, among children under five (26).

A recent cause-of-death study conducted by a surveillance of cemeteries in Addis Ababa and using a verbal autopsy method revealed that of the total 1565 deaths occurring between 2006 and 2009 (inclusive), 40% of all deaths in the city were due to communicable diseases. Tuberculosis accounted for 12% of all deaths, while respiratory tract infections caused 3% of the deaths. Among non-communicable diseases, which accounted for 50% of the deaths, asthma was the primary cause of 1%. Therefore, in combining the three diseases which may have direct links with indoor or outdoor air quality, they account for about 16% of all deaths (27,28).

Similarly, the same authors investigated the cause of death among persons who died at public and private hospitals in Addis Ababa and found that tuberculosis and respiratory infections accounted for the second (11%) and third (8%) leading causes of deaths, or approximately equal to deaths caused by HIV/AIDS (11%) (27, 28).

Transport Sector: Policy, implementation and Air Pollution Control

According to statistics from Federal (Roads) Transport Authority (July 2012), the total estimated number of vehicles in the country is approximately 474,140. The majority of vehicles are found in few regions/plate codes, with about half in Addis Ababa (46.2%; 219,217), about one in five having a plate coded - ET (21.9%; 103844), and the rest with regional plate codes. The report is limited, however, as some information is lacking: for instance, some regional offices might show a slight discrepancy in the total number of vehicles. Figure 1 shows a bar graph using absolute number of vehicles.



The number and type of motor vehicles in the country are given in the table below (Table 1). By type of vehicle, the largest number is automobiles (106,205), followed by Dry Cargo (58,487), Field Vehicle (33,651), Mini Bus (32,207), and Double Cabin (25,199). The year of manufacture of the vehicles is also shown in Table 2.

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Table 2. Type and number of vehicles by Year of Manufacture up to 2012, Ethiopia

Description	Below 1974	74 - 78	79 - 83	84 - 88	89 - 93	94 - 98	99 - 03	04 - 08	09 - 11	2012	**Not Specified	Tot
Automobile	7391	3684	6664	20090	16253	7794	10521	15010	3682	359	14757	10
Crane	59	33	54	101	105	61	69	179	102	14	255	10
Double Cabin	310	268	519	1891	1684	2875	4154	6164	4029	426	2879	25
Dry Cargo	2088	2017	2555	4536	3978	4388	5945	15146	7036	512	10286	58
Dump Truck	569	294	331	716	1247	689	642	3472	2600	940	1998	13
Field Vehicle	507	255	666	2220	4888	4698	4877	6750	3379	166	5245	33
Higher Bus	70	53	75	141	50	371	93	214	522	146	303	20
Liquid Cargo	129	85	110	165	141	292	489	799	561	30	686	34
Midium Bus	115	76	116	171	148	304	547	934	311	11	400	31
Mini Bus	652	378	1268	6591	3949	4849	5886	3592	1222	108	3712	32
Motor Cycle	2023	68	74	147	285	234	885	7649	4403	188	6902	22
Panel Van Dry	28	12	11	45	41	173	576	547	399	33	140	20
Pick Up	127	106	223	671	579	564	580	833	623	45	523	48
Power Dry	67	38	105	416	703	507	397	1406	1038	21	841	55
Semi Trailer Dry	238	99	157	370	126	156	169	847	1024	40	524	37
Trailer Dry	606	444	485	961	417	366	821	1914	1516	116	3051	10
Trailer Liquid	61	38	44	74	17	87	363	412	349	8	537	19
Undefined	123	4	3	12	7	15	26	1387	1177	21	409	31
	2215	904	1549	4263	3553	2266	2410	1227	134	7	12952	31
Others*												38

*Mobile House, Ambulance, Mixer, Farm Tractor, Glass Van dry, Semi-Trailer Liquid, Power Liquid, Low Bed, Refuse Collector, S
Trailer, Mobile Garage, Fire Fighting, Refrigerator, Farm Trailer, Advertising .

**Please note that for each type of vehicle significant numbers are not categorized by year of manufacture though included in th
sum. **Source: Transport Authority**

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Fuel sources currently used for vehicles are benzene and gasoline. Since 2008, benzene has been mixed with ethanol at 5%, and then upgraded to 10%. According to the current standard, a 15% mix of ethanol is now used with benzene. Until recently, the gasoline imported from Sudan was rich in sulfur content, contributing to the pollution of ambient air.

Energy Sector: Policy, Implementation and Air Pollution Control

Energy Policy

Ethiopia's Energy Policy was issued in 1994. Based on the policy's highlights and using an unofficial translation from Amharic, the policy provides a rationale for ensuring that the development of energy sources is compatible with caring for, rather than harming, the environment. Hence, one of the objectives of the energy policy is to make certain that development and utilization of energy resources are consistent with practices that are ecologically and environmentally sound. The policy gives priority to the environmental matters described as it pays close and appropriate attention to ecological and environmental issues during the development of energy projects.

The main policy issues and strategies focus on a gradual transition from traditional to modern sources. Hence, undertaking an aforestation program would be a preferred strategy to enhance the supply of fuel wood for consumers, while hydropower is considered the "backbone" of the country's energy sources. The policy dictates the development of the country's geothermal and coal resources if deemed economically profitable. Moreover, the development and utilization of natural gas resources are among options to be considered. It also considers oil and natural gas exploration in promising areas and presents the possibility of geothermal energy and other alternative sources of energy including solar, wind, and coal.

The energy policy delineates the energy supply into the following category: household, transport, agricultural, and industrial energy. The government's policy on the energy supply for households focuses on achieving balance between supply and demand, and stabilizing prices by using alternative energy sources, which would also reduce the burden on the environment by relieving the pressure on wood resources.

The policy on transport sector energy supply emphasizes formulating measures of improved and appropriate transport technologies while focusing on rural areas. Moreover, it suggests adoption of conservation measures leading to a reduction in the use of petroleum products by substituting with new non-petroleum fuels wherever possible.

For the agriculture sector, the focus of the policy is on increasing the supply of modern energy sources.

For the industrial sector the energy policy focuses on ensuring that the industrial energy supply is consistent with Ethiopia's industrial development. It also ensures that the use and supply of energy to the industrial sector will be based on efficiency and economic criteria.

The policy discusses measures for energy conservation and the strategy to bring energy efficiency into the aforementioned four sectors and in commercial and service sectors, as well as the mining and construction sectors.

The policy on comprehensive measures emphasizes energy and the environment, i.e., that energy generation, transmission, and use should be environmentally friendly; while the policy on energy science and technology addresses traditional energy sources, as well as all aspects of energy development and utilization with aims to increase the energy supply reliably, halt deforestation, and control environmental pollution resulting from energy use. One focus of research on traditional energy sources is the efficiency of traditional stoves and the development of more energy-effective practices.

With regard to electrical energy, the policy stresses the need to build national capacity in design, development, operation, maintenance, and consultancy in the electricity sub-sector. It also recognizes the need for gradual capacity- building of the local manufacturing of electrical equipment and appliances.

The policy also describes energy policy planning and management, emphasizing the necessity of developing the relevant manpower to undertake effective energy development programs and least-cost energy planning. It also addresses the importance of creating institutions entrusted with formulating policy, setting priorities, and coordinating all energy-sector development activities.

In general, the energy policy of the country emphasizes environmental sustainability during development and utilization of energy sources, and it includes various sources of alternative energy options among its priorities. It includes, for example, highlighting aforestation while working to arrest deforestation, as the transition from traditional to modern fuel sources will be gradual; and stressing the importance of reducing petroleum use by substituting non-petroleum sources of energy, including hydropower, while developing green alternative sources such as solar, wind, and geothermal energy.

Implementation of the Energy Policy

The energy sector in Ethiopia implemented a 5-year strategic plan in 2006. In 2010, at the end of the 5-year period, the Ministry had reached a dissemination target of 7.01 million improved energy-saving cookers, 1,300 biogas cookers, and 12,500 pieces of solar technology equipment. The goal for the second 5-year period (2011-2015) is to bring these figures to 9.42 million, 26,000, and 153,000, respectively.

Moreover, the Ministry incorporated a target dissemination goal of 3,013,500 solar technology lamps, cookers and heaters and 20,000 household biofuel cookers and extraction equipment, and other technologies such as charcoal-making and biomass briquetting .

Given the performance of the previous five year plan, the current strategic plan seems likely to succeed. With that assumption, the use of cleaner cooking stoves and lighting equipment would substantially decrease the rates of the leading recurrent respiratory illnesses such as ALRI among children and eye problems among children and adults.

In the power subsector of Ethiopia, electricity generation is among the major infrastructures. The 5-year strategic plan defines the present power supply systems using two categories: the interconnected system (ICS) that is “mainly supplied from hydropower plants”, and the self-contained system (SCS), which consists of “a mini hydropower plant and a number of isolated diesel generating units that are widely distributed over the country”. In Ethiopia, the energy pattern is characterized largely by traditional energy sources rather than modern sources, which represent the lowest proportion of energy use. Based on the performance of the energy sector’s first 5-year strategic plan, the Growth and Transformation Plan (GTP) of the country, which aims to end poverty and achieve middle-income country status, set an ambitious plan in the second 5-year energy plan (2011-2015) – the first arm of the GTP. Consequently, the current level of energy generation has tripled compared to energy levels recorded at the beginning of the first 5-year period. The power generation capacity has now reached about 1,963 MW and an average energy capacity of about 9019.6 GWh/yr through ISC installed power plants, although SCS has a relatively low total installed generation capacity of about 45.7 MW . The total installed capacity of both systems is 2008.7 MW. The current power development efforts have intensified to the extent that a single project, e.g. Gibe III, which was launched in 2008, is expected to be completed next year (2014) with a capacity of about 1870 MW, an amount equivalent to that currently generated from all hydropower plants. Seven more new, commissioned, or under-construction power generation projects, including the Grand Energy Renaissance Dam (GERD), are scheduled for completion by 2015. GERD will have 5250 MW initial capacity (later revised to 6000 MW) of hydropower energy production, making the total energy added from hydro projects in the GTP-I period 8767 MW and 28,932 MWh. Moreover, there are seven new wind power plant projects and at least one geothermal power generating project planned and expected to be completed by the end of GTP-I. The wind power plant is expected to produce 866 MW and 3306 MWh when completed, while a geothermal power project will provide additional 70 MW of energy and an average output of 526 MWh.

The number of customers will double from 2.03 million (2010–base year) to about 4 million by 2015. The access to electricity is also expected to increase from 41% (2010 –base year) to about 75% by 2015.

Biofuel production is an important strategy for decreasing dependency on imported petroleum fuel and saving hard-gained foreign currency in the country. Hence, the blending of benzene with ethanol (E5) was introduced for the first time in 2008. The goal in the GTP-I is to reach a target production capacity of 64.38 million liters of bioethanol per annum, with an ethanol blending proportion of 25% (E25). This would enable a production capacity of 1.6 billion liters of biodiesel fuel per year. In addition to power generation, the power transmission lines are set to grow by about three-fold from about two thousand (2010 as a base) to over six thousand by the end of the planning period.

In general, if the plan is executed well -- as it has been so far -- Ethiopia could solve its energy balance equation with a solution to balance the supply of electrical energy with the ever-growing demand for energy by households, the transportation sector (e.g., railways supplied with electric power), and the industrial sector.

Industrial Sector

Given the country's large cattle population and its fertile lowland areas suitable for producing cash crops such as cotton, a focus of development of the industrial sector is textile and leather production. For many years, raw materials have been exported after initial processing. Recently, however, direct foreign investment has increased in these two areas largely due to the government's policy on increasing the development of Ethiopia's industrial sector. Thus, the Leather Industries Development Institute and the Textile Industries Development Institute were established under the Ministry of Industry to provide support and capacity-building in these sectors.

In the boxes below, Case Studies 1 and 2 are based on the field assessment of the respective institutes located in Addis Ababa. The focus of the assessment was on how the industries are working to prevent pollution, specifically air pollution, and if they are on target to meet the EPA guideline for emission/effluent standards in pollution control, which is set to be implemented as early as the beginning of 2014.

Case study 2: Textile Industry Development Institute

The Ethiopian Textile Industry Development (TIDI) was established with regulation no. 180/2010 to facilitate the development and transfer of the textile and apparel industries' technologies and to enable the industries to become competitive and develop rapidly. To this effect, TIDI established a Research Laboratory Technology Directorate that tests water and waste water to enable the textile industries to prevent and control pollution.

Currently, there are about 16 textile industries processing textile (not necessarily finishing) that are assisted and monitored by the TIDI.

The Institute, through its Research Laboratory Technology Directorate, takes samples of water and wastewater, analyzes the samples collected at the laboratory, and provides guidance and feedback to the textile industries. No similar effort is underway, however, with regard to air pollution due to the lack of appropriate laboratory facilities and expertise.

The Ethiopian Environmental Protection Authority (now the Ministry of Environmental Protection and Forest) has issued guidelines for emission/effluent values from pollutants to seven sectors. The textile sector is one of those given specific guideline values to meet by the end of 2013. The textile industries in Ethiopia seemed ready to meet the EPA requirements on effluent discharge requirements, though not all other parameters, by December 2013. The textile industry is not prepared to monitor air pollutant emission at this time.

Case study 1: Leather Industry Development Institute

Currently, there are about 30 leather-related industries functioning in Ethiopia, with seven in Addis Ababa. The remaining companies are in various regions throughout the country, with most (12) found in the Mojo area while three are around Addis Ababa (in Finfine Surrounding Zone of Oromia region). By-products of the leather processing industries are potentially polluting the environment. The pollutants include organic pollutants (BOD), inorganic pollutants (COD) such as chromium (+3), and gases including hydrogen sulfide (H_2S) and ammonium (NH_3), which produce malodorous gases. While the pH level of the waste water is deviant to neutral, most of the industries have only waste water treatment systems. The use of diesel as a source of fuel to boilers is notably a source of ambient air pollution. Moreover, the methane produced from the activated sludge process of the wastewater system is also contributing to air pollution.

The Ethiopian Environmental Protection Authority (EPA) provided guidelines of Environmental Impact Assessment (EIA) for periodical environmental self-auditing for the industries in the country. The leather sector is among those working towards cleaner production and pollution control. To realize the Pollution Control proclamation (300/2002), EPA issued a national standard for seven categories of industries. The leather sector has its own standard with a 5-year grace period, which is set to expire on December 2013.

The Ethiopian Leather Industry Development Institute (LIDI) was established upon regulation 181/2010 to support the sector technically through technology testing and transfer and capacity-building, including human resources development. To this effect, LIDI has established the Environmental Technology Directorate and the Water and Waste Water Laboratory Testing Directorate to enable the leather industries to prevent and control pollution. According to LIDI, most leather processing industries have the infrastructure to treat waste water at the primary treatment level, some (5) at the secondary level, and three with no infrastructure for wastewater treatment at all.

The question remains whether these leather industries are ready to fully comply with the current EPA standard guideline levels as the deadline for the grace period looms. According to LIDI experts' assessment, most industries, especially those with only primary treatment levels, are not in a position to meet the current Ethiopian EPA standard. However, those with secondary level water treatment may be in a better position to meet the standards. There are gaps in the technical skill gaps needed to keep the treatment facilities functioning, as well as a lack of expertise and technological capacity to quantify air pollution at the national level.

The LIDI experts believe some parameters including TDS, chlorine content, and nitrogen content will not be met within the foreseeable future due to the technical, technological, and financial capacity of the sector. Therefore, in assessing the current situation, a pragmatic solution is to negotiate with EPA to extend the grace period to give the industries the opportunity to meet the standards. This would include enforcing the use of the standards set forth for primary treatment levels during the current grace period which ends December 2013.

Emerging Issues: Municipal Solid Waste Management

Plastic bags used for packing shopping items are sometimes recycled for various useful purposes, such as sewn shopping baskets (bags). To protect the environment from pollution due to non-biodegradable, used plastic bags, the government issued legislation (Proclamation 513/2007) that regulates issues such as, for example, a ban of producing or importing plastic bags with a wall thickness of 0.03 millimeters or less (Article 8/2). It appears, however, that plastic bags are frequently used to facilitate the start-up and combustion of charcoal fires, especially in urban settings. Plastic bags are also burned along with other solid waste in open fires, despite the requirement for proper solid waste disposal by the law (solid waste management proclamation No. 513/2007) issued to regulate solid waste management (29).

Open burning of solid waste is a common practice in towns despite efforts to educate the public. The burning contributes to ambient air pollution that would otherwise be caused primarily by vehicular emission.

Role of the GEOHealth Hub on AP and Health

One of the main roles of the GEOHealth Hub is to generate information through air pollution research. Moreover, it has great potential to serve as a platform for training experts practicing in the field of air pollution research and students who will be future resources for the country in its effort to control and prevent pollution and monitor the environment. It is also envisaged that the GeoHealth Hub will serve as a research and training center of excellence for East Africa not just in the area of air pollution, but also for other relevant environmental health issues of importance to developing nations such as Ethiopia.

Thus, the current situational analysis and needs assessment on air pollution intends to set the baseline on the body of evidence available to date and to identify policy and implementation gaps for future research. The GeoHealth Hub also has great potential for training and to better implement pollution prevention and control activities and prioritize actions. Therefore, to accomplish its mission, through the collaborative efforts of partners from the three other East African countries (Kenya, Rwanda and Uganda), plans are underway for a joint proposal that will be submitted to the NIH to establish the full GEOHealth hub to create a platform of research and training for East Africa. The center will have sub-centers in the three selected East African countries as well as the necessary facilities conducive for research and training activities. We note that the GEOHealth hub is not intended to undertake regular air quality monitoring activities, but it will create a conducive environment and necessary manpower for such activities through planned research projects.

The gaps, needs, and priorities associated with air pollution prevention and control in Ethiopia are summarized in the subsequent sections.

Needs Assessment

Identified Gaps on Air Pollution in Ethiopia

The needs were assessed using interviews with primary sources. These were key expert informants from the stakeholder ministries, as well as other relevant governmental and non-governmental authorities.

Research Gaps

- There is very little research (published and unpublished) conducted to date on AP related to indoor and outdoor environments, including traffic, in either rural and urban settings. Therefore, with the current level of research, it is difficult to draw conclusions and inferences relevant to bringing about viable policy changes to improve the current level of air pollution in Ethiopia.
- There is no strategic direction or priority agenda set for the country on air pollution research.
- National reference laboratories for air quality monitoring (such as those available at the Addis Ababa EPA) are not functioning well due to lack of proper equipment and technical capacity.
- There are no established 'criteria' pollutants for the country based on the evidence of measured pollutant concentrations and related health effects.
- Priority research areas such as indoor air quality, traffic-related air quality, and ambient air quality related to industrial output have not received the necessary attention to date.
- Exposure assessment studies with strong epidemiological designs to evaluate the health impacts of air pollution are lacking.
- Research-based evidence on emission levels of new clean cook stove technologies is negligible, despite some attempt by MoWE to determine fuel/energy efficiency but not health effects. Hence, it is difficult to make a national recommendation for these clean cook stove techniques for scale-up interventions.
- There are no systematic studies to date on the magnitude and health effects of air pollution in Ethiopia.
- There is no research database on air quality and air pollution in the country that can serve as a baseline for researchers and practitioners to move forward.
- There is little practice of multi-sectoral and multi-disciplinary research approaches on air pollution.

Training Gaps

- Training centers with regard to air pollution are not available in the country, either for long-term or short-term levels of training for targeted users.
- On-the-job-training and short-term training opportunities are limited for those working directly in the areas of air quality and air pollution.
- There is a skills gap in the monitoring of air pollution in Ethiopia.

- There is a skills gap in academia for longitudinal data management and analysis of air pollution and climate change.
- Related training by academia in such fields as Meteorology does not address on air pollution.
- There are few or no regional/sub-regional training centers.
- The capacity to interpret the data trends of air pollution and to bring the results forward into policy analysis and use is limited.

Capacity Gaps

- Capacity is lacking with regard to research laboratories, technical expertise, budget allocation, financial issues such as carbon trading, training and research centers, and technological accessibility related to air pollution.
- EPA /MOEPF, universities, and training centers do not have research facilities to enable the generation of evidence.
- Also lacking are training centers and venues with available facilities that include the necessary equipment to test improved stoves, air quality, and analysis software to demonstrate data management skills and teach theoretical backgrounds.

Policy and Regulation Gaps

- The general policy and regulation framework is available; however, alignment of air pollution control activities with the country's strategic plans such as CRGE and GTP seem to be lacking in the relevant ministries.
- Air pollution is not currently viewed as an important problem by policy makers. However, the limited available evidence shows the significant disease burden and deaths attributable to both indoor and outdoor air pollution.
- The road and building construction boom in the country does not seem to be subject to any regulation and enforcement to minimize its impact on ambient air pollution.
- EPA/MOEPF is mandated to regulate and enforce legislation related to point (stationary) air pollutant sources in the country. However, there is a clear gap in its technical capacity to discharge its responsibilities. It is worth noting that the relatively low priority accorded by EPA/MOEPF to the country's air pollution problems (including traffic-related air pollution) could hamper its actions.

Gaps in the Organizational Framework

- The Ethiopian EPA /MOEPF appears to be the only relevant and responsible organ of government to handle issues related to air pollution.

- There is little collaboration observed among concerned governmental bodies on air pollution, although recent cooperation between EPA and the Ethiopian Transport Authority on related activities shows promise.
- There is currently a diffusion of air pollution monitoring responsibilities between EPA/MOEPF and NMA and a lack of common ground to collaborate on a common goal (i.e., with regard to a Memorandum of Understanding and/or Inter-sectoral Implementation Framework agreements).
- Indoor air pollution prevention is promoted by MoH and MoA at the grass roots level; however, the issue of indoor air quality monitoring is left unaddressed.

Monitoring and Evaluation (Surveillance) Gaps

- There is no regular monitoring of air quality in either the ambient/ traffic-related environment or the indoor environment. Hence, strategic information is lacking on air quality and air pollution issues that arise from monitoring data.
- Air quality monitoring stations do not currently exist in Ethiopia, although efforts are underway by NMA to establish stationary stations at two locations in Addis Ababa.
- There is a gap in information-sharing. There are, for example, no annual scientific forums that focus on air quality and air pollution that could inform the public and the scientific community and draw lessons from the experience and technology of other countries.

Identified Needs for Air Pollution Control

Research Needs

- More research should to be encouraged by MoST, academia, MoT, EPA/MOEPF, MoH, and other relevant bodies on air pollution in various micro environments to mitigate climate change and protect public health.
- Key pollutants to be monitored and targeted for control should be identified.
- Strategic directions and a research priority agenda are needed for air pollution control.
- Academia should be encouraged to undertake high-quality research on air quality, including establishing agent-health effect (dose-effect) epidemiological relationships for key air pollutants.
- There is a need to establish a testing center for new cookstove technologies that could potentially reduce pollutant emission, use energy efficiently, and reduce negative health impacts on users and their families.
- There is a need for an ongoing systematic review of the relevant evidence on air pollution as it becomes available.
- A web-enabled interactive database on air quality and air pollution should be created.

- There is a need for multi-sectoral and multi-disciplinary research on air pollution, as exemplified by the collaboration between EPA/MOEPF and ETA.

Training Needs

- Short and long-term training programs and courses should be designed to address the human technical capacity gaps at all levels.
- On-the-job-training is vital for those actively engaged in the field.
- Metrological field-training institutions should ensure that their courses adequately address issues relating to current air pollution levels.
- The relevant leaders should establish regional centers of excellence for air quality and air pollution control training in Ethiopia that could serve East African countries as well as the African continent as a whole. The M & E Certificate program in collaboration with Measure Evaluation (USA) for Anglophone African countries at Addis Ababa University is an excellent example of how several institutes/schools can collaborate to run a program.

Capacity Needs

- There is a great need for research capacity building in the areas of human technical expertise and equipment and facilities. This applies to concerned institutions such as EPA /MOEPF, universities training graduates in the fields of air quality, environmental health, and air pollution, and those providing short-term training.
- Adequate financial resources must be allocated to the relevant government bodies and research organizations for air pollution control.

Policy and Regulation Needs

- There is a need to synchronize the efforts undertaken by the government to prevent pollution and mitigate climate change through air pollution control.

Organizational Framework Needs

- Actively engaging MoH, MoA, MoT, MoI, ETA, ERA, MoFED, NMA and other GOs, NGOs/Civic society, led by EPA/MOEPF, should strengthen the country's efforts to control air pollution.
- The work done on climate change adaptation should serve as a model for air pollution control.
- There is a need for a working framework and understanding among relevant institutions concerned about air quality and air pollution for smooth and effective coordination and collaboration.
- There should be a structure from the ground up that could systematically gather indoor air pollution data in the entire country and inform policy makers beyond the sporadic research activities carried out by academic institutions. MoH, in collaboration with MoA, is well positioned to undertake the task, given its mandates to protect public health.

Monitoring and Evaluation (Surveillance) Needs

- There is a need to establish more air quality monitoring stations that could provide relevant information to initiate policy dialogue and inform the government's decision-making process.
- There is a need to organize an annual or bi-annual event for the scientific community to share information on the state of the environment, including air pollution.

Strengths and limitations

Strengths

This is the first attempt to comprehensively review the body of literature on air pollution in Ethiopia. Therefore, it could be used as a baseline to assess the problem, identify gaps, and ascertain priorities. The participatory approach of engaging stakeholders is believed to build the institutional capacity of the partner institutions. The participation of members of the EPA/MOEPF and NMA technical staff and partners from HoAREC and the Climate Center – both affiliated with AAU -- is an example.

The use of both primary data from key informants working in the area and secondary data from reviews is helpful to triangulate the information obtained from the various sources.

The helpful technical guidance of the lead investigators from the partner institutions (AAU and USC) and the opportunity for the Ethiopian lead investigators to visit USC and learn onsite what is being done about air pollution in the developed world are assets that add strength and flavor to the report.

Limitations

The time constraint to cover the published and unpublished secondary sources as well as to interview the key informants to assess, identify, and prioritize the needs was pressing, given the limited availability of some key officials for discussion.

Lack of research-based references pertaining to studies conducted in Ethiopia is another limitation, which is due to the meager amount of research activity undertaken so far in the field of air pollution.

Conclusions and Recommendations

Conclusion

The policy framework on the environment is in place and relatively adequate in its mandates, if actually applied. However, the key stakeholders do not have a functioning co-operative implementation framework among them that could help in coordinating the promotion of prevention activities to reduce the impact of air pollution. There is little capacity in terms of technical, financial, and training facilities. The research capacity and actual conduct is very minimal. The current scientific evidence base is not

adequate to set regulatory criteria for key pollutants. However, even based on the limited available data, nitrogen oxides, respirable particulate matter, and carbon monoxide were identified as critical pollutants for indoor as well as ambient air quality. There is little or no training directly related to air pollution in either short term or long term courses in training institutions throughout the country. There is no regular monitoring or surveillance on air quality, and current laboratory facilities and equipment are insufficient for the task. The instrumentation for the available equipment lacks staff expertise and necessary reagent inputs. There is no functioning co-operative implementation framework on air pollution among key stakeholders. Therefore, role-overlap exists and creates gaps in air quality monitoring and regulation. The capacity to enforce air quality standards is limited by lack of equipped laboratory facilities and expertise. The priority given to air pollution is minimal compared to the emphasis given to climate change adaptation, which shows a relatively more coordinated effort among key stakeholders. The implementation of CRGE is a positive development that contributes to the improvement of air quality in both indoor and outdoor environments. However, with the exceptions of EPA/MOEPF and NMA, air pollution is not of high enough priority among key stakeholders as an issue that should be addressed while implementing CRGE.

Recommendations

Based on the needs that have been identified in the SANA and discussed in this report, the major recommendations are as follows:

1. Establish a research and training center that helps to develop, test, and train experts on prevention and control of air pollution; the center would solicit research funds, and conduct studies with key stakeholders and researchers to address the problem of air pollution in Ethiopia.
2. Establish air quality monitoring sites with fixed stations to regularly monitor ambient air and indoor air quality.
3. Set up air quality management districts (annexes) that routinely sample air and analyze the data to help regulate and enforce air pollution standards. The US EPA's Air Quality Management Districts can serve as models.
4. Initiate opportunities for long and short term training on air pollution. This may include on-the-job training, undergraduate courses in related fields, and graduate studies at the masters and PhD/Post-doctoral levels. The capacity built at the current level would help mitigate emission and reduce the burden of disease. Moreover, it would also help to properly implement the Climate Resilient Green Economy (CRGE) strategy and prevent future pollution that might result from increased industrialization as Ethiopia moves towards its goal of becoming a middle-income country by 2025 and beyond.
5. Give priority to air pollution control and hence receive the necessary organizational structure, budget, and expertise. EPA/MOEPF and MoH are at the forefront to implement this recommendation on ambient and indoor air quality, respectively, along with other responsible government bodies.
6. Implement a framework among key partners such as EPA/MOEPF, MoWE, MoH, and academia to join together on operational research, training and coordinated activities, and enforcement to control

air pollution. The WASH Implementation Framework (WIF) agreement between MoH, MoWE, and MoE is an example.

7. Establish reference laboratories for air quality monitoring at the national and regional levels to help experts enforce the law in the abatement of air pollution and set standards based on the evidence.
8. Implement an Indoor air quality monitoring system. This field needs a legitimate owner (EPA/MOEPF or MoH) and coordination among stakeholders to bring about improvements and set standards on indoor air quality.

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Annexes

Annex 1: Criteria for checking the quality of data, reports and published materials with regard to methodological soundness and representativeness:

1. Adherence to the principles of objectivity in the collection, processing, and dissemination;
2. Methodological soundness (using accepted standards, guidelines, sample size, representativeness, geographic coverage);
   2.1. Higher ranking for larger sample size and wider geographic coverage
3. The type of Study Design;
   3.1. Higher ranking for longitudinal versus cross-sectional
   3.2. Higher ranking for prospective versus retrospective
4. Accuracy and reliability (source of data and statistical techniques are sound and statistical outputs sufficiently portray reality);
   4.1. Higher ranking for studies with appropriate statistical analysis for the set objectives
   4.2. Higher ranking with clear presentation of study findings and proper interpretations
5. Ethical clearance obtained/or have no/any ethical concern;
6. Higher ranking for studies with ethical clearance and/or studies which have no/any ethical concern.

Annex 2: Definition of Air Pollution

Air Pollution can be defined as any atmospheric condition in which certain substances are present in such concentrations that they can produce undesirable effects on humans and their environment. These substances include gases, particulate matter, radioactive materials and many others. The gases include oxides of sulfur, nitrogen oxides, carbon monoxides, hydrocarbons, etc.; particulate matter includes smoke, dust, fumes, and aerosols. Most of these substances exist naturally in the atmosphere in low concentrations, also known as background concentrations; air pollution is said to occur when the concentration of the substances exceeds the background concentrations [Mengesha A., Mamo W. 2006]. Air pollution could affect the health of humans, plants, and animals. It has also the potential to affect buildings, statues, and other stationary objects (FEPA 2008).

Section II

Situational Analysis and Needs Assessment:

OCCUPATIONAL SAFETY AND HEALTH IN ETHIOPIA

Establishing a GEOHealth Hub for East Africa

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Wondu Gosay	Artistic Printing Press
Belay Habtu and Abebe Wesen	Yirgalem Addis Textile Factory PLC
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Mesfin G/Mariam	Kaliti Metal Tools Products Factory

Summary

Background

The School of Public Health (SPH) at Addis Ababa University (AAU) and the University of Southern California (USC) are currently collaborating on a project called “Establishing a GEOHealth Hub for East Africa”, funded by the Fogarty International Center at the National Institutes of Health in the United States. The project aims to assess the current status and identify the most critical gaps and needs in the

areas of indoor/outdoor air pollution and health, climate change and health, and occupational safety and health (OSH). The outputs of this assessment will assist in determining what research training, projects, and capacity building will be undertaken in Ethiopia. The approach used in this assessment will be useful for other East African countries (Kenya, Uganda, and Rwanda) through the creation of a regional GEOHealth Hub. This section focuses on OSH-related issues in the Ethiopian context.

Methods

This comprehensive situational analysis assessment used secondary data from published articles and relevant reports. Journal articles, thesis reports from academia, government reports and national statistical reports were the main sources of information.

Structured data collection guidelines for OSH contents were consistent with the objectives and aims of the GEOHealth hub planning grant and the current practices in OSH in Ethiopia. Data were identified and then keyed, with source and method of statistical analysis included. Data collectors with expertise and experience on the practices of OSH were carefully recruited, trained and monitored for data collection until the draft write-up was completed in April 2013. The progress of the data collection process and its management was monitored weekly from January-March 2013.

The needs assessment followed two approaches. First, possible gaps were identified through the situational analysis based on secondary data sources. The second approach involved collection of primary information from stakeholders using semi-structured discussion guidelines. Data for this purpose were sought by interviewing key informants from the federal, regional, zonal, and Wereda levels of the OSH Administration.

The responses to the assessment questions related to OSH that were identified in respective data sources were compiled in a spreadsheet that was used to transfer data into specifically designed software called the GEOHealth database. This database is used for data storage and retrieval. A thematic description of findings was used in writing the assessment report.

Findings

Type of workplace

There are two broad types of workplace administration: workplaces governed by civil service and those covered by labor proclamations. The Federal Ministry of Labor and Social Affairs is the authority mandated to manage all aspects of occupational safety and health in Ethiopia. Broad classes of workplaces include large and medium scale, small scale, micro and small enterprises based on the number of workers and use of machines. Of the total number of employees (n=31.4 million), the majority, 89%, are engaged in agriculture, while about 5% are in manufacturing, construction and mining sectors. Males predominate in all sectors of employment.

Health effect and occupational exposures

A handful of data sources indicate the type and magnitude of relevant health outcomes and respective occupational risk factors. Exposure measurements in workplaces were only available in a few studies with regard to cotton dust, noise, and cement dust. Workplace exposure was characterized subjectively in many studies by using operational definitions of the research questions. Information on the rate of injury was commonly found in the reviewed documents.

The overall rate of byssinosis in Bahrdar Textile factory was 17%, which was strongly associated with blowing and carding workplaces. The gradient of exposure by workplace to cotton dust is consistent with two other studies done at the Akaki textile factory at different times. Noise as an exposure was only dealt with in one study that detected the prevalence of noise-induced hearing loss at 34%. Excess noise was associated with hearing loss. One study found that sleeping disorder as a health problem was associated with a poor working environment.

The workplace in textile factories was perceived to be hot, noisy, and without adequate ventilation. Workplaces in small-scale enterprises were found to be characterized by excess dust, noise, heat and poor working conditions. Poor illumination, unguarded machines, heat, electrical hazards, and unhygienic workplaces were common hazards in oil processing mills. Ergonomic problems and exposures to dust, noise and flying objects were characteristics of the construction sector. Excess cement exposure was found to be a factor for chronic respiratory symptoms and reduction of lung functions in a recent study.

The rate of occupational injuries varied among studies. The annual injury rate varied from 65 to 335 injuries per 1000 exposed workers. Multiple factors were involved in the occurrence of injuries, including unguarded machines, splitting materials, slippery floor, lack of safety training, sleep disturbance, job stress and dissatisfaction, job categories, poor lighting, low education and young age.

Organization of occupational health services

The organization of health services varied depending on the scale of the enterprises. Large-scale manufacturing sites and state-operated farms tend to have clinics that are managed by nurses. Some enterprises have both clinics and hospitals, while the vast majority of workplaces have a unit that provides first aid assistance. Most facilities use a contracted public or private health service for the medical needs of their workers. In many cases, there is no link between health services and hazard prevention

Existing practice of workplace safety

The theoretical concept of hazard management through its avoidance, reduction, or isolation is minimal due to such different factors as working with obsolete machines, poor accountability of employers, poor knowledge and awareness of workers about workplace risks, and limited training on safety issues. Control at the person level through the provision of personal protective devices is a common practice. Hazard signs are not properly identified because of limited training among employees.

Existing practice of workplace hazard prevention

A hierarchical approach of managing hazards through recognition, evaluation, and control is the accepted approach used in hazard prevention. However, hazard evaluation for measuring the extent of the hazard is not commonly practiced in routine workplace inspections. This is due to the limited availability of monitoring instruments and lack of training on their use.

The enforcement mechanism involves instructions from an expert and orders issued using citations. The inspector has the authority to charge the employer if the employer fails to carry out the order. However, bureaucratic obstacles often discourage inspectors from exercising this option.

Occupational safety and health information management

The organization of accident/injury data collection, compilation, and dissemination of reports is managed manually. Easy access to data is not possible, and web-based management of information is currently in the planning phase.

Policy and regulatory frameworks

The current labor proclamation is the basis for exercising the delivery of OSH services. An operational guideline (OSH directive) details procedures and provides standards or cutoffs for hazard prevention, although existing policy documents do not address emerging issues of development, including the construction and floriculture industries. A National OSH Policy has been submitted to the Council of Ministers for approval.

Organization of occupational safety and health

OSH is organized at the federal and regional levels through teams of 2-3 experts whose duties are to conduct labor and workplace inspections. At the zonal level OSH representation is one multi-purpose expert, while an expert is not involved at the Wereda level of administration.

Human resource management

A total of 291 OSH inspectors operate at the national level. Those found in Addis Ababa (27.5%), Tigray (26.8%), Oromia (18%), Amhara (12.7%) and Southern Nations (8.6%) make up approximately 95%. Many do not have professional training when they are recruited, and only 10% of the current OSH pool of inspectors has some kind of on-the-job OSH training.

Research, monitoring, and evaluation

Operational research is carried out in some regions: it is mainly descriptive in nature and often does not involve measuring exposures over regular working hours to estimate the extent of personal exposures. Scarcity or complete lack of monitoring instruments is the major constraint, with lack of basic training on the operation of instruments also a challenge.

Financial resources of OSH

Financial resources for OSH at the federal level are limited to salaries and stationery supplies. Allocation of funding to OSH is less than 5% of the annual budget. Regional MOLSA Offices can request a capital budget that allows for the purchase of monitoring equipment. A small amount is also allocated to carry out basic operational research.

Conclusions and recommendations

The literature review and discussions with experts in the field of OSH suggest that OSH has multiple gaps that challenge the productiveness of the service. These gaps major gaps, listed below, require immediate intervention:

- uncoordinated research with loose sets of agendas
- low capacity of human resources in the collection of hazard measurements
- lack of proper professional training, scarcity or lack of hazard monitoring equipment in a lab setting
- a shortage of OSH inspectors
- limited capacity of the organizational units
- and poorly organized monitoring and evaluation of OSH services are the major gaps that require immediate intervention.

Acronyms and Abbreviations

AAU	Addis Ababa University
CSA	Central Statistical Authority
FMOLSA	Federal Ministry of Labor and Social Affairs
ILO	International Labor Organization
LIS	Labor Inspection Service
M & E	Monitoring and Evaluation
OSH	Occupational Safety and Health
PEL	Personal Exposure Level
PPD	Personal Protective Device
RBOLSA	Regional Bureau of Labor and Social Affairs
SANA	Situational Analysis and Needs Assessment
SPH	School of Public Health
USC	University of Southern California

Introduction

As a result of paired applications to the Fogarty International Center at the National Institutes for Health (USA) in March 2012, Addis Ababa University and the University of Southern California won paired grants of $100,000 USD for a two-year implementation period. The project was funded under the program for Planning Grants for Hubs of Interdisciplinary Research and Training in Global Environmental and Occupational Health (GEOHealth), which is designated as "Establishing a GEOHealth Hub for East Africa". It aims to assess the existing country situation and to identify the gaps in three major areas of environment and health: air pollution, climate change and health, and occupational safety and health. The first phase of the assessment focuses on the Situational Analysis and Needs Assessment for GEOHealth (SANA-GEOHealth) in Ethiopia. In Year 2 of the planning period, the SANA will be expanded to cover the other East African countries participating in the consortium: Kenya, Rwanda, and Uganda. The outputs of this assessment will be used to identify gaps and needs to determine which training, research projects, and capacity building will be considered for Ethiopia and the other three countries through the creation of a regional GEOHealth Hub. This section deals with the situational analysis and needs assessment related to occupational safety and health (OSH).

The core theme of this SANA is to take inventory of existing data/information and to identify gaps with regard to environmental risk factors. Data searches covered the extent, magnitude, and description of intervening factors at the various levels of the risk. The situational analysis also describes the OSH policy framework along with the institutional, legal, and resource arrangements.

A systematic collection and evaluation of past and present OSH data and information was undertaken to identify relevant problems and gaps as well as priorities that could be addressed through collaborative mechanisms. The findings of the SANA are expected to provide the baseline for assessing subsequent interventions through the creation of a training and research center: the GeoHealth hub.

Methods

The first phase of the project focused on determining the current national status on OSH and addressed questions such as:

- How is the workplace characterized? Type of workplace and work force?
- What is the magnitude of occupation related health problems? Illness? Injury?
- What is the extent of workplace hazards? Health risks?
- How is OSH organized? How are OSH services rendered?
- What are the existing practices on workplace hazard prevention and control?
- What are the policy and organizational frameworks?
- What is the extent of the research on M and E systems in OSH?
- What resources are available for OSH services?

Data sources and instruments

Data sources can be classified under two generic sources.

(i) Secondary data:

- **A comprehensive literature review** from published articles including theses and dissertations
- **Government reports**; annual performance reports; and other written documents
- **Statistical reports and bulletins,** primarily from the work of the Ethiopian Central Statistical Agency (CSA).

(ii) Primary data:

- The situational analysis included formatted checklist and question guidelines, as well as interviews with stakeholders on policy, implementation, and resource issues. Federal and regional MOLSA and local enterprises were the main sources of data.
- The needs assessment involved a question guide addressed to OSH directors and other relevant professionals.

Two data collectors engaged in the practice of OSH were carefully recruited, oriented, and trained. Their progress was monitored weekly throughout January-March 2013 until the write-up of the report was completed.

Data management and analysis

Data in the form of quantitative and qualitative information were collected by investigators who are currently working in the area of OSH. A literature review was conducted using appropriate key words in the Pub-Med database and local journals. Unpublished reports available from stakeholders' archives were alternative data sources. The relevance of the information in the documents was categorized by key topic area.

Summary information was transferred to a spreadsheet organized by key assessment questions. Key questions and responses were entered into a common GEOHealth database that could quickly provide information and storage for future use. Descriptive analysis was mainly used for the write-up of selected OSH sub-themes.

Data quality assurance

The assurance of data quality was critical from the beginning of the GEOHealth project. The following steps were implemented to improve the data quality according to plans outlined in the GEOHealth hub planning proposal:

1. The development of the proposal was helpful in ensuring that a proper sequence of main activities was carefully followed: situational analysis followed by needs assessment.

2. The designed SANA implementation guide contributed to the consistency of data collection and write-up.
3. The recruited data collectors were experienced professionals in the field of OSH. They were well-oriented before they began data collection.
4. The orientation of research team members to the purpose of GEOHealth and data collection was useful in collecting the appropriate data.
5. Supervision was structured through weekly meetings for the research teams, and biweekly meetings with the Principal Investigators of the GEOHealth Hub. All research team members met biweekly to assess progress and to share experiences. These were useful forums to adjust and adapt the necessary tools of data collection.
6. The inception meeting with stakeholders was held prior to the start of data collection (January 2013), eliminating communication gaps that might have otherwise occurred.
7. The weekly Skype meetings between the core teams at AAU and USC were effective settings to discuss the progress and challenges of data collection and write-up.
8. The write-up and synthesis of the findings were reviewed locally for consistency and relevance. The draft report was further checked and edited by the senior investigative teams at AAU and USC in advance of the final report.

Assessment Findings: Section I - Occupational safety and Health in workplaces

Characterizing workplaces

The types of workplaces in Ethiopia can be categorized broadly into two groups: 1) a public/civil service workplace governed by the Federal Civil Servant Proclamation No.515/2007, and 2)a workplace mainly regulated by the labor proclamation No.377/03.

While workplaces administered by the civil service proclamation are fully owned by the government for nonprofit public service, workplaces covered by the labor proclamation often have a profit motive featuring an employer-employee relationship. This second group of workplaces includes state-owned profit-making enterprises, privately owned businesses and shareholder firms, and nongovernmental organizations and charitable institutions.

Workplaces characterized as micro and small enterprises usually operate with limited capital but employ a large labor force, and thus are considered as strategic to the development of a productive and private sector in the country.

Workplaces commonly classified as informal sectors often lack the capacity to meet the minimum labor standards required by the labor law. Despite providing significant employment opportunities, they operate without a business license under relatively poor health and safety working conditions.

Formal workplaces covered by the labor proclamation No.377/03 are broadly classified into 9 industrial groups:

1. Agriculture, hunting, forestry and fishing
2. Mining and quarrying
3. Manufacturing
4. Electricity, gas and water
5. Construction
6. Wholesale and retail trade
7. Transport, storage and communication
8. Finance, insurance and business services
9. Community, social and personal services.

The 2005 Labor Force Survey indicated agriculture employed a significant share of the workforce: 80%, with a 1: 0.9 male to female worker ratio. The mining, manufacturing, and construction sectors absorbed 6.6% of the workforce. Overall employment status in other sectors, except for agriculture, was greater in urban areas than in rural areas, as urbanization generates employment opportunity related to investments in factories, hotels, transport, and trade sectors (Table 1).

The fourth national survey of small-scale manufacturing industries was conducted in Ethiopia in 2009/10. Small-scale manufacturing establishments are defined as those having less than 10 persons and using power-driven machinery. Of the 43,338 surveyed, 53.3%, 19.8% and 10.1% were grain mills, furniture and metal manufacturing establishments, respectively. There were 138,951 workers employed, with an average of 3.2 workers engaged in these establishments. Nearly 90% of all workers were males, 40% were unpaid family workers, and 84% were literate (1).

In 2010, a survey of 2,170 large- and medium-scale manufacturing industries was carried out (2). A manufacturing establishment with 10 or more employees working with power-driven machines was defined as a large or medium manufacturing industry. The survey found that more than 40% (874) of the manufacturing industries were located in Addis Ababa, followed by Oromia with almost 23%, Amhara with 11%, and the Southern nations with 11%. Close to 65% of the 2,170 surveyed industries were engaged in manufacturing of food and beverages (32%), non-metallic minerals (19%), and manufacture of furniture (13%). Average employment opportunity for the five years (2006/7-2010/11) addressed by the survey was about 154,000, with a 9.3% annual growth rate. A total of 175,984 persons were engaged in
this sector in 2010/11.

Table 1: Employed population by sex, residence, and major industrial divisions, National Labor Force Survey, 2005, Ethiopia (Total= 31,435,108)

		Overall			Residence	
SN	Industrial divisions	Total	Male	Female	Urban	R
1	Agriculture	80.2	84.3	75.5	13.0	8
2	Mining and quarrying	0.3	0.3	0.2	0.5	0
3	Manufacturing	4.9	2.6	7.5	14.3	3
4	Construction	1.4	2.1	0.7	5.4	0
5	Wholesale and retail trade, Repair of vehicles, personal and household goods	5.2	3.9	6.8	21.8	3
6	Hotels and restaurants	2.5	0.6	4.6	10.8	1
7	Transport and communication	0.5	0.8	0.1	3.5	0
8	Financial inter-mediation	0.1	0.1	0.1	1.1	0
9	Real estate, rental, and related business activities	0.2	0.2	0.1	1.4	0
10	Public administration, defense, compulsory social security	1.2	1.4	0.9	7.1	0
11	Education, health, and social work	1.2	1.3	0.9	6.5	0
12	Other social, cultural, personal, and household activities	1.4	1.8	0.9	7.6	0
13	Private households with employed persons	0.8	0.1	1.6	5.9	0
14	Extra-territorial organizations and bodies	0.2	0.3	0.2	0.7	0

Updated information regarding the number of entities, i.e., government, private, nongovernment, small scale, etc., is not available at the national level. However, based on statistical reports taken from official administrative records, there were 220,000 micro and small enterprises registered in 2012 providing employment opportunity for 1.72 million citizens (3).

The Ethiopian labor inspection audit report of 2010 (4) estimated the labor force to be about 34.1 million, while the Ministry of Labor and Social Affairs reported 24,513 enterprises officially registered as operational in 2010.

Table 2 shows the employed population by employment status and sex, according to the 2007 population and housing census.

Table 2: Number of Employed Population in 2007, population and housing census, Ethiopia, 2007

	Employment Status	Sex			%
		Male	Female	Total	
Paid Employees	Government	747937	357701	1105638	3.7
	Government Parastatal	178889	86836	265725	0.9
	Private	618120	307086	925,206	3.1
	NGO/INTL Employees	53707	32410	86117	0.3
	Domestic Workers	335802	295602	631404	2.1
	Other Employees	77094	34699	111793	0.4
	Sub-total	2011549	1114334	3,125883	10.4
Other Employed Persons	Self Employed	11360738	7357973	18718711	62.2
	Unpaid Family Workers	2071688	4177272	6248960	20.8
	Apprentices	42344	30911	73255	0.2
	Cooperatives	24521	15539	40060	0.1
	Employers	64634	20326	84960	0.3
	Other	843438	961997	1805435	6.0
	Sub-total	14407358	12564018	26971381	89.6
Total		16418912	13678352	30,097264	100.0

As shown in Table 2, 62.2% of the total employed population was self-employed, followed by unpaid family workers (20.8%). The proportion of paid workers is about 10%, while that proportion administered by Proclamation 377/03 is estimated at less than 8%. There is a striking gender disparity in employment status, with males comprising about 70% of paid workers. According to the 2010 urban employment and unemployment survey (5), of the 4.8 million total employed population in urban areas, which includes 57% of the male population, 34.1% were engaged in the informal economy. The same report indicated that951,763 (19.8%) were engaged in wholesale and retail trades, 644,185 (13.4%) people were employed in manufacturing, 532,796 (11.1%) people worked in agriculture, and 388,932 (8.1%) were employed in hotels and restaurants. The survey report also disclosed that the construction sector

employed 322,546 (6.7%) people, while transport and communications employed 233,027 (4.9%) people (Annex 1).

As the backbone of the country's economy, the agricultural sector is the largest employer, providing livelihood for about 85% of subsistence farmers in rural Ethiopia (6).

Information regarding the working population by type of work (i.e., temporary and permanent) is not available. A anecdotally, however, a significant proportion of the labor force is employed on a contractual/temporary basis.

The Government of Ethiopia (7) indicates further expansion of industries in construction, sugar production, textile factories, and production of fertilizers. Future agricultural productivity is expected to depend greatly on the use of fertilizers and pesticides, although there is interest in the use of compost and natural methods of pest management.

Demographic characteristics of workers

Statistical information from the 2007 population and housing census (8) showed that participation in the labor force is high in the 25-59 age category, and that the labor force participation rate for males is significantly higher than for females in all age groups (Table 3).

Table 3: Labor force participation rate by age group and sex, population, and housing census, Ethiopia, 2007

Age range	Male, %	Female, %	Total, %
15-19	58.4	56.1	57.2
20-24	76.6	69.8	73.1
25-29	90.1	73.2	81.0
30-34	94.0	73.8	83.8
35-39	94.9	74.2	84.2
40-44	94.3	73.8	84.2
45-49	94.4	73.2	84.1
50-54	93.0	69.7	81.1
55-59	92.4	66.6	80.5
60-64	88.0	60.8	75.0
65-69	85.1	56.4	72.3
70-74	76.5	48.0	63.2
75+	63.2	42.2	54.4
Total	81.6	67.3	74.4

The 2006 urban employment/unemployment survey also reported that males dominated the paid employment category, while females make up a large proportion of domestic and unpaid family workers.

With regard to education, an unpublished assessment report by the International Labor Organization (ILO) (9) on the educational level of the work force in Ethiopia shows that females a lower literacy rate compared to their male counterparts in the workforce (Table 4).

Two national labor force surveys (NLFS) have characterized the demographic distribution of the work force. The first survey reflected data for 1999 (10), while the second addressed 2005. In these surveys, employment was defined as engagement of a person aged greater than 10 years working one week prior to the survey. The NLFS report indicated that overall employment at the country level was 31.4 million (76.6%), with more males employed than females (84.7% vs. 69%). Eighty two percent of total employment occurs in rural areas given the agrarian nature of the Ethiopian economy. The overall literacy rate is 38.5% but for females it is only 14%, about 2.7 times less than that of males. About 85% of the labor force is concentrated in three regions: Amhara, Oromia, and Southern Nations. The same survey indicated close to 200,000 (0.6%) of the total employed population employed in manufacturing plants as machine operators or assemblers, which is an indication of factory work force.

Table 4: Distribution of Labor Force by residence, education and region, National labor force Survey, 2005, Ethiopia

Background variables	Total population	% Employment			% Share of employment to the total pop
		Males	Females	Total	
Country	41,018088	84.7	69.0	76.6	100
Urban	6, 867045	57.7	43.7	50.2	17.0
Rural	34,151043	89.8	74.4	82.0	83.0
Literacy status					100
Literate	15,477691	77.6	53.4	68.7	38.0
Illiterate	25,540,397	91.6	74.8	81.4	62.0
Regions					100
Oromia	15,999486	85.4	69.8	77.5	39.0
Amhara	10,917015	88.5	72.8	80.5	26.6
SNNPR	8,265977	87.4	72.9	79.8	20.2
Tigray	2,686727	80.2	67.0	73.2	6.6
Addis Ababa	1,800669	54.5	35.9	44.4	4.4
Other Regions	1,352215	74.7	57.1	65.6	3.3

Other*: Afar, Somali, Benshangul-Gumuz, Gambella, Diredawa, Harari

Characterizing health risks in occupational settings

Workplace exposures

Many workplaces, such as textile and cement factories, are characterized by their dustiness. Cotton dust measurements in all work sections in the Bahrdar textile factory were above the Personal Exposure Limit (PEL) of the U. S. Occupational Safety and Health Authority (OSHA). The highest measurements were found in the blowing and carding section, at about 5 times greater than PEL. The overall proportion of byssinosis was about 17%, with significant levels in the blowing and carding section. Byssinosis, chronic bronchitis, and asthma were related to working duration and level of respirable dust concentration (11). A 2010 study at an Akaki textile factory found that chronic bronchitis was associated with work stations; blowing, carding, and roving; and increased years of work (12). The same study reported that mean concentrations of cotton dust using aerial measurements varied from 2 mg/m^3 in the weaving section, to 8 mg/m^3 in the carding section, to 32 mg/m^3 in the blowing section, with a mean respirable dust size of 4.0 µm.

Small-scale enterprises are booming in Ethiopia. The Ethiopian government considers that such enterprises are the precursors of industrialization and agriculture. As a significant number of employees are expected to be engaged in this sector, OSH is a concern in these workplaces, as supported by the available literature. The working environment in 37 surveyed small scale enterprises (with work employment of 5 to 50 workers) was characterized by excess noise (24%), air borne dust (57%), heat stress (14%), electric hazards (57%), and insufficient use of personal protective devices (PPDs) (36%), based on expert judgment and observation (13).

Noise is one of the most significant hazards in workplaces such as textile mills and metallurgy factories. Most of the machinery in these sectors appears to be very old and known for excess noise generation. A study in one of the textile factories estimated a 34% prevalence rate of noise-induced hearing loss, which was highly associated with the type of workplace (spinning and weaving), exposure duration (>10 years), and level of noise at the workplace (> 85dB) (14). Noise level was measured at 42 workstations in 5 factories (2 textile, 3 metal). Noise levels in 24 (57%) work stations exceeded the OSHA permissible level of 90dBA (15).

There is a growing concern that changes in work shift, as part of the working environment in textile factories, contribute to sleep disorders, which in turn may increase the risk of injury. In one study in a textile factory, close to 60% of the surveyed workers had a sleep disorder, which was significantly associated with rotating shift work, external environmental noise, and working in the spinning department (16). The same authors found that inadequate air movement, dusty environment, noisy workplace, and heat stress were perceived as hazards of the working environment. Close to 40% of the respondents were not satisfied with their workplace environment (17), and the majority of the workers (53.6%) described their work environment as hot. For 66.8%, the physical condition around the working departments was at its worst during the hot season. The workplace was perceived as dusty and noisy by 47.2% and 36.0% of the respondents, respectively. The distributions of complaints about adverse environmental factors varied by work department. A higher proportion of the workers in the spinning

department complained of inadequate air movement (64.5%) and a dusty workplace (53.3%); whereas those in the weaving department complained that the workplace was hot and noisy (60.5%, 53.5%, respectively). Aprons were used by 95.7% of workers, but other personal protectors such as ear protectors, gloves, and goggles were rarely used. In general, 228 (57.9%) workers were satisfied but the rest were dissatisfied with their work environment. To improve the hygienic conditions in the workplace, 71.2% of respondents suggested using other types of personal protectors.

Hazard signs are used in the workplace to prevent accidents. The identification of the signs is very much dependent on the skill and knowledge of the workers. In a cross-sectional survey among workers in two metal factories, 69% of the respondents recognized at least one safety sign. Only 52.3% of respondents had some kind of training on occupational safety and health information, while the practice of working with PPDs was relatively good: 71.5% of the respondents used gloves and 48.2% used boots (18).

The construction sector in Ethiopia, which includes mainly housing and road infrastructures, has been growing rapidly over the last few years. A study among a construction workforce found that workers suffered from shoulder aches, back pains, skin-related diseases, eye problems, and breathing and noise irritations. The proportions of study subjects (n=100) with musculo-skeletal disorders, skin disorders, eye problems, workplace accident (serious and medium), and noise irritation were 64%, 69%, 31% and 46%, respectively. The work environment was characterized by tasks with repetitive movement of body parts, working in the open air, and the presence of dust and excess noise. Limited awareness by workers to occupational hazards, inadequate utilization of personal protective devises, and poor personal hygiene were cited as factors that are closely related to the adverse health effects discussed above (19).

Migration has emerged as a way to find a better life. Thousands of men and women each year are leaving their homes for many Arab countries and developed nations. Studies conducted abroad indicate that migrants who come from Ethiopia have limited knowledge of health and safety systems and have not worked in a system that involves continued promotion, monitoring and evaluation of the provisions indicated in health and safety regulations. Consequently, they have limited understanding of workplace safety (20). Lack of continued education about work safety issues is a problem in industrial settings as well. Training workers both before starting and while on the job serves to establish knowledge of practices that ensure work safety.

A study of cement workers in DireDawa Cement factory found that their exposure to cement dust was in excess of the international standard concentration (21). The geometric mean dust concentrations in the crusher and packing sections were 38.6 mg/m^3 and 18.5 mg/m^3, respectively, with both much higher than at the relatively non-exposed guard posts (0.4 mg/m^3). The prevalence of respiratory symptoms was also higher among dust-exposed workers than among the guards. Total cement dust exposure was related to acute respiratory symptoms and acute ventilatory effects as measured by peak expiratory flow rate (21). The same authors found personal exposures to total and respirable dust exposure to be 549 mg/m^3 and 6.8 mg/m^3 in the Muger factory, and 153 mg/m^3 and 2.8 mg/m^3 in the Mossebo factory, with the respirable dust concentrations in excess of the personal exposure limits of 1.0 mg/m^3 (22)). In a

follow up study, the findings of high concentrations of respirable dust among cement cleaners were consistent with the high prevalence of chronic respiratory symptoms and reduction in lung function (23).

Occupational hazards and safety provisions vary by workplace type. Mills for processing edible products are widely found in Ethiopia. An assessment of occupational safety and health practices in edible oil processing factories (n=38) in two regions (Amhara and Oromia) indicated a wide range of occupational hazards: poor illumination, presence of unguarded machines, heat, electrical hazards, slippery and unleveled floor, dust, oil mist, ergonomic hazards, and unhygienic workplaces (24).

Occupation health and safety practice was assessed in 25 small micro enterprises (SME) using observation and worker interviews. Commonly observed hazards included poor ergonomics (heavy manual lifting), slippery and unleveled work surfaces, excessive noise and dust, UV radiation, vibration, and electrical hazards (25).

Workplace exposure in agriculture

Agriculture contributes significantly to the national economy in Ethiopia. The flower and horticulture sector has been booming for the last few years and growing as a major means for earning foreign currency. Within the span of less than 10 years, Ethiopia emerged as a global player in the cut flowers market, now ranking second to Kenya. Private involvement in floriculture started in 1997 and showed progress during the 2005-2009 period. In 2010 the total land area covered by floriculture was 1600 hectares, creating job opportunities for about 35,000 workers, 80% of whom were females. The exported value of cut flowers in the first 10-month period of 2010 was US $250 million. Currently there are more than 89 companies producing and exporting flowers; the companies are largely owned by foreign investors, privately or in partnership with citizens (26).

The total generated employment and earned currency from floriculture were 85,000 workers and USD$200,000, respectively. The types of chemicals used as insecticides and fungicides, many of which are hazardous to workers' health, are diverse: as many as 127 different chemicals (organo-chlorines and organo-phosphates) are used in the business of greenhouse production globally. Other occupational hazards include extreme temperatures, ultraviolet radiation, infectious agents, and ergonomic, mechanical, and psychological risks. Little information is available on occupational exposures and adverse health effects in this agricultural sector.

Insecticides are used intensively in the agriculture sector to improve productivity. Spraying of organo-phosphorous chemicals either manually or machine-assisted is commonly practiced. In the past, planes were used for spraying extensively. A cross-sectional survey of one of the state farms located in southern Ethiopia using pre-and post- exposure test reported an 80% and 28% increase in plasma and erythrocyte cholinesterase, respectively, among 81 workers involved in spraying. The post-exposure level of cholinesterase was considerably different from its baseline, indicating a significant exposure to organo-phosphorous insecticide. Worker ignorance about the toxicity of pesticides, poor personal hygiene, and total absence or improper use of personal protective devices were found to be determinants of pesticide exposure (27).

The overall occupational injury prevalence rate was 783 per 1000 exposed workers per year in a state farm located in the northeastern Ethiopia. Injury was a factor for the loss of 6,153 workdays, or an average of 11.4 days per injured worker per year. Working more than 48 hours per week, absence of health and safety training, sleeping disorder, alcohol consumption, job dissatisfaction, and absence of protective devices were significant factors contributing to occupational injuries (28).

Two studies addressed floriculture workers in the Holeta area. In the first study, the prevalence rates of illness symptoms were 76.5% (fatigue), 73.4% (headache), and 67.7% (skin disorders) in the 12 month-recall period for data collection (29). This study did not include a reference population for comparison. A comparative cross-sectional study was undertaken in the same floriculture area to identify any difference in illness and associated factors. Reported prevalence of respiratory, skin, and general illness symptoms (headache, fatigue, sleeping disturbance, and body irritation) over the one-year period prior to the survey was higher in workers in floriculture than in the general population. In particular, respiratory symptoms and skin disorder symptoms were substantially higher among floriculture workers than in the general population (48.6% vs. 14.1% for skin disorder symptoms, and 75.5% vs. 42.2% for respiratory illness symptoms), or 3.5 and 1.8 times higher than in the general population, respectively. Poor awareness by workers of the hazards of floriculture and limited training on safety issues were significantly associated with reported respiratory and skin disorder symptoms (30).

Workplace exposures and determinants in health facilities

Exposures to biological agents are common among health workers employed in health facilities. Available published studies focus on exposures to HIV and hepatitis.

A cross-sectional survey of 475 health workers in 10 hospitals found that life-time risks of needle stick and sharps injuries (NSSI) were 30.5%; and 25.7%, respectively. The same study showed a one-year risk of needle stick and sharps injury to be 17.5% and 13.5%, respectively. Exposures to blood and body fluids were high, at 28.8% and 20.2%, respectively, for a lifetime and one year, respectively (31). Suboptimal practices and poor professional behavior of health workers were cited as main contributing factors for acquiring illnesses such as HIV and hepatitis B occupationally.

The prevalence of NSSI among health care workers in the preceding 12 months, while performing activities such as providing injections, setting IV lines, opening the needle cap, and performing operations, was 30.8% (n=344). Lack of training on occupational safety and health, working more than 48 h/week, dissatisfaction with work environment and work culture, greater than 10 years of work experience, and having low and moderate perception of risk were found to be significantly associated with NSSIs (32).

Exposure to NSSI in the management of patients and the handling of medical waste exposes workers to infectious agents. The overall infection rates of hepatitis B and C were found to be significantly higher among medical waste handlers compared to those who were non-clinical waste handlers, indicating that the profession of health care waste management is risky. The duration of work experience and the

provision of training in OSH were associated with the level of knowledge and recognition of safety signs (33).

Workplace illness and injury: Magnitude and related factors

Workplace related illnesses and injury represent a major public health concern in Ethiopia, given the rapid expansion of industrialization. The National Growth and Transformation Plan (7) anticipates that Ethiopia will have a major shift towards industrialization in the coming decades. Occupational diseases and injuries globally are known to affect the GDP due to economic loss for compensations and medical expenses (34), although this contribution in the Ethiopian context is not yet known.

Information on occupation-related diseases and injury or accident is not well organized or systematically recorded, evaluated, or monitored in the Ethiopian work setting. The Ethiopian Labor proclamation of 377/ 2003 (35) contains definitions and provisions on occupational accidents and occupational diseases (article 97 and 98); it does not, however, indicate how data should be generated and systematically monitored and evaluated. Given the above limitation, there are few published and unpublished reports that indicate the status of injury and prevailing illnesses in the Ethiopian workplace. The rate of injury in many studies is operationalized as the number of injuries divided by the exposed working population for a given reference period. The injury rate among 4,462 industrial workers surveyed cross-sectionally in Addis Ababa was 80 per 1000 exposed workers per year (36). Reports from the Department of Environmental Health of the Ministry of Health in the country indicated that among 16,610 large-scale industrial workers in Addis Ababa, a prevalence rate of 65 injuries per 1000 exposed workers was observed (37).

Small-scale establishments are the backbone of socio-economic development. They are closely linked to a community's life by providing related services. Flour mills, construction works, and metal works generate many employment opportunities. However, associated health risks are a concern, given poorly organized OSH services. The prevalence rates of major respiratory diseases were higher among mill workers than the general population, even when controlled for potential confounding factors (age, smoking, and gender) in a comparative cross-sectional study (38).

In Ethiopia, very limited attempts had been made to identify work-related injuries and their determinants using appropriate epidemiological study designs. A case-control study among 3,100 textile factory workers in Addis Ababa found an incidence rate of 200 injuries per 1,000 exposed workers per year (39). In this study, 50% of injuries were caused by machinery and being struck by objects, with the finger the most frequently injured body part. Limited use of PPDs, lack of training, poor lightning in workplaces, limited education, young age, work shift, and working in weaving and spinning sections were factors associated with increased risk of injuries.

A cross-sectional study in small and medium manufacturing establishments in Gondar Zuria in 2004 found that the annual and two week prevalence rates of work-related injury were 335 and 120 per 1000

exposed workers, respectively. Of the total work-related injuries, 114 (35.5%) and 208 (32.4%) occurred among workers in small and medium-scale operations, respectively (40). About 75% of the injuries involved hands, fingers, and eyes that resulted in abrasions, cuts, and eye injuries. This study also found that service duration of 5 years or less in the present job, working 48 hours or more per week, lack of workplace supervision, sleep disorder, job satisfaction, and job categories were major determinants of injury in the workplace.

Injury statistics are recorded and analyzed at the Federal Ministry of Labor and Social Affairs (FMOLSA) level. FMOLSA obtains injury reports from the Regional Bureau of Labor and Social Affairs (RBOLSA) and compiles and disseminates the information. The 1993 through 2003 report included the following injury data (41):

- The rate of *injury* varied from 63 to 82, with an average of 73 per 1000 exposed workers;
- The accident fatality rate varied from 0.1 to 0.23 per 1000 exposed workers;
- The number of days lost due to injuries varied from 192 to 681 per 1000 exposed workers.

The above data, however, need to be carefully interpreted because of the under-reporting of injuries by about 10% of those surveyed.

A 2009 case-control study in two large textile factories found that young age (<30 years), male gender, poor health and lack of safety training, sleep disturbance, and presence of job stress were significant predictors of occupation-related injury (42). Most of the factors were similar for small and medium scale manufacturing establishments (40).

The prevalence of injury among workers engaged in operations in two metal factories was 333 per 1000 per year. Flying subjects, falling, and machinery caused 43% of the injuries. Workplace hazards including unguarded machines, splitting materials, metal sparks, molten metal, excessive heat, and slippery and unleveled floors contributed to injury occurrence (43). Operational plans on OSH and IEC materials were non-existent in these factories.

Organization of occupational health services

Health services organized at enterprise levels operate under licenses given by the federal and regional health offices. Even though many enterprises do not have a stand-alone health facility at their work premises, they utilize public and private health providers for access to health services upon formal request and based on agreed-upon constitutions.

As such there is no mandatory legal provision in the labor law requiring employers to organize health services at the workplace. Those entities with operational health facilities have different organizational levels, i.e., from first aid rooms (the majority of undertakings), to mid-level type of clinics (such as BerhanenaSelam Printing Press), to higher level hospitals (such as the Wonji Sugar Factory). Hospital-level service is equipped with all of the necessary instruments and materials to provide standard services as prescribed by Ministry of Health regulations.

These facilities focus on curative services, specifically serving workers when they become sick or injured. Staffing of health personnel in workplaces follows the guidelines of MOH. In most cases, a health service at the enterprise level is managed by a full-time nurse with other assistant staff. A part-time doctor on a weekly visit schedule (about 4 to 6 hours per week) attends referral cases.

Health staff employed by industries usually lack on the job training and other capacity-building opportunities, mainly due to their employment outside of the "Public Health" circle. Enterprises with health facilities often lack a plan to build capacity of their health staff in order to provide prevention-oriented health services.

Pre-employment medical assessments related to workplace exposures rarely exist within the current OSH practice. In almost all enterprises, a general assessment of workers' health is done before a new employee begins the job. The medical checkups, however, often do not consider the nature of the job and the associated health effects. Very few enterprises have a standard pre-employment medical examination procedure for newly recruited employees; exceptions include Ethiopian
Air Lines and Ethiopian Shipping Lines.
Regular monitoring of workers' health (periodic medical checkup) that can possibly bring about health problems through time is exercised by some enterprises involving hazardous tasks or operations.
Workers at horticulture farms exposed to toxic chemicals or involved in formulation and spray of pesticides undergo periodic medical checkups (i.e., a Cholinesterase test) to assess the level of toxicity with regard to organophosphates.

The Ministry of Labor in consultation with employers and workers' organizations, and with regional labor and social affairs bureaus, developed a five-year labor sector development program (2010-2015). In this program the document "Promoting Safety and Health Services" identifies priority areas, and development of a national occupational safety and health policy and program is given high priority. Both the policy and program documents drafted in 2011/2012 are in the final phases of adoption by the government.

The challenges of organizing occupational safety and health services in Ethiopia include:

- Absence of a comprehensive policy;
- Absence of legal standards and operational guidelines, such as notification of occupational diseases, pre-employment and periodic medical examination;
- Shortage of OSH professionals;
- Weak enforcement capacity;
- Low level of awareness of OSH issues at all levels;
- Weak coordination mechanism with related ministerial partners (Ministry of Health, Environmental Protection Authority Radiation Authority, Ministry of Agriculture);
- Budget constraints;
- Absence of a strong monitoring and evaluation system;

- Weak partnerships among stakeholders.
- Existing practice of workplace safety provisions

Strategies to promote safety at the workplace as stated in the national OSH directive (44) are:

- To eliminate the hazard from the source;
- To remove the individual from exposure;
- To isolate the hazard;
- To use warning signs;
- To train and instruct workers;
- To use personal protective equipment properly.

In many enterprises, however, only two strategies -- training workers and providing personal protective equipment -- are widely practiced.

Causes of unsafe workplaces or causes of accidents can be divided into three categories: unsafe conditions, unsafe acts, and human failure.

Among the unsafe conditions, machinery and equipment account for a significant proportion of accidents in Ethiopia. Human error also contributes to a considerable number of accidents. Exposure to chemicals, being struck by falling objects, heavy lifting, unguarded machinery, and slippery floors and uneven surfaces are some of the main causes of accidents in Ethiopian workplaces.

If an accident occurs at a workplace, the employer's primary responsibility is to provide emergency first aid service to the victim and refer the injured person to a hospital for further treatment. Medical payments are usually made for direct care costs (e.g., for drugs and beds) and through compensation for bodily injury.

In most cases, however, accidents occurring at the workplace are not properly investigated and documented by authorities or by safety and health committee members. Safety issues are routinely monitored through inspections of workplaces and by writing reports to improve safety conditions. These activities are the regular function of the OSH experts --- inspectors who are deployed by the federal government. In addition, safety and health committees organized at workplaces conduct inspection visits every three months to ensure compliance with safety standards. The recommendations of the committee are subject to compliance by the responsible manager.

Safety provision at the workplace is organized through two distinct methods: 1) through establishing safety and health committees, and 2) by assigning a safety officer to handle day-to-day safety-related activities.

In most cases newly recruited workers do not receive safety induction training. Challenges related to workplace safety provisions include:

- Weak enforcement capacity;
- Inadequate number of OSH inspectors;
- Labor inspectors' low level of competency.

Existing practices of workplace hazard prevention (inspection and surveillance services)

Three principles of hierarchical exposure prevention are central to OSH practice. These are: 1) control at the source (hazard elimination or avoidance); 2) control at the path of transmission of the hazard; and 3) control at the worker's level. These principles are based on hazard identification, exposure analysis, and measurement of the hazard (evaluating the hazard) using direct instrumentation or other analytical methods. However, because lack of monitoring equipment and lack of training of OSH inspectors in evaluating hazards facilitated by measurements, decisions to design effective preventive interventions are made using personal experience and expert judgments based on observation and learned practice. This approach holds true at all levels of OSH administration. As a result, the control principle is focused on work organization (proper workplace arrangements, and rotation of workers) and use of personal protective devices (e.g., supply of protective devices to protect the head, eye, ear, body, and foot). These provisions are also strongly sustained during the annual bargaining between the workers union and the employer (called the collective agreement).

The OSH inspectors follow the procedures below, as stipulated by Labor proclamation 377.

1) Exercising inspection of OSH either by unscheduled or scheduled visits. Public complaints could provoke inspection as well.
2) Providing expert advice after synthesizing the information collected using an observation checklist.
3) Providing a citation, a written instruction stating that the employer must intervene within specified of time.
4) Following up of the recommendation indicated in the citation.
5) Bringing the matter to the court's attention if the employer fails to comply with the inspector's recommendation.

Perceptions are mixed regarding the efficiency of the implementation of advice by suggested experts, based on interviews with OSH inspectors. One group indicated that implementation is on a voluntary basis and not as a result of the inspectors' authority. Others suggested that implementation is possible if there is harmony and understanding between the regulatory authority and stakeholder managers, that the economic benefits and the investment needs of the country undermine the power of managers to exercise the policy provisions in OSH.

The type of workplace technology is currently playing a critical role in aligning preventive principles with work. Enterprises which use older technology are typically government-owned, use hazardous chemicals, and have old machines, old process methods, and heavy manual handling systems. Most machines were initially produced without much safety consideration, and the toxicity of chemicals was not taken into consideration. The application of engineering controls (source control) to hazard prevention is less likely to occur; instead, the use of PPDs is widely practiced.

Enterprises with modern technology are assumed to better consider hazard and safety issues. Machines are assumed to be designed to avoid, eliminate, or provide maximum reduction of hazards. This provides the possibility of practicing hazard prevention using the hierarchical principles.

Occupational safety and health information management

At present, the federal government does not collect or process information on accidents and injuries. Enterprises and factories at Wereda level provide accident reports to regional offices of MOLSA (RMOLSA) using a structured formation (Annexes 3-7). RMOLSA summarizes and submits the information to FMOLSA, which releases bi-annual accident and injury information as hard-copy reports. The reports are also disseminated to other stakeholders. Data storage is in archived format, and analysis is often done manually or using simple calculators. The system is not computerized, prohibiting easy retrieval, nor is such information made available for the public on a website. The likelihood that the information will be proactively utilized is, therefore, very limited.

OSH-related data at the factory and enterprise levels are collected manually and often stored in hardcopy. Even simple databases receive little use.

Policy and regulatory frameworks

Policy documents

Four policy documents are the foundation for the practice of OSH.

1. **The Ethiopian Constitution**(45). The operational constitution contains many chapters with regard to OSH. They are laid out as follows.

   Right to Equality

   All persons are equal before the law and are entitled without any discrimination to the equal protection of the law. In this respect, the law shall guarantee to all persons equal and effective protection without discrimination on grounds of race, nation, nationality, or other social origin, color, sex, language, religion, political or other opinion, property, birth or other status **(Article 25)**.

   Right of women: Women have the right to maternity leave with full pay. The duration of maternity leave shall be determined by law taking into account the nature of the work, the health of the mother, and the well-being of the child and family. Maternity leave may, in accordance with the provisions of law, include prenatal leave with full pay **(Article 35/4).**

   Right of Children: Every child has the right not to be subject to exploitative practices, neither to be required nor permitted to perform work which may be hazardous or harmful to his or her education health, or well-being **(Article 36/4)**.

   Rights of labor: Factory and service workers, farmers, farm laborers and other rural workers, and government employees, whose work compatibility allows for it and who are below a certain level of responsibility, have the right to form associations to improve their conditions of employment and economic well-being. This right includes the right to form trade unions and other associations to bargain collectively with employers or other organizations that affect their interest. They also have a right to express grievances including the right to strike (**Article 42**). In addition,

   - Women workers have the right to equal pay for equal work.
   - Workers have the right to reasonable limitation of working hours, to rest, to leisure, to periodic leaves with pay, to remuneration for public holidays as well as a healthy and safe work environment.

   Environmental Rights: All persons have the right to a clean and healthy environment (**Article 44/1**).

   Economic objectives: Government shall endeavor to protect and promote the health, welfare and living standard of the working population of the country (**Article 89/8**).

Social objectives: To the extent the country's resources permit, policies shall aim to provide all Ethiopians access to public health and education, clean water, housing, food, and social security (**Article 90**).

Environmental objectives: Government shall endeavor to ensure that all Ethiopians live in a clean and healthy environment (**Article 92**).

Proclamation No. 4/1995 indicates the powers and duties of the Ministry of Labor and Social Affairs. It determines standards and measures for the safety and health of workers and follows up on their implementation. MOLSA under this proclamation is authorized to inspect workplaces, collect relevant information, compile and disseminate the findings on safety and health of workers

2. **Ratified international agreements as supremacy of the Constitution and its application**

   It is also declared that all international agreements ratified by Ethiopia are an integral part of the law of the land (**Article 9/4**). Thus, all conventions which are ratified by Ethiopia become the law of the land.

   The fundamental rights and freedoms specified in this Chapter shall be interpreted in a manner conforming to the principles of the Universal Declaration of Human Rights, International Covenants on Human Rights and international instruments adopted by Ethiopia (**Article 13/2**).

3. **The Health Policy of 1993** provides a policy direction for OSH for those workers who sustain specific exposures in the workplace. It states the need for designing promotive, preventive, and rehabilitative interventions in workplaces. Articles within the policy consider OSH to be a high-priority public health matter.

4. **The Labor Proclamation of 377/2003**(35):

   This proclamation was instituted in reference to implementing OSH constitutional rights and the exercise of the duties and responsibilities of MOLSA. It is comprehensive and encompasses 191 articles on the rights of labor and OSH.

   Article 92 displays the duties and responsibilities of the employer in the maintenance of workers' health. By this provision employers are responsible to safeguard the workplace from any source of hazard and to provide the necessary OSH services to workers.

   Article 93 provides the responsibilities of the worker in promoting OSH. Workers are called on to cooperate and support in the prevention and reduction of workplace hazards.

   The definition of accident and the conditions at which accidents are of workplace origin is stated in **Article 97**. This provision defines "occupational accident" as any organic injury or functional

disorder sustained by a worker in connection with the performance of his work or carrying out the employer's order.

The nature of "occupational disease" is indicated in **Article 98**. An "occupational disease" is defined as any pathological condition caused by physical, chemical, or biological agents, which arises as a consequence of performing the work or in connection of work performance. This article states the provisions for listing a schedule of diseases to be considered occupational in origin. The absence of a disease on the list requires sufficient proof to claim that it is not of occupational origin. However, the article provides room to classify a disease as being of occupational origin if it occurs frequently among employed persons of a common type of occupation.

The various conditions and types of disability due to consequences from injury and its definition and assessment are indicated in **Articles 99** through **102**. The terms of compensation with regard to payment and medical benefits due for incurred injuries are described in **Articles 103 - 110.** The law guarantees the right of a worker to access such benefits given proof that the injury is due to the workplace.

Article 170 provides the power of the Minister of MOLSA to issue directives on OSH and protection of the working environment. Providing guidelines on standards of working conditions and classification of hazardous jobs are also among the provisions.

Article 177 provides the means of implementing the provisions of the proclamation through Labor Inspection Services (LIS). LIS includes the needs for inspection services, listing of occupational diseases, classifying dangerous trades, undertaking training in OSH, and seeking administrative measures to manage hazards, among others.

Article 178 provides the powers and duties of Labor Inspectors, with particular regard for the right of entrance into premises, collecting relevant data, and taking samples relevant to hazard assessment. Article 179 provides the measures to be taken by Labor Inspectors. These are instructing the employer to correct hazardous conditions, issuing an order to the employer upon failure of taking actions according to the instructions, and any measures necessary to prevent imminent danger to the safety or health of workers. The Inspector appeals to the court for the enforcement of his order if the employer refuses to respond in a prescribed time.

Occupational safety and health directives (44)

This is a working guideline prepared in response to the power of MOLSA vested by the proclamation No 377/2003. It provides the conditions and procedures for handling various kinds of hazards in the workplace. It briefly defines hazardous jobs and undertakings, and provides the safe handling of hazardous equipment and working methods, as well as workplace procedures with respect to handling and management of hazardous jobs, equipment, and conditions. The guideline also describes the

management of safe workplaces and occupational hazards in the construction and agriculture industries.

Ethiopia has committed to exercising ILO Conventions. Twenty conventions are ratified and addressed in the labor proclamation. These ILO conventions include:

- Elimination of forced labor: convention 29/1930 and 105/1957
- Freedom of association and right to collective bargaining: convention 87/1948 and 98/1949
- Abolition of child Labor: convention 138/1973 and 182/1999
- Elimination of discrimination in employment: convention 100/1951 and 111/1958
- Weekly rest (Industry): convention 14/1921 and 106/1957
- Occupational safety and health: convention 155/1981.

The above local policies and legal frameworks establish basic provisions for the management of OSH. There are, however, some concerns based on discussions with experts.

1. The above policy statements seem not to address the current emerging development/ investments issues. The role of the employer in striking the balance between prevention and curative health, and the need of inter-ministerial coordination require a new policy direction. It was stated that a new draft OSH policy that addresses these issues has been submitted to higher authorities for approval. The policy draft is also in response to Occupational Safety and Health and Working Environment Convention No 155/1981
2. The OSH directive does not fully address all workplaces. The need for updating to a wider perspective is a concern.
3. The translation of policy statements is not well-documented or exercised at the enterprise level. The limited information available indicates that the enterprise management does not have a policy statement that directs implementation of OSH at the enterprise level.

Organization of occupational safety and health

OSH is organized by teams at the federal and regional levels, with limited number of OSH inspectors whose duties are to conduct labor and workplace inspections. At the zonal level a multi-purpose expert oversees OSH, while at the Wereda level of administration no expert is on site reviewing OSH.

The organization of Ethiopia's occupational safety and health service is compatible with the structure of the country's federal government. At the federal level the service is organized in two teams, which are responsible to the State Minister of Social Services. The teams are:

Labor inspection Service Team, overseeing inspections to ensure that safety and health provisions are implemented in accordance with Labor Proclamation No 377/2003;

Occupational Safety and health Service Team, responsible for safeguarding workers from HIV/AIDS and promote cleaner workplaces and production. OSH at the regional level is organized in varying structures. In developed regions (Amhara, Oroma, Tigray, and SNNPR), the service is organized at the "OSH team level", while in developing regions the service is organized under the labor section by one or

two professionals. At the zonal level a professional expert represents the entire service. The structure is absent at Wereda level.

Among the challenges and limitations are the following:

- Weak organizational structure that could not meet its purpose.
- Inadequate staff.
- Budgetary constraints.
- Absence of OSH monitoring equipment.

A memorandum of understanding was signed between the federal and regional bureau heads to cooperate and work jointly in all labor administration issues including occupational safety and health. In this respect, the federal structure becomes involved in regional occupational health matters only when invited by concerned regional professionals.

With respect to follow-up of occupational safety and health activities, a quarterly reporting system and an annual joint meeting are conducted to evaluate progress. Unions at the federal level (Confederation of Ethiopian Trade Union, CETU) have one fulltime safety and health expert to support trade union representatives on safety and health issues. At the enterprise level respective trade unions participate on safety and health committees and engage in collective bargaining to maintain the benefit of protecting workers from harm.

Workplace inspections are organized into four major categories, according to labor proclamation No.377/03:

1. Planned inspection
2. Follow-up inspection
3. Complaint-based inspection
4. Accident investigation inspection.

Often the inspection citation is the result of complaints or official requests from management groups. In some cases, inspection citations are based on the nature of the industry or subjective perception by the inspector with regard to occurrence of accidents.

A corrective measure arising from an inspection is enforced through submission of inspection reports to enterprises. The implementation of OSH expert advice depends on the good will of the workplace manager, and often this is not adequate to generate correction or improvement. The OSH inspector has the right to bring charges to a court of law to enforce his expert advice, but the court procedure can be inefficient and is often unproductive. Punishment can be as high as 1200 Birr for an OSH violation.

The low level of awareness, accountability and unresponsiveness are important challenges to maintaining standard OSH services in workplaces.

Occupational health and safety and environmental service delivery at the factory level

To explore existing OSH activities and services, seven factories (Annex 8) were selected and visited. Information was collected using an open-ended thematically structured questionnaire (Annex 9). The findings follow.

Existing guidelines on OSH

Seven documents reflect the needs of Ethiopian Labor Proclamation No 377.

1) **Strategic Plan**: a long-term prospective policy document that encompasses the general framework of the undertaking including vision, mission, objectives, and strategic elements. The document has general descriptions of OSH and sustainable development.
2) **Collective Agreement:** a mandatory document for all factories operating under the Labor Proclamation. The Employer, on the one hand, and the representatives of local Trade Union, on the other hand, agree on the provisions of benefits and the management of environmental risks. OSH related agreements include responsibilities of partners, safety measures in work places, various kinds of personal leave, working duration and hours, fire safety, provisions of personal protective devices, sanitary facilities, and health services. The collective agreement is applicable only to workers working with machines and related activities.
3) **A guideline for management workers**: a document intended for management staff (organizational heads and administrative workers) and contains the provisions for the maintenance of basic working conditions (personal protective devises, working hours, personal leave, etc.).
4) **Operational document**: an assessment-based document, produced by OSH experts, lays out the various provisions for each type of work or job. Focus is given to safety measures and protective devices.
5) **Policy on HIV/AIDS**: a national directive developed by the Federal Ministry of Health to operationalize support and care to victims of HIV/AIDS.
6) **Workplace safety guideline**: directives on managing safety issues (fire safety, preventing accidents) as well as work place hazards (mainly physical, chemical, and ergonomical).
7) **Emergency response directive**: a document containing provisions about safety, health, and the environment that facilitate the ISO certification of a factory. Certification falls into two categories: Environmental Management System (EMS) and Quality Management System (QMS).

OSH services

The provision of occupational safety and health services is ensured through the following activities.

1. **OSH inspection services**: this service is provided in one of three ways.
    a. **Inspection by a Safety Committee (Hazard identification and risk assessment)**: The Safety Committee, which is usually composed of 5-6 members from various units of production, initiates an inspection at least biannually of each workplace unit for safety and

health hazard identification. Discussion with workers and observation using checklists are the methods of gathering information, while the safety and sanitary conditions, use of personal protective devices (PPDs), work organization, and floor conditions are subject to inspection. Detection of violations and good practices are made on the spot at the respective unit. Decisions on the outcome of the inspection are discussed in wrap-up meetings in which specific violations are reviewed and suggestions for interventions (resources, advice, etc.) are made. Finally, the recommendations are submitted to the General Manager for approval.

b. **Inspection by the Safety Officer**: the person in this position usually has a background that includes on-the-job training on safety issues; he carries out the routine inspection, scheduled 2-3 times weekly, of workplaces with potential safety and health risks. The safety officer also follows up on the interventions suggested by the Safety Committee. Subjects of inspection include hazard detection (sanitary conditions of floor and equipment, fire hazards, electrical hazards, use of PPDs, and chemical hazards); a n d checklists are the main tools for data collection. The safety officer also keeps records and recommendations on safety issues.
c. **Inspection by complaints and emergency:** this type of inspection occurs when the need arises. Workers and management staff could imitate this type of inspection by notification.

The records containing inspection results, with recommendations and decisions made by higher levels of management, are stored securely in the office of the safety officer.

2. **Medical examination and surveillance**: Two types of medical examinations fall under OSH services. The p**re-employment medical examination** is health screening performed just before a placement worker starts in his or her position. It focuses on the examination of organ systems (lung with chest x-ray, blood (HgB, HCT), stool and urine samples, eyes (visual acuity and trachoma), ears (infections and audiogram), and the nervous system. The **periodical medical examination** (usually annually)is carried out only for those workers believed to have a known exposure to health hazards, such as noise, painting, welding, chemicals, or ergonomics. This service is provided by specialized clinics engaged in a contract with the respective workplace. In addition, **emergency and routine medical examinations** are provided on an as-needed basis by workplace clinics and referral clinics(audiogram, muscle strengths, vision, etc.), as necessary.
3. **Provision of Personal Protective Devices** (PPDs). The provision of PPDs is laid down both in the collective agreement document and in the technical guidelines. The selection and the type of PPDs are based on the type of hazards. Commonly used PPDs include gowns (for all workers), safety shoes, gloves (heavy duty for mechanical hazards and leather gloves for chemicals), goggles, ear muffs and ear plugs, helmets, and dust and gas masks.
4. **OSH Training**: This activity, usually lasting 3 to 5 days, is provided to management staff and safety officers by regional and federal MOLSA officials. Safety officers in turn provide on-the-job training to workers, focusing on safety in the workplace.
5. **Provision of sanitary facilities:** Facilities required for personal hygiene and cleanliness are supplied by the factory management. Such facilities include latrines/toilets, hand washing supplies,

showers, and locker rooms. Standards to accommodate the respective facilities are based on the number of workers.

6. **Social services**: Canteens provide workers with food and drinks at reduced costs. Cafeterias are managed by the factory- level trade unions to ensure affordable cost and good quality.
7. **Organization of health services**: These are organized under a health service unit that has a medium-level clinic headed by a health officer (BSc), nurse (BSc), or physician (MD). They are staffed by various categories of health professionals, including nurses, lab technicians, and a druggist. Routine services include examination, lab analysis (stool, urine, x-ray), diagnosis, and treatment. The medium-level clinic has a link to referral health facilities to provide specialized services and medical assistance as needed.
8. **Accident investigation:** An accident is an undesired incident that culminates in injury, disability, or death. An accident with loss of life and visible material damage is reported to a higher level of OSH services, and an team from either the regional or federal MOLSA is authorized to investigate the extent, type, and cause of the accident. A complete report on the accident provides the basis for decisions regarding compensation and related interventions. Minor injuries that do not threaten the life of the injured worker, however, are managed by factory clinics through the provision of medical assistance.

   9 **HIV/AIDS prevention and control services:** The prevention and control of HIV/AIDS is guided by a protocol set out by the Federal Ministry of Health. Although the spectrum of the prevention activities differ from factory to factory, the following activities are essential. **Care and social support**: Antiretroviral therapy drugs are freely supplied to HIV/AIDS patients by authorized health facilities (hospitals and health centers). HIV/AIDS patients who disclose the status to the factory management are closely followed for medical assistance, provision of sick leave, and light work duty. Some factories are encouraged to provide allowances to supplement patients' nutrition (in kind or in cash). The factory management ensures that HIV/AIDs patients are not discriminated in work placement or benefits. **Voluntary counseling and testing (VCT)**: This is an informed voluntary activity that is organized by the factory clinic in collaboration with public hospitals and NGOs (e.g., Mekdim). All workers are encouraged to use the VCT services freely. Care and support is then linked to individuals who seek the service.
10. **Health promotion:** Improvement of the behavior of workers regarding their health and relationship with the workplace is managed through information, education, and communication. Individual and group education is primarily used to create awareness. Some factories have mini-media and use leaflets to reinforce knowledge of health risks.

Commonly observed morbidity

Both communicable and non-communicable diseases are observed routinely by factory clinic staff. The majority of workers complain of fatigue and abdominal and respiratory problems. Occupationally related diseases are also observed, including contact dermatitis in painting units and workplaces using chemicals; chronic obstructive lung diseases (asthma, chronic bronchitis) in dusty work places; eye

problems in workplaces requiring visual function; and loss of hearing in noisy environments. These are not yet formally recorded as occupational diseases, but are based on long-term observations. Non-communicable diseases, including hypertension and diabetes, have been observed more recently at factory clinics.

Engagement of bi-party and tri-party in OSH services

On matters related to OSH, the labor proclamation states the need for mutual consultation and agreement among the 3 parties: public authorized institutions on the behalf of the government (regional and federal Ministry of Labor and Social Services), trade unions (federal, regional, and local), and the employer (Employers Association and local employer). Factory-level consultation usually occurs between two parties: the employer and the factory-level trade union representative. Such consultations occur when organizing an inspection (grand or routine), a safety committee, or the proceedings of a collective agreement.

Role of private insurance companies in OSH

Every factory enters into agreements with insurance companies to compensate for loss due to unforeseen events. Insurance companies are mainly involved in the payment of compensation for accidents, injuries, and related disabilities. Some insurance companies are engaged in advising factory management after identifying unsafe workplaces. Every incidence of compensation and related information is documented.

Cleaner production

The concept of sustainable development is practiced in the Ethiopian factory setting. The Federal Environmental Protection Authority, in collaboration with UNDP, guides and monitors the implementation of cleaner production. One example is a tannery factory which is making strides in waste recovery and improving productivity. A liquid waste primary treatment plant has been installed to recover chromium and convert corrosive sulphides into sulfates. Treated waste is released after sedimentation and aeration to biodegrade organic chemicals. There is a plan to install a biological treatment plant (oxidation pond) to improve the quality of effluent. Animal hair and unwanted parts of skin and hides are recycled into useful products. The tannery works closely with its employees and the neighborhood community to create awareness using green park meetings and soliciting feedback about the cleaner environment. The tannery has been certified with an ISO 1401 Environmental Management System.

Human resource management and development

There are currently 284 labor inspectors with diverse educational backgrounds in Ethiopia. About 38% (107) of the inspectors have training in basic sciences (biology, physics, and chemistry), and 43% (123) in social sciences. A total of 10% (29) inspectors have some on-the-job training in OSH (Table 5). The federal and regional OSH structures are staffed by degree holders (basic science and social science), while the Wereda level is staffed by diploma and certificate holders in areas of technical and vocational

education. A formal training degree (BSc) in OSH was initiated at the University of Gondar in 2006, but was terminated in 2011 due to minimal demand.

With regard to regional distribution, close to 95% of the labor inspectors are based in larger regions where factories are highly concentrated: Addis Ababa (28%), Tigray (27%), Oromia (18%), Amahara (13%), and Southern Nations (9%) (Table 6).

Table 5: National labor inspectors profile, FMOLSA, March 2013

Level of education	No.	%
Certificate	4	1.4
Diploma	61	21.5
Degree	216	76.1
Master Sc	3	1.1%
Total	284	100.0
Field of basic education		
Basic science	107	37.7
OSH (short term training)	29	10.2
TVET	14	4.9
Law	11	3.9
Social Science	123	43.3
Total	284	100.0

Source: Federal Ministry of labor and Social Affairs April 2013

Table 6: Distribution of labor inspectors

Region	Male	Female	Total	%
FMOLSA	5	2	7	2.4
Addis Ababa	47	33	80	27.5
Amhara	36	1	37	12.7
Oromia	49	3	52	17.9
Tigray	43	35	78	26.8
SNNPR	16	9	25	8.6
Harari	1	1	2	0.7
Afar	2	0	2	0.7
Dire Dawa	1	0	1	0.3
BenshangulGumuz	2	0	2	0.7
Gambela	2	1	3	1.0
Somali	2	0	2	0.7
Total	206	85	291	

Source: Federal Ministry of labor and Social Affairs April 2013

Training in OSH

Although OSH service in Ethiopia is in its infancy, some promising initiatives are underway, especially in human resource development at Addis Ababa University and the University of Gondar.

Formal training at the BSc level in OSH was initiated in 2004 at the University of Gondar following discussions with MoLSA, MoE, the ILO regional office, and other stakeholders. The three-year program includes courses in the basic sciences, environmental health, and other public health fields, as well as OSH courses. The first of its kind, it graduated 40 students in 2006, with a total of about 200 students through 2011.

The University of Gondar was the first in the country to start training students in environmental health, formerly called sanitary sciences. At the university, the BSc in OSH and the BSc in Environmental Health were given separately until 2009. The curricula were evaluated with a needs assessment from major partners, including MoLSA, MoE, and relevant employers. The feedback from potential employers included the importance of recruiting professionals who are trained in both the occupational safety and health and environmental health aspects of the field.

To meet the current need for OSH services, the curriculum was revised and improved, and the duration of the program was upgraded from three to four years of study. The OSH laboratory component was strengthened by purchasing measuring instruments through the DIF project for financial assistance from the MoE.

Since 2010, the program's course composition has required an equal number of credit hours for both the occupational safety and health and environmental health components. This adjustment made the curriculum more comprehensive in adequately addressing both components as they relate to workplaces.

The need assessment feedback from the MoLSA and MoE identified gaps in research capability, labor inspection capacity, and OSH management skill in the labor sector at the federal, regional, and lower levels. Hence, the University designed a two-year postgraduate program and has enrolled students since the 2011/12 academic year. Interested students from all regions can apply for scholarships through MoLSA. The first 10 MPH graduates received their diplomas in Occupational Safety and Health Management in 2013, and the program continues its effort with the second round of postgraduate students coming from throughout Ethiopia. There are still many challenges, however, in training at both the undergraduate and postgraduate levels due to few skilled professionals in the fields of OSH and ergonomics available to teach at the university level, and the lack of advanced laboratory capacity, as well as the geographic limitation of offering this particular program at only one site in the country.

Other university pioneers in the training of environmental health professionals include Addis Ababa University and Jimma University. These universities are involved in the producing of MPH graduates with baccalaureate degrees in environmental health. Thesis work includes the identification and recognition of hazards and symptoms of illness in workplaces.

Research, Monitoring, and Evaluation (OSH Surveillance)

Workplace hazards require measurements using appropriate, calibrated monitoring equipment, which is currently only available in a few regions (Addis Ababa, Amhara, and Oromiya). At the federal level there is no OSH monitoring equipment and no training for users on the operation and handling of newly purchased equipment. The presence of hazards is usually determined by the inspector, the national OSH directive, and consideration of workers' complaints. The absence of research units at each level of OSH organization limits the effectiveness of hazard recognition and evaluation. Whenever available, research findings are disseminated in workshops and consultation forums.

Challenges regarding monitoring and evaluation include:

- Absence of clear indicators that can be monitored for compliance;
- Weak follow-up mechanisms for compliance.

Financial resources of OSH at the ministry level

The budget allocation for managing OSH programs at the federal level is approximately 3.2 million Birr for the 2012 fiscal year. The allocated amount for OSH comprises about 5% of the entire budget, with budget constraints presenting a challenge to running effective OSH services.

Identified gaps

Based on the situational analysis, the following gaps were identified.

Research gaps:

The main function of OSH is to recognize and evaluate occupational hazards and maintain a safe workplace. The need for capacity to quantify the extent of exposure to hazards is a high priority. However, available measurements of exposure are primarily subjective and are prone to subjective errors. Moreover, the regulatory measurements are not supported by adequate instruments. Personal exposure measurements are needed in both routine inspection and surveillance activities.

Training gaps

OSH services are often carried by inspectors who often lack sufficient training in OSH, either at the undergraduate or graduate levels. Decisions on the findings of inspections are made largely using knowledge established through personal experience, short-term training, and internet-based information.

Capacity building

The provision of basic resources is critical for effective OSH services. Limited access to and use of instruments, and limited laboratory availability are some of the technical challenges substantially limiting exposure assessment. Moreover, insufficient resources are also evident in the limited distribution and numbers of OSH inspectors and the limited funds for research and inspection.

Policy and regulation needs

Labor Proclamation No 337 is the foundation of OSH services. Although the presence of this OSH directive is a strength, the further translation of the regulatory document into action is limited due to the absence of many operational guidelines (e.g., a listing of occupational diseases), and inspection guidelines for various workplace sectors. Improvement in OSH is not only dependent on the routine inspections provided by OSH inspectors, but also on the contribution made by employers, another key aspect of OSH that requires review. OSH policies need to encourage employers to take actions that parallel those taken by MOLSA.

Organizational gaps

The vast responsibility of OSH services is difficult to fulfill, given the current inadequate organizational capacity. While the concentration of OSH inspectors in larger regions is well understood, substantial evidence shows that the workload does not reflect or coincide with the available human resources.

Monitoring and Evaluation gaps

The absence of well-established monitoring and evaluation (M & E) programs is an area that needs urgent attention. Addressing this gap requires the selection of OSH indicators that show the patterns and trends of OSH. The only available indicator that appears to be monitored routinely is injury/accident, but monitoring efforts have dwindled recently. In general, indicators related to sudden events (accident, poisoning), exposure to hazards (noise, dust, chemicals) and recording occupational diseases require detailed work linked to the preparation of operational guidelines, tools of data collection and analysis, and means of measuring hazards. All of these efforts are poorly organized at all levels of OSH management.

Needs assessment on occupational health and safety

The OSH situational analysis provides the opportunity to recognize gaps using six domains: research, training, capacity, policy and regulation, organization, and monitoring and evaluation. In addition to the use of available secondary sources, face-to-face discussions took place with focal organizations to evaluate the consistency of information and further refine the real needs on OSH. Organizations taking part in the discussions included:

1. Experts at FMOLSA
2. Regional MOLSA of Addis Ababa City
3. Regional MOLSA of Oromia
4. Safety and health Officers of Berhanena Selam Printing Press
5. Safety and health Officers of Awash Wine Factory
6. Experts of MOLSA of the Gamo Gofa Zone.

Structured discussion was used to facilitate information-gathering related to concerns using the following questions as a guide:

Question guides

1. What are the activities in OSH? Ideal activities or performance under ideal conditions?
2. What are the felt gaps (needs) in areas of OSH?
3. Classifying the gaps by (Organizational? Resources? Guidelines?) Research gaps; Training gaps; Capacity gaps; Monitoring and Evaluation gaps; Policy and regulation gaps; Organizational gaps
4. Are the gaps consistent: federal vs. regional? Public vs. private?
5. Why do such gaps persist? (Organizational? Resources? Guidelines?) Research gaps; Training gaps; Capacity gaps; Monitoring and Evaluation gaps; Policy and regulation gaps; Organizational gaps
6. What are possible solutions? What plans are in place?

The following were gaps or areas of need consistently expressed across MOLSA Office hierarchies: training, capacity building (monitoring equipment, lab settings, training in instrumentation), limited use of monitoring equipment, limited trained human resources with frequent turnover, weak enforcement of OSH citations, a poorly managed information system, and managing operational scientific researches.

Identified needs in OSH

The gaps are indicated below by each domain of the assessment.

Research gaps

MOLSA's capacity for scientific research is very limited. Currently hazard assessment is based on an expert's experience and individual judgment using observations. The evaluation of exposure to hazards is not monitored using standard equipment, and the research gaps in particular include the following:

1. There is no policy direction to address research needs in OSH. The available studies are not well-coordinated or focused on addressing national OSH priorities. Limited financial assistance is also a barrier to encouraging researchers to develop a link between academia and industry.
2. The volume of information on the commonly observed hazards does not capture the national context. Only a few small assessments are available, and those are due to the efforts of individual researchers who are usually affiliated with training at universities.
3. The volume of research on work-related injury is greater than on occupational-related diseases. However, although emphasis has been placed on the relatively high injury rates as indicated by existing studies, there may have been inconsistencies in operational definitions, recall time, and standard tools used to collect data. Existing injury rates varied between 63 and 335 per 1000 population, although a partial explanation for the difference might be differences in the study populations.
4. Because there is no definitive document listing "occupational diseases", the few available studies focus mainly on symptoms rather than particular diseases. Study designs, including those in MOLSA reports, have not considered baseline at employment. Consequently there is difficulty linking exposures to health outcomes.
5. Studies on workplaces such as construction, micro-enterprises, and floriculture are limited, although these sectors are growing rapidly and have huge employment opportunity.
6. The need for a periodic survey on OSH is evident to monitor trends and patterns of workplace injuries, diseases, and related hazards. The Ethiopian Demographic Survey is a suitable model for adoption.

Training gaps

1. The backgrounds of most OSH inspectors involve the basic sciences (i.e., chemistry, physics, or biology). Many have not had formal training in OSH with the exception of very few individuals who had recent baccalaureate training in OSH. These groups lack expertise in exposure assessment and related instrumentation. Overall, lack of formal OSH training both at the primary and secondary degree level is currently an area of critical need.
2. Lack of training on the operation of existing monitoring equipment is a substantial challenge for OSH inspectors. Serial monitoring is needed to track exposures, and measurements need to be reliable and quality-assured for this purpose.
3. Three- to five-day "on the job training" sessions are conducted for safety officers and members of Safety Committees with the goal of improving health and safety conditions. Similar one-to-two

day training sessions are held to create awareness about healthy workplaces. The effectiveness of these training sessions in improving OSH conditions, however, has yet to be evaluated.

Capacity gaps

1. Access to relevant monitoring instruments is a major OSH challenge. Limited or lack of appropriate OSH monitoring equipment and laboratory support greatly reduce the efficiency and productiveness of the labor inspectors. Although a few regions strive to purchase and use some basic exposure assessment equipment (noise meter, dust meter, light meter, spirometer), the absence of training on these instruments limits their use.
2. FMOLSA does not have a laboratory for OSH. MOLSA is assumed to lead the country's promotion of OSH through the provision of technical assistance to regional MOLSAs. The majority of regional MOLSA centers appear to have very few measurement instruments and MOLSA cannot address this gap.
3. The efficiency of OSH inspections very much depends on the inspectors' previously established knowledge and skills for assessing exposure. Predicting any improvements in workplaces with regard to health and safety is a challenge, with the very limited number of such professionals and their lack of relevant OSH training.

Policy and regulation gaps

The direction of OSH policy issues are well addressed in the health policy and labor proclamation. It is understood, however, that such legal documents do not address the emerging issues of investment, such as floriculture and the construction industry. The coordination mechanisms at the national level are also poorly understood. Existing legal frameworks do not monitor the prevention of hazards by every employer.

1. An understanding of current practice shows that many enterprises lack OSH policies and guidelines in response to existing laws. Local policies should reflect the direction of OSH with regard to the mission and vision within the enterprise's business culture, express goals, objectives, and strategies to achieve a safe and healthy workplace; state the organizational structure needed to reach the goals; show commitment to involving workers as partners; and plan to allocate sufficient resources. FMOLSA has drafted a new OSH policy that could address these issues; it is currently under consideration by the Council of Ministers of Ethiopia.
2. The OSH directive, which is operational at the national level, is not well structured to address emerging industries in Ethiopia such as the floriculture and construction industries, and there are gaps related to exposure measurement. There is a strong need for updating this document.
3. The labor inspectors have the power and responsibility to carry out OSH inspections and to provide instructions and orders for the management of hazards in the workplace. Employers, however, commonly fail to implement the inspector's orders. The court procedure to settle the dispute between the inspector and the employer is time-consuming and often impossible for the inspector to pursue. The settlement often culminates with the monetary punishment of Birr 1200,

an insignificant amount for the employer. Such actions do not promote positive motivation for the inspector to carry out his/her duties and thus motivate changes in OSH.

Organization gaps

1. Organizational aspects of OSH at all levels (including federal, regional, zonal, and wereda) are very much restricted and unable to meet the objectives as prescribed in related policies and proclamations. The number of OSH inspectors is not proportional to the overall volume of inspections, particularly in cities such as Addis Ababa where factories and other workplaces are concentrated. The available human resources for regional MOLSA offices are often limited to 4-5 inspectors who cover both the social sector and OSH services. The number of inspectors at the zonal level is even lower, lacking capacity for OSH inspections, and there is no formal representation of OSH inspection at the Wereda level. OSH organizational support with regard to appropriate budget levels and other resources is limited.
2. Coordination of efforts on the OSH agenda appears to lack structure. The use of a coordinated plan and report is absent. The FMOLSA lacks a strong system to guide the overall effort to sustain progress of OSH. Coordination with agencies concerned directly with OSH is weak, as is coordination across national stakeholders (e.g., MOH). The absence of a declared list of occupational diseases exemplifies the poor coordination among the major stakeholders.
3. OSH is a multidisciplinary activity that requires the attention of multiple professionals. Universities are expected to generate information on various areas of OSH, but this is limited to a small number of research projects (e.g., Master's Theses) initiated independently absent coordinated efforts with MOLSA and its branches. Poor coordination is a major challenge in carrying out a strategic research agenda and using funds optimally.

Monitoring and evaluation (OSH Surveillance)

1. The assessment of occupational risk factors requires a systematic approach based on real needs and well-designed frameworks. Although some exposure limits (standards/cut-offs) are indicated in the OSH directive, the protocol (frequency for monitoring, instrumentation, and calibration needs, for example) and evaluation of measurements are lacking. There is a clear need for baseline medical data on workers upon recruitment, but such data are generally absent. The lack of occupational physicians and nurses who are specifically trained to handle work-related cases further complicates diagnosis, treatment, and prevention.
2. Overall there is no well-organized M and E system that addresses the needs of the country in reference to the management of workplace hazards. Nationally agreed-upon indicators regarding types of hazards have not been systematically established. Accident data collection, analysis, and dissemination are not well-organized at the central level. No unit is formally accountable for planning, organizing, and implementing M and E activities. The manual handling of injury data makes the information difficult to access and analyze, which is problematic the regional and enterprise levels.

3. Peer discussion suggests that accidents are not well-investigated. Workplace managers focus mainly on medical assistance for the injured worker and the respective compensations. Accident investigators called from regional or federal MOLSA during crises are rarely involved due to other competing priorities. The possibility of learning lessons from such accidents is often limited.
4. The labor proclamation clearly states that every accident requires investigation. However, accidents are largely under- reported, with only 10% of events believed to be reported (41).

Strengths and limitations

Strengths

The implementation of the SANA followed a very competitive application process to secure the planning grant. The coordinated collaborative nature itself contributed to the quality of the proposal and thereafter its implementation. Some of the notable strengths of the assessment are listed as follows:

1. Introduction of the GEOHealth project to stakeholders in a one-day inception meeting, which was a platform for understanding the stakeholders' perceptions and for obtaining feedback on the conduct of the project;
2. The use of the SANA implementation guideline that endorses structured tools for data collection;
3. The deployment of experienced research assistants for data collection, compilation, and write-up;
4. The use of participatory approaches in information collection that engage relevant stakeholders in the fields of health, environment, and OSH;
5. Regular follow-ups of the progress of SANA locally as well as the joint effort between the AAU and USC teams;
6. The use of literature reviews to identify gaps and needs, integrated with interviews with the relevant bodies, providing a useful mixed approach, and data checking, which was carried out whenever an inconsistency was noted in the gathered information;
7. The involvement of relevant OSH experts for data collection, making the process efficient and economical.

Limitations

There are several constraints:

1. Limited interviewing of the local MOLSA offices;
2. Limited availability of research information. Some of the available data were collected many years ago, with limited documentation.

Conclusions

OSH faces multiple and diverse challenges. The research, training, and capacity gaps are currently too big to reach the goals stipulated in Ethiopian Labor proclamation No 337/2003. The current capacity and organization are inadequate to accommodate OSH functions. Based on the absence of monitoring and evaluation of OSH functions and existing hazards in workplaces, it is difficult to make any reasonable policy recommendations at this time.

Priority needs for intervention

Ethiopia has pressing OSH needs given the rapid development of investment. The growth of the industrial and agricultural sectors is likely to increase workers' exposures to occupational hazards. The need is even more critical if we also consider the extent of environmental insults that these investments may generate. Given the main findings as stipulated in the SANA, the priorities are clear:

1. Aligning research work in OSH with the priorities compatible with the national interest is an important area of intervention. The absence of a research system that handles the implementation program to address the national OSH priorities has led to inefficient efforts by various researchers, mainly university-based. Currently available research addresses pocket areas, often not representing the national context, with a very narrow coverage of topics and content.
2. The training and educational capacity of MOLSA at all of its levels of administration is currently inadequate and needs improvement. Within the current organizational structure, existing trained workforce cannot meet the country's OSH needs.
3. The measurement of occupational hazards for workplace exposure assessment is a serious challenge for the management of OSH. Although there seems to be a limited effort in acquiring basic monitoring equipment (Addis Ababa, and Oromia MOLSA), the lack of integrating this equipment acquisition with the training of experts and technicians for such instrumentation is frustrating to OSH inspectors.
4. The overall and large responsibility of MOLSA in areas of OSH does not coincide with available human resources. The quantity and the quality of human resources are of great concern. The placement of a career structure for the profession based on training seems crucial for advancing OSH.
5. MOLSA is adequately equipped with the necessary policy and legal frameworks. It has an up-to-date legal proclamation to run OSH services. However, the policy directions to address the emerging investments and direct the preventive roles of employers need adjustment, as synthesized by concerned authorities. Employers currently focus on the medical aspect, to the neglect of the public health issues.

6. The monitoring and evaluation aspect of OSH is poorly addressed. The lack of a national plan of action that addresses priority issues of information management is a critical gap hampering improved performance.

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Assessment Findings: Section II - Situational analysis and needs assessment on agriculture occupational health and safety

Introduction

The challenge of providing enough food for the citizens of Ethiopia has been and continues to be among the most pressing and urgent issues in the country. This is a real challenge calling for an integrated approach towards increasing productivity, food production, and protection during pre-and post-harvest periods. The efforts to increase food production and protection should be carried out in a manner that does not adversely affect the environment.

Many experts agree that if the amount of losses in developing countries caused by the various pests in the field and in storage are effectively reduced, there can be a significant improvement in food availability and security. In some years in Ethiopia, the average national annual crop losses due to pests reach 30-40% (1).

Given the severe damage pests cause to crops in Ethiopia, there is an urgent need for farmers to control pests to protect their crops. For farmers with access to information and purchasing power, the most common approach is chemical treatment or applications of pesticides. Once introduced into the environment, however, pesticides can accumulate in soil, surface and ground water, sediments, and the air, affecting plants and animals and then moving up the food chain and ultimately reaching humans. This behavior of pesticide residues in the environment illustrates the basic ecological intricacy and interactions among the organisms and their physical and biotic surroundings; it also demonstrates the tipping of the delicate balance by human interference.

Government policy on private investment and development of irrigated vegetable production by small-holder farmers has substantially increased the number of farms. Commercial flower farms, which require the use of different pesticides having different levels of persistence, are increasing at an alarming rate. The Ethiopian Rift Valley, for example, is one of the “hot spots” for big flower farms for numerous reasons, including the availability of adequate sources of water and abundant land, favorable climate, reliable road infrastructure with relatively close proximity to transport farm inputs and outputs, and cheap labor.

An Ethiopian pesticide production plant, Aadami-Tulu Pesticide Processing Share Company, started producing pesticides in 1997. The plant can produce up to 1,500 tons of pesticides in the form of liquid, water dispersal, and dust annually. Generally, six organophosphate and two organochlorine pesticides, including Malathion and DDT, have been produced in differing concentration levels. These pesticides have been used to control a variety of pests that attack maize, sorghum, teff, wheat, barley, pulses, vegetables and cotton, and for malaria mosquito control purposes. Even if DDT has been phased out from use as a result of the Stockholm Convention, the remaining pesticides in use are still unsolved problems in Ethiopia.

The production and importation of different pesticides and large-scale consumption of varieties of related products both by mega-hectare farms and small holders -- with little or no attention to the adverse effects of these products to public health, biodiversity, sensitive and fragile habitat and pristine environment -- is beginning to receive special attention in an effort to mitigate the problem.

In addition – and prior to -- the deep residual effects of pesticides, the negative impacts start from handling, transportation, preparation, and application in the field. The most widely disseminated prevention mechanism in these processes is the use of proper Personal Protective Equipment (PPEs). Most surveys conducted in Ethiopia and other regions of Africa, however, show that the use of PPEs is almost negligible because i) of the scarcity of PPEs in the market due to high importation taxes (e.g., 125% in Ethiopia), and ii) those applying pesticides find that the PPEs, which were not originally made for tropical regions, are problematic in the hot climate.

It is also advisable to note that those who apply pesticides generally have a low level of awareness about the negative impacts of pesticides on human health.

This review, therefore, attempts to assess available literature on pesticide- related occupational safety and health in small-holder farms and flower farms.

Health impacts of pesticides

According to Rotterdam Convention documents (www.pic.int) and other health related studies of pesticides, pesticide poisoning is classified as mild, moderate, and severe.

The symptoms of mild pesticide poisoning are headache, fatigue, skin irritation, loss of appetite, weakness, perspiration, eye irritation, thirst, and irritation of the nose and throat (2).

The symptoms of moderate poisoning include those mentioned above and trembling, excessive salivation, blurring of vision, chest pain, difficulty of breathing, flushed (yellow) skin, abdominal cramps, vomiting, mental confusion, twitching of muscles, weeping, excessive perspiration, profound weakness, rapid pulse, and persistent cough.

The symptoms of severe pesticide poisoning include the symptoms of mild and moderate poisoning plus severe stages of inability to breath, constriction of pupils, convulsion and secretion from the respiratory tract, fever, and death.

Pesticide impacts in small holder farmers

According to the studies conducted in the Ethiopian Rift Valley of small holder farmers, most farmers are not using PPEs, even during application of pesticides.

The survey of 422 farmers conducted by Amera and Abate in the Ethiopian central Rift Valley (3) found that in general 31.0% of the respondents always felt some discomfort and 9.0% (38) sometimes felt discomfort after pesticide application. After pesticide application, headache was reported by 25.8% of the farmers; 21.3% reported a feeling of nausea; 19.9% indicated vomiting; 10.2% indicated skin irritation; 9.7% indicated eye irritation; and 2.1% reported other health problems (Figure 1). Only 24.2%, however, knew that a channel for reporting negative health impacts of pesticide use was available and 18.2% indicated that the channel of pesticide reporting is the local agriculture office.

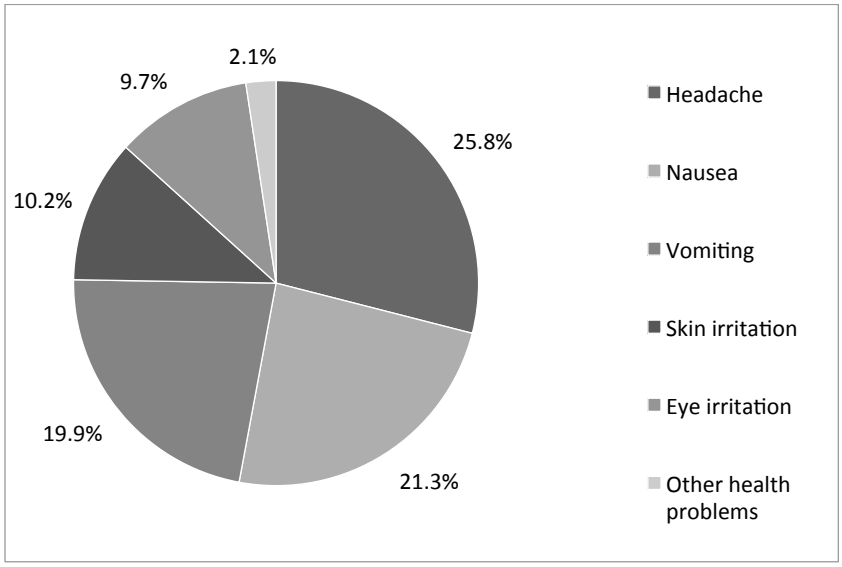

Figure 1: Impacts of applying pesticides on farmers' health in Ziway and Arsi Negele, 2007(3)

With regard to incidents of pesticide poisoning within families, 14.2% of the families in the study reported an occurrence, of which 10.2% of the total number of families were poisoned and recovered; 2.6% had long-term injuries, and 1.4% died because due to pesticide poisoning.

A 2008 comparative study of farmers in three districts around Arba Minch, found that 28.6% of those trained in Integrated Pest Management (IPM) techniques and 33.0% of untrained study participants experienced symptoms after pesticide application (Figure 2). The most common symptom for IPM trained farmers was headache (24.2%), while nausea was a common symptom for 30.8% of the untrained participants (4).

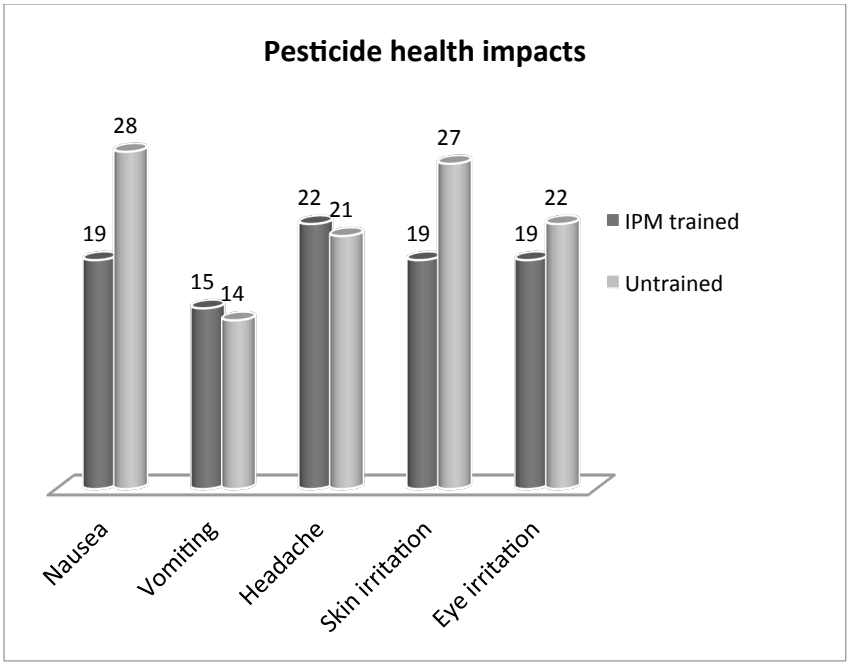

Fig. 2 Health problems reported by farmers after using pesticides in ArbaMinch Zuria , Mirab Abaya and Humbo, 2008 (4)

The study conducted by Amera in 2011 (unpublished) of vegetable- producing farmers in the Dugda and Dale districts also showed that 12.4% in Dale and 10.8% in Dugda ever felt mixed symptoms of mild, moderate, or severe poisoning after pesticide application. None of the poisoned farmers were using proper PPE when they applied pesticides and only 5 from each district went to health institutions for treatment.

Among the pesticide sprayers who were poisoned, 26% were fathers who applied pesticides in Dale and 24.4% were fathers who applied pesticides in Dugda. The main causes of pesticide poisoning were improper handling during preparation (48% in Dale and 11% in Duga or during application (48% in Dale and 66.7% in Dugda), and poor storage (4% in Dale and 15.5% in Dugda). Intentional suicide attempt was reported as the cause for 6.7% of the farmers in Dugda district.

When farmers were asked if they have heard of pesticide poisoning incidents in their communities, 34 respondents from each of the districts replied that they had heard of such incidents. Twenty-five respondents from each district reported that they knew people who were poisoned but recovered; 11.8% of farmers from Dugda indicated that they knew people who were poisoned but recovered with long term effects; and 26.5% from Dale and 14.7% from Dugda said that they knew people died from incidents of severe pesticide poisoning.

Suicide attempts using pesticides were anecdotally a common phenomenon during the time of survey, although the authors did not encounter anyone in the randomly selected households of the two districts who had attempted suicide. They did speak with families who lost husbands, sons, and daughters

because of suicide committed using pesticides, but family members were not able to provide the type of chemical used, what stages they passed through during poisoning, or the reasons for committing suicide. Families from both districts reported taking the victims to the nearest health institutions for treatment.

The assessment of health institutions in the two districts, however, indicated that the health professionals lack proper training on how to handle pesticide poisoning incidents. It is also noted that every pesticide poisoning incident was registered as merely caused by Malathion, rather than checking the container involved in the incident. Moreover, it was difficult to access separate records for pesticide poisoning incidents.

The following are selected cases of misuse of pesticides identified during the survey in 2011.

Case 1:

A family member informed one of the data collectors that a woman drank pesticide to commit suicide but the family member could not identify the pesticide. The family and neighbors tried to treat her by forcing the unconscious victim to drink a mix of milk and soil to induce vomiting, but it was unsuccessful. With the woman still unconscious the next day, they took her to the nearest health institution where the health workers were unable to assist the victim because of the length of time since the time of poisoning. The woman died on the fourth day.

Case 2:

A farmer in Dale bought Malathion to kill a hyena which ate his goat. The farmer attempted to kill the hyena for several days but was unsuccessful. When he noticed fleas and ticks on the neck of his cow, he used the Malathion to treat the cow, applying it bare-handed. The next day the family found the cow dead and the farmer unconscious. They took him to Yirgalem hospital where he received treatment for 15 days and was unable to farm for six months. A farmer in Dugda also applied Malathion to treat his cattle for fleas and ticks but two of his cattle licked the Malathion sprayed that was on their bodies and died. Once the farmer realized the danger, he continued to apply Malathion to the cattle but dusted their bodies with soil to deter licking.

Case 3:

A family in Dale bought Malathion for bedbug control, but also using it to treat head lice on a little girl by mixing it with raw butter. Just a few minutes after the application of the Malathion mixed with raw butter, the little girl began to weaken and finally became unconscious, although the family did not realize the relationship to the pesticide. Neighbors urged the family to take the girl to the nearest health post, where she received treatment and recovered after several days.

Pesticide storage and empty containers

The low level of pesticide risk perception among farmers was also reflected in storage practices. The preferred pesticide storage location for 76.7% of the farmers in Dale and 71.4% of the farmers in Dugda was the kitchen. Other locations in the house were also used for pesticide storage for 23.3% of farmers in Dale and 21% of farmers in Dugda.

Pesticide containers were found thrown in the fields and near water bodies. The farmers in Dale (56.4%) and Dugda (41.2%) also reported that they use pesticide containers for water and/or food storage.

Case 4:

Three children who were preparing food in the absence of their mother found pesticides in the house; they assumed the pesticide was a spice and applied it to the food. After eating the food, all the children became sick and the family took them to Yirgalem hospital where they received treatment and recovered.

Floriculture pesticide incidents

The conducting of OSH-related studies in greenhouses at flower farms is a sensitive issue. Most of the health-related cases involving pesticide use at flower farms have, therefore, been limited to evidence from studies in Kenya and Latin America, along with several interview-based surveys conducted in Ethiopia.

As the majority of the workers are young girls and their physiological nature makes them more vulnerable to pesticide poisoning, the interview-based surveys in some at the flower farms may not represent the reality.

The young girls employed at the flower farms are usually contracted as casual laborers, with no data on length of service in that sector and no mechanism to follow them for any immediate or long-term impacts of pesticide poisoning from work exposure. This, coupled with the limited knowledge of health professionals on dealing with pesticide-related health issues, complicates the handling of these cases.

According to a cross-sectional study conducted by Defar in West Shewa (5) 74.9% of the workers in the surveyed flower farms were females. The study reported no difference in the occurrence of health symptoms among the various sections of the farm, with 93% of study subjects showing at least one health symptom in the 12 months prior to the study period. In addition, 67.8% reported at least one skin problem and 81.1% had at least one respiratory health symptom in the prior 12 months. The most frequent OSH symptoms were fatigue (76.5%), headache (73.4%), and sleepiness (63.5%).

The code of conduct

The Ethiopian Horticulture Producers and Exporters Association Code of Practice (EHPEA) (6) is the result of an initiative to introduce a system of continuous professional and technical development, monitoring, and self-regulation in this sector. In developing the Code, the Association has considered:

- The industry's own need and responsibility to implement sustainable practices, provide suitable facilities and working conditions, protect farm employees, and safeguard the local environment and communities;

- The need to remain competitive and to protect and enhance the reputation of the Ethiopian flower sector in the international marketplace;

- The concerns of Ethiopian society and the international marketplace about the implementation of good agricultural practices, protection of the environment, and the welfare of employees.

The Code has been developed by a team comprised of EHPEA members and local stakeholders and guided by external expertise provided through the Ethiopia Netherlands Horticulture Partnership Program. The development process involved a number of activities carried out during 2006-2007, including:

- Analysis of existing market labels and codes relating to 'state of the art' sustainable flower production and to the market segments of particular interest to the Ethiopian flower producers;

- A review of current production practices and relevant Ethiopian legislation on sustainable management and employment issues;

- Consideration of experience relating to the design and implementation of Codes in other producer countries, including Kenya, Columbia, and Zambia;

- The scheduling of several farmer and stakeholder workshops to review and enrich the content, format, and method of implementing and managing the Code.

The resulting document explains how the Code is to be managed and standards are to be monitored, and provides clear guidelines for farmers on the standard that is required at each level of the Code. The content, structure, and level of the Code have been endorsed by the EHPEA membership and the local stakeholders involved in its development. A number of these local stakeholders from the public sector and from civil society have agreed to provide advice, guidance, and services that assist the Ethiopian flower producers and exporters in achieving compliance. Memoranda of understanding and agreements to cooperate have been made with these stakeholders.

Prior to finalizing the code of conduct and signing of the memoranda, civil society groups on the flower farms strongly advocated for more ethical and worker- oriented work environments. This movement from

the civil society groups and other citizens, however, declined after the signing of the memoranda, and as yet there has been no follow-up to determine if the agreement is implemented.

Summary

Exposures in agriculture workplaces

The need of productivity in agriculture requires the use of various types of chemicals, including pesticides for insects and other pests, and herbicides for weeds. The applications of such chemicals have effects not only on the sprayers, but the chemicals also tend to accumulate in the soil with further entry into the food chain. The use of personal protective equipment is widely advocated, despite the low compliance in practice. Symptoms such as nausea, headache, and skin and eye irritation are observed among workers who spray pesticides. Poor knowledge and awareness on the health-damaging effect of pesticides were factors for the incidences described above.

Floriculture is an emerging farming practice with a young workforce. Limited surveys conducted at flower farms indicate that symptoms such as skin irritation, respiratory symptoms, fatigue, headache, and sleepiness are found among workers in greenhouses and those who apply pesticides.

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Annexes for occupational safety and health

Annex 1: Currently employed population of urban areas aged 10 years and over by industrial divisions, 2010

Major industrial division	Total	% of the total	Male	Female	% of Males
Total employed population	4,798,467	100.00	2,739,770	2,058,697	57.1
Wholesale and retail trade	951,762	19.83	480,289	471,473	50.5
Manufacturing	644,165	13.42	370,304	273,861	57.5
Agriculture, hunting, forestry, and fishing	532,796	11.10	340,977	191,817	64.0
Hotels and restaurants	388,932	8.11	106,392	282,540	27.4
Other community, social and personal service activities	383,748	8.00	249,447	134,301	65.0
Public administration and defense	343,304	7.15	236,617	106,687	68.9
Education	325,976	6.79	192,242	133,734	59.0
Construction	322,546	6.72	267,024	55,522	82.8
Domestic work (private households)	244,835	5.10	23,614	221,221	9.6
Transport, storage and communications	233,027	4.86	213,521	19,506	91.6
Health and social work	148,670	3.10	71,463	77,207	48.1
Real estate, renting, and business activities	96,498	2.01	66,535	29,963	68.9
Financial intermediation	87,759	1.83	53,357	34,402	60.8
Electricity, gas and water supply	38,783	0.81	27,941	10,842	72.0
Extra territorial organizations	31,737	0.66	22,341	9,396	70.4
Mining and quarrying	20,081	0.42	16,019	4,062	79.8

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Annex 2 : Distribution of injury and its rate by year, 1993- 2004,
Federal Ministry of Labor and Social Affairs

S.R. No	Year in G.C	No. of Factories	No. of Workers	Non-Fatal	Fatal	Lost Days	Salary Paid	Injury rate Per 1000	Fatality rate Per 1000	Lost days Per 1000
1	1993/94	60	48,695	3,896	6	9,360	29,827	80.01	0.12	192.22
2	1994/95	80	66,094	5,236	6	13,146	122,770	79.22	0.09	198.90
3	1995/96	87	64,227	4,831	7	35,322	206,414	75.22	0.11	549.96
4	1996/97	112	60,164	3,998	14	40,990	128,988	66.45	0.23	681.30
5	1997/98	129	64,247	5,288	13	13,260	167,659	82.31	0.20	206.39
6	1998/99	98	59,391	4,417	11	14,105	317,164	74.37	0.19	237.49
7	99/2000	94	57,230	4,115	12	14,669	200,014	71.90	0.21	256.32
8	2000/01	103	65,073	4,119	8	14,253	213,151	63.30	0.12	219.03
9	2001/02	105	62,183	4,740	14	18,352		76.23	0.23	295.13
10	2002/03	29	16,122	1,269	3	3,583	56,297	78.71	0.19	222.24
11	2003/04	72	47,072	2,994	7	10,453	181,596	63.60	0.15	222.06
	Total	**969**	**610,498**	**44,903**	**101**	**187,493**	**1,623,880**	**73.55**	**0.17**	**307.11**

Source: Ministry of Labor and Social Affairs. Occupational Safety and Health profile for Ethiopia. October 2006.

Annex 3: Accident notification form for enterprises

1. Name of enterprise_____
2. Address: Region _____ Sub city _____ Kebele _____ T.No _____ P.0 Box
3. No. of workers: Male _____ Female _____ Total _____

No.	Full Name of Injured worker	Injured person						Accident		Work location	What was the injured person doing at the time of accident?	Remark
		Age	Sex	Level of education	Salary		Profession	Day	Time			
					Birr	Cent						

Cause of accident	Injured body part	Type of accident	Response taken to avoid accident recurrence	Total sick leave days	Lost time in term of money	
					Birr	Cent

Annex 4: Cost of accident by industrial code

Ind code	No of organization	Total number of works			Non-fatal Accident			Fatal accidents	Total injured persons			Total sick leave days
		Male	Female	Total	With sick leave	Without sick leave	Total		Male	Female	Total	
01												
02												
03												
04												
05												
06												
07												
08												
09												
Total												

Annex 5: Type of Accident by industry code

Name of Region _____

Coverage of the Report _____

Industrial code	Type of accident												
	Abrasion	Burn	Cut	Puncture	Wound	Sprain	Fracture	Dislocation	Eye injury	Drowning	Death	Other	Total
01													
02													
03													
04													
05													
06													
07													
08													
09													
Total													

Annex 6: Cause of accident by industrial code

Industrial code	Machine	Electric	Hand tools	Fire and Explosion	Acid	Slippery floor	Side	Splinter	Collision	Mishandling	Falling objects	Transport	Animals	Mistakes	Other
01															
02															
03															
04															
05															
06															
07															
08															
09															
Total															

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Annex 7: Location of injury to the body by industrial code

Industrial code	Location of injury							
	Head			Upper body	Middle body	Lower body	Other	Total
	Eye	Ear	other					
01								
02								
03								
04								
05								
06								
07								
08								
09								
Total								

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Annex 8: Companies contacted for the description of OSH services at the factory level

1. Berhanna Selam Printing Press
2. Awash Winery
3. Artistic Printing Press
4. Yrgalem Addis Textile Factory PLC
5. Kaliti Metal Tool Products Factory
6. Awash Tannery
7. Kaliti Metal Tools Factory

Annex 9: SANA-GEOHealth: A checklist for OSH services at the factory level

Name of Undertaking: _____; Date: _____

SN	Item	Description/ findings
1	**Existing OSH policy, guideline** Probe: presence of any guideline, stakeholder's	

	guideline	
2	**Describing OSH Services:** Probe definition? Probe: training, education, awareness creation, inspection, control, haz evaluation, HIV prevention, FP	
3	**OSH service Organization** Probe: OSH Committee, Clinics	
4	**Engagement of bi-party and tri-party interventions?** Probe what areas? Concerns? Effectiveness? Efficiency?	
5	**Role of insurance company?** Probe involvement in compensation? Medical assistance?	
6	**Labor inspection/ inspector** Probe capacity? Frequency of inspection? Link with OSH services? Adequateness of inspection? Suggesting independent company that does inspection or OSH advice?	
7	**OSH Committee** Probe: members? Activity? Work schedule?	
8	**Cleaner production?** Probe activities related with cleaner production? Waste management? Air pollution mgmt.?	

Section III

Situational Analysis and Needs Assessment:

CLIMATE CHANGE AND HEALTH IN ETHIOPIA

Establishing a GEOHealth Hub for East Africa

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Summary

Background

Climate change is recognized to have a potentially severe impact on public health in the African Region, especially East Africa. Ethiopia has been identified as one of the countries vulnerable to the effects of climate change, primarily due to population pressure, poverty, a fragile ecosystem, and the country's reliance on a climate-sensitive economy. Climate change-related health problems, such as mortality and morbidity due to floods and heat waves, vector-borne diseases, water-borne diseases, meningitis, and air pollution-related respiratory diseases are increasing. Efforts to mitigate and adapt to the impacts of climate change are being undertaken by various sectors but are lacking coordination. Moreover, there have been limited trained personnel, laboratories and other facilities to support climate-related research. Taking these facts into consideration, the aim of the Situational Analysis and Needs Assessment (SANA) on climate change and health was to assess the country's existing situation on issues related to the environment, climate change, and occupational health, and to identify gaps and needs for which research, training, and capacity-building projects can be developed in Ethiopia and other East African countries.

Methods

This SANA assessment was carried outby conducting a comprehensive review of available secondary data and interviewing key informants in various national organizations involved in climate change adaptation and mitigation activities. Published documents were searched using select online keywords, while secondary data from hard copies of various policy and program documents were extracted. Semi-structured questions (checklists) were used to interview key informants in various organizations who were responsible for managing and overseeing the climate-related activities.

Findings

Information obtained both in the situational analysis and needs assessment revealed that climate change currently represents one of the greatest development challenges in Ethiopia. Sensitive systems such as agriculture, health, and water have been affected, and the effects of climate change will continue to magnify without the right adaptation and mitigation measures. The current stage of research on climate change and health is rudimentary; research findings and other activities tend to appear largely fragmented and uncoordinated. As a result, there are few spatially detailed, methodologically consistent climate impact studies available for the country.

In Ethiopia, there have been repeated drought, floods, malnutrition, extreme temperature events (extreme heat and cold), and re-emergence of climate-sensitive diseases. Increased environmental survival of pathogens and creation of new ecological niches for vectors to propagate diseases are also observed. While the impact of climate change on health and other related issues is recognized by various governmental stakeholders, the specific actions and responses have little oversight.

This assessment identified the existence of poor collaboration between different organizations on planning and executing activities related to climate change and health, and a lack of trained professionals who can independently perform climate change and health-related research and activities at various levels. The SANA also revealed a lack of well-organized structure in the various organizations and poor inter-sectoral collaboration; poor coordination and communication among different stakeholders; lack of policies and programs that independently target climate change and health; inability of the existing policies to consider the gender and community dimensions of climate change; and weak monitoring and evaluation efforts on climate change and health activities at various organizations.

Conclusion

With the understanding of the current status, we suggest that additional and well-targeted efforts need to be in place to halt the current weak multidimensional climate change induced problems through organized community, professional, and organizational collaboration and networking.

Acronyms and Abbreviations

AAU	Addis Ababa University
ACCRA	African Climate Change Resilience Alliance
APP	Adaptation Program Plan
AWD	Acute Watery Diarrhea
CCF	Climate Change Forum
CFR	Case Fatality Rate
CGE	Computable General Equilibrium
CO_2	Carbon Dioxide
CRGE	Climate Resilient Green Economy
CRGEvision	Climate Resilient Green Economy Vision
CSA	Central Statistical Agency
CSE	Conservation Strategy of Ethiopia
DDAEPA	DreDawa Administration Environmental Protection Agency
DRMFSS	Disaster Reduction Management Food Security Sector
EC	Environment Council
ECPA	Ethiopian Consumers Protection Association
EDHS	Ethiopian Demographic and Health Survey
EDRI	Ethiopian Development Research Institute
EIAR	Ethiopian Institute of Agricultural Research

EPACC	Ethiopian Program of Adaptation to Climate Change
EPE	The Environment Policies of Ethiopia
EPA	Environmental Protection Authority (Ethiopia)
FDRE	Federal Democratic Republic of Ethiopia
FfE	Forum for Environment
FMOH	Federal Ministry of Health
GCM	Global Climate Models
GDP	Gross Domestic Product
GEOHealth	Global Environmental and Occupational Health
GoE	Government of Ethiopia
GTP	Growth and Transformation Plan
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
LDC	Less developed countries
LEAP software	Livelihoods, Early Assessment and Protection' software platform
MDG	Millennium Development Goals
MIS	Management Information System
MOA	Ministry of Agriculture
MOWE	Ministry of Water and Energy
NAMAs	Nationally Appropriate Mitigation Actions
NAPA	National Adaptation Programs of Action
NAWDPC	National Acute Watery Diarrhea Prevention and Control
NGOs	Non Governmental Organizations
NMA	National Meteorology Agency
PASDEP	Plan for Accelerated and Sustainable Development to End Poverty
PSNP	Productive Safety Net Programme
RDPS	Agricultural and Rural Development Policy Strategies
SANA	Situation Analysis and Need Assessment
SLMP	Sustainable Land Management Program
UNDP	United Nations Development Program
UNFCCC	United Nation Framework Convention on Climate Change
WB	World Bank
WFP	World Food Program
WHO	World Health Organization

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Introduction

Climate change and health

The global climate is changing due to the carbon-intensive paths of development that have been pursued by high-resource countries since the beginning of the industrial revolution. During the past century, the size of the human population and its impact on the environment have increased dramatically. The emission of greenhouse gases, especially the release of carbon dioxide (CO_2) into the lower atmosphere, have increased from a pre-industrial value of about 280 ppm to 400 ppm in 2010 (1). The concentration of CO_2 in the atmosphere has increased by nearly 30% and most of the CO_2 released each year has been contributed disproportionately by the United States, Canada, Australia, the countries of Europe, and, more recently, China (1).

During the last century, the world's average surface temperature increased by approximately 0.8ºC, and about two-thirds of that warming has occurred since the 1970s (2, 3). The Third Assessment Report (4) of the Intergovernmental Panel on Climate Change (IPCC) projected an increase ranging from 1.4 to 5.8°C in average world surface temperature over the course of the twenty-first century, absent effective intervention. Accumulation of greenhouse gases such as CO_2 in the lower atmosphere has contributed to the recent uptrend in world average temperature. The IPCC report also revealed that most of the warming observed over the last 50 years is attributable to human activities.

Climate change and health in Ethiopia

Climate change has been recognized as having a severe impact on public health in the African Region. Despite their insignificant contributions to the emissions of CO_2, countries in Africa including Ethiopia are disproportionately affected by the harmful effects of climate change. The African ecosystem is further characterized by poor physical infrastructure, fragile environments, dominance of climate-sensitive industries such as horticulture, and low adaptive capacity to climate change (4) The impacts of climate change usually occur as a result of anomalies in temperature and rainfall. The major health effects include under-nutrition due to variability in agricultural production and food security; increasing incidence of climate sensitive diseases such as malaria, meningitis, and diarrhea; and other adverse health impacts due to scarcity of water and natural disasters such as floods and droughts.

Climate change is of critical importance to Africa and in particular Ethiopia. Human-induced climate change will bring further warming over the next century at unprecedented rates. Climate models suggest that Ethiopia will see further warming in all seasons between 0.7°C and 2.3°C by the 2020s and between 1.4°C and 2.9°C by the 2050s (5), Ethiopia has a total population of 74 million (6)(CSA 2007) that grows annually by 2.6% and is expected to more than double by 2050. Agriculture is the backbone of the country's economy, engaging more than 85% of the total population. The country is extremely vulnerable to the impacts of climate change, which could potentially hold back economic progress or reverse the gains made in development and thus exacerbate social and economic challenges.

Ethiopia has been identified as one of the countries in the world most vulnerable to the adverse effects of climate change (4). The country's vulnerability to climate change is further increased by high levels of

poverty, rapid population growth, reliance on rain-fed agriculture, high levels of environmental degradation, chronic food insecurity, frequent natural drought cycles, poor infrastructure in drought-stricken areas, and low adaptive capacity. Recurrent droughts and floods have resulted in loss of life and property as well as displacement of people. Drought frequency is predicted to increase, placing stress on already vulnerable food production systems. Climate change is expected to bring fiercer competition for water and other resources.

Climate-Resilient Green Economy

In view of this vulnerability and its consequences, Ethiopia has committed to building a Climate-Resilient Green Economy (CRGE) to ensure economic development that pursues a low-emissions path while building resilience to climate change (7). The Government of Ethiopia (GoE) has recognized the need to capitalize on opportunities created by climate change to realize these goals through partnerships with international institutions. Thus, the GoE's green economy strategy targets seizing the financial opportunities and sustainability co-benefits of low emissions development, while its climate-resilient development strategy focuses on managing risk and building resilience to shocks through sequenced measures (7).

The aim of the Global Environmental and Occupational Health (GEOHealth) Situational Analysis and Needs Assessment (SANA) project in Ethiopia is to evaluate the country's existing situation in issues related to the environment, climate change, and occupational health, and to identify gaps and needs for which research, training, and capacity building projects can be developed in Ethiopia and other East African countries.

Methods

Before the commencement of information gathering from various sources, the AAU based Principal Investigator and other senior co-investigators provided an orientation to team members who were selected to assist in project research. Keywords for literature reviews and semi-structured questions were prepared and agreed upon among the AAU and USC based investigators.

An extensive literature search of published documents with a focus on Ethiopia was conducted online using keywords such as 'impact of climate change', 'health', 'economy', 'water-borne disease', and 'vector-borne disease'. In addition, relevant policy and program documents published in hardcopy by various key stakeholders were reviewed.

Semi-structured questions (checklists) were used to interview key informants who were responsible for managing and overseeing climate-related activities in various organizations including the MOWE, MOH, MOH-PHEM, MOA, MOA-DRMFSS, and NMA. This step was taken to obtain primary data aimed at understanding the gaps and needs of each institution with regard to climate change and health-related capacity.

Assessment Findings: Situational analysis on Climate Change and Health

The state of climate in Ethiopia

Ethiopia's First National Communication (8)analyzed historical temperature and precipitation data from 1961 to 1990, and identified high spatial and temporal variability: a more or less constant average annual precipitation at the national scale, but with declining trends in the northern areas and increasing trends in the central parts of the country. The study also found that Ethiopia has experienced both dry and wet years and a warming trend in temperature over the last 50 years.

Rainfall variability

In addition to high inter-annual rainfall variability in Ethiopia, some researchers have reported that rainfall has recently exhibited a downward trend in parts of the country. This situation, however, is non-uniform and varies by the region or period of time used for analysis. For example, FEWS (9) reported a significant decreasing trend of rainfall during the rainy season (*Kiremt*) in the southwestern highlands of the country for the period 1961-1996. Conway (2000) reported absence of any long-term trend for annual rainfall in the northern and north-eastern parts of the country. Conway and colleagues (10) analyzed the 104-year rainfall record of Addis Ababa in the central Ethiopian highlands and found no upward or downward trend over the period 1898-2002. This pattern was supported by (11) who found no significant trend in the annual and seasonal rainfall totals in the central, northern, and north-western parts of the country over the period 1965-2002. Seleshi and Zanke (2004)(11), however, did find significant declines in the annual and kiremt rainfall totals in the eastern, southern, and southwestern parts of Ethiopia. Meze-Hausken (12) also reported absence of a declining trend in rainfall in the northern and north-eastern areas of Ethiopia, despite local people's perceptions that the total rainfall had decreased over the past 25-30 years because of the loss of spring rains (March-May, belg) and a shortened kiremt. Bewket and Conway (13)analyzed rainfall in the Amhara region and found that during the 1990s it had recovered from a dry phase in the 1980s, although rainfall levels in 2001-2003 were average or slightly lower than average. Rainfall in the central and northern highlands has recovered substantially since the 1980s, with intermittent dry years.

A detailed study of Ethiopian rainfall trends by Funk et al. (14) identified some notable features, as summarized in Figure 1.

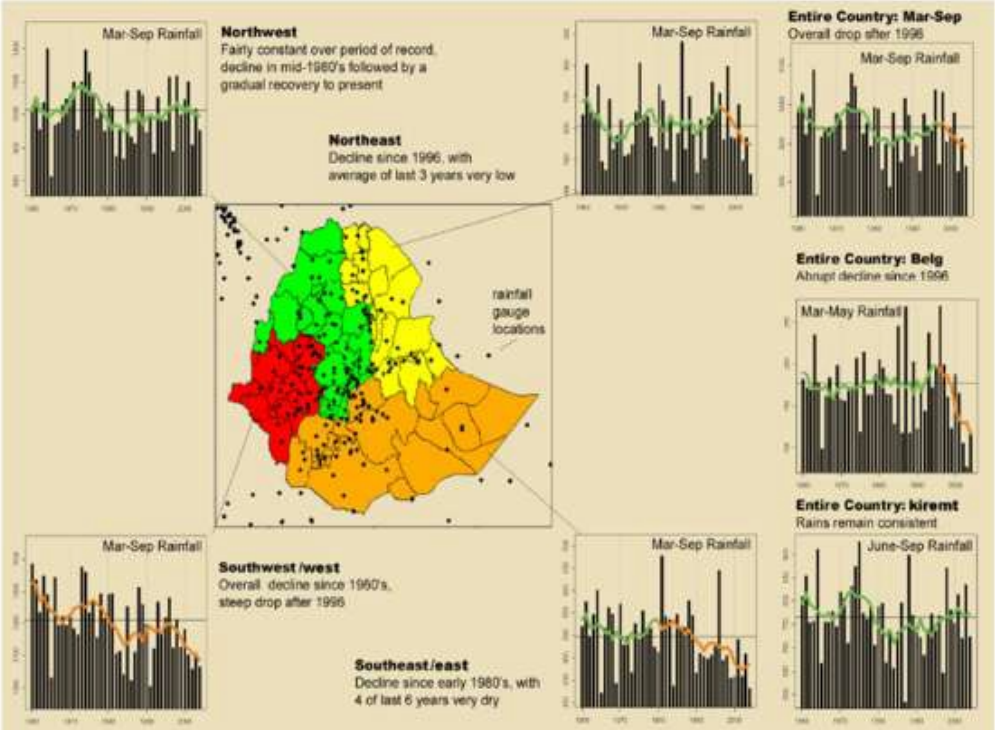

Figure 1: Time series of March-September rainfall at a national scale (right column) and for four regions (left and center). Black bars show seasonal rainfall. Heavy colored lines show running 7-year means. Colors have been added to describe long-term variation patterns. Orange lines denote rainfall tendencies likely to increase food insecurity. Source: (14)

Multiple sources of evidence converge on a post-1997 tendency towards lower rainfall, especially during the Belg (March-May) season. This finding appears to hold for many parts of eastern Africa'…'Positive temperature anomalies in the southwestern Indian Ocean may increase oceanic precipitation and decrease rainfall over eastern Africa, especially during March-May. If rapid warming (about 1°C in the last 50 years) of the Indian Ocean is related to reduced rainfall over eastern and southern Africa, then continuing rainfall deficits may be likely(14).

Changes in the frequency of extreme events

Ethiopia has been experiencing climate extremes, such as droughts and floods, increasing temperature, and erratic rainfall (15). Studies show that the frequency and magnitude of droughts has increased over the past few decades, especially in the lowland areas of the country (16). Drought occurrences are becoming endemic to Ethiopia (Figure 2) and are severely affecting the livelihoods of millions of people. According to the 2010 World Bank report, Ethiopia has been affected by frequent severe droughts since the early 1980s—five of which have led to famines—in addition to dozens of local droughts (17). Severe droughts resulted in the drying of water sources, leading to serious water shortages, especially in the lowland ecosystems of Diredawa. This compromised personal hygiene resulting in escalated faeco-oral transmission of diseases (18).

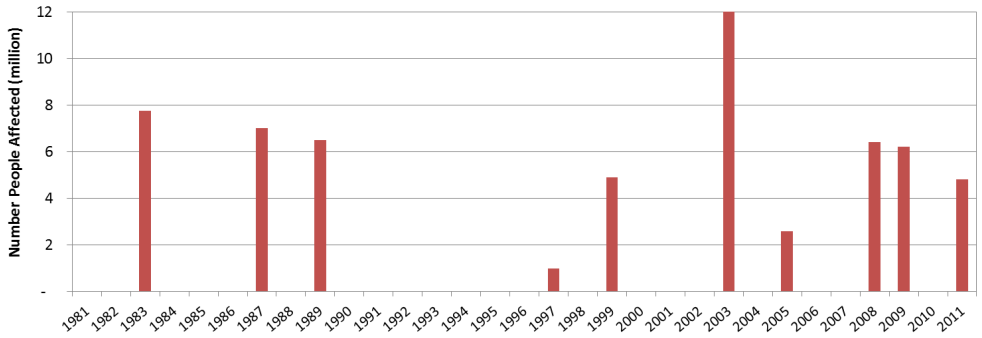

Figure 2: Drought occurrences in Ethiopia for the period 1981 to 2011

(Source: EM-DAT: The OFDA/CRED International Disaster Database, www.emdat.be –Université Catholique de Louvain - Brussels - Belgium. Accessed May 19, 2010 (19).

Many areas of the country are prone to flooding, which is the second most important natural disaster; its increasing occurrence adds more stress to local governments' spending and increases the vulnerability of households in Ethiopia (Figure 3). The major floods that occurred in 1988, between 1993-1996, and in 2006 resulted in considerable loss of life and property (15).

A recent study by Abaya and colleagues assessed the flood risks and health-related issues in the Gambella region of the country. This study identified three critically important weaknesses including lack of flood-specific policy, absence of risk assessment, and weak institutional capacity(20). The 2008 Gambella flooding was one example of the increased frequency and magnitude of flooding in other parts of the country over the past decade. Nevertheless, the floods in Gambella were attributed to land-use changes (deforestation and over cultivation) as well as climate change. The presence of rivers such as Baro, Akobo, Gilo, and Alwero and low lying homogeneous topography were also contributing factors to the floods in the area.

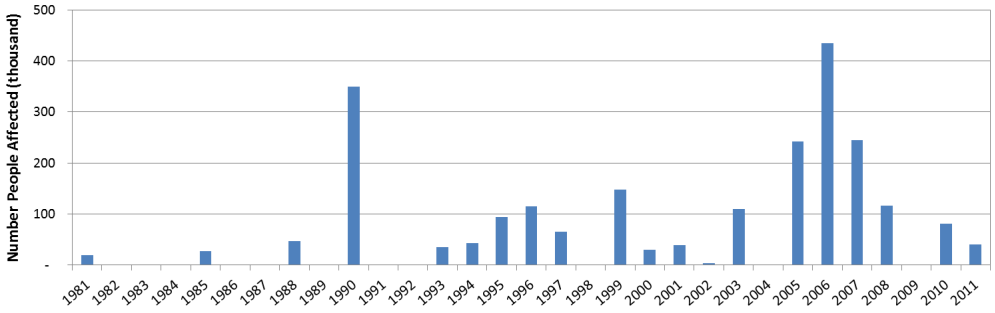

Figure 3: Flood occurrences in Ethiopia for the period 1995 to 2007

(Source: EM-DAT: The OFDA/CRED International Disaster Database, www.emdat.be –Université Catholique de Louvain - Brussels - Belgium. Accessed May 19, 2010 (19).

In the Afar region, climate-related risks such as drought and floods have always posed problems to human health. The region has one of the highest child mortality rates in the country, and the number of people suffering due to heat waves has been rising (21). The problem is aggravated by the inadequacy of medical facilities and qualified and trained local personnel (21).

Another report indicated that drought, erratic rainfall, animal diseases, shortage of water, and human diseases induced by climate change were the major hazards in Chifra wereda of the Afar Region (22). Trends are evident not only for increasing temperatures and declining short rains, but also for population growth, rangeland degradation, significantly decreased herd size per household, increase in basic infrastructure and incentives for settlement (22). The same report also found that there have been increasing temperatures, shortening rainfall, population growth, deforestation, shrinking plot sizes, and decreased availability of grazing land in the Gemechis district of Oromia Region (22).

In the Borana and Somali communities of Ethiopia, increased human health problems are already present due to high temperatures, increased dust from stronger winds over barren lands, and drinking water scarcity. Most of the natural, financial, human, and social resources on which Borana and Shinile communities depend are already significantly affected by climate-related hazards (23). Higher temperatures and increased rainfall intensity may lead to flash floods that result in more water-borne diseases in Borana, while hotter and dryer seasons in Shinile could change the distribution, range, prevalence, incidence, and seasonality of sanitation-related and vector-transmitted diseases (23).

Floods also damage crops and inundate farmland, resulting in food shortages that may lead to malnutrition. For instance, the 2006 flood in the Gambella region caused damage to 1,650 ha of maize crops (20). According to local reports, production was reduced by 20%, mainly due to waterlogging on the farmlands. Most people affected by this flood were very poor and were considered highly vulnerable with regard to food security. Though it is difficult to relate flooding to nutritional status without comparison to prior surveys, it is very likely that shortages of food caused by flooding exacerbate existing malnutrition in the country.

Local experiences of climate variability and change

Some published studies reported that Ethiopians have perceived changes in local climatic conditions. For example, a survey of 1000 households in the Blue Nile Basin found roughly 68% of respondents perceived an increase in mean temperature during the last 20 years, with just 4% reporting a perceived decrease and 28% reporting unchanged temperature (24). For mean annual rainfall, 18% of respondents perceived an increase, 62% a decrease, and 20% no change. Roughly 58% and 42% of people had not adopted adaptation measures in response to long-term shifts in temperature and precipitation, respectively. Reasons for lack of adoption included lack of information (main reason), as well as shortages of labor, land, and money (24).

Village surveys conducted for a World Bank study on cost of adaptation noted that in several focus group discussions, participants indicated that the quantity and periodicity of rainfall had changed over

the past decades (25). Experiences varied between the highland, midland, and lowland areas. The spring (belg) rains were noted to be almost disappearing from the highlands, especially during the previous five years, and the report quoted one highlander as saying: "*Before, we used to produce twice during the year but these days we are not seeing belg rains regularly; and the quantity of kiremt rains that we are getting in the past five years does not even amount to the belg rains that we used to get like ten years ago'.* Farmers from the midland and lowland areas indicated that they had been affected by lower rainfall and higher variability at the onset of the rainy season. In all areas, the start and finish of the rainy seasons were found to be more irregular (25).

Climate model projections for Ethiopia

Global climate models (GCM) provide the most reliable sources of information on the characteristics of future climate change. The results of GCM experiments to simulate future response of the climate system to increasing concentration of greenhouse gases globally are generally referred to as scenarios. Scenarios often comprise changes in temperature, rainfall, some other climate variables, and limited information about changes in extremes. It is important to present results from several GCMs to account for the range of possible changes that could occur due to differences in the rate of emissions of greenhouse gases and differences between GCM simulations of the behavior of the climate system.

McSweeney et al. (26), using 15 GCMs (an 'ensemble'), averaged them to provide a guide to the overall direction of changes across all models, while values from the warmest/coolest and wettest/driest models were used to illustrate the range of uncertainty in the scenarios. The study concluded that all scenarios showed continued warming throughout Ethiopia accompanied by complex patterns of rainfall change, with considerable differences between GCMs. Higher rates of emissions produce faster rates of warming, while the warming itself is associated with greater frequency of heat wave events. Higher temperatures are likely to lead to higher rates of evaporation and, assuming other influences remain unchanged, higher rates of surface water evaporation and higher soil moisture deficits.

The magnitude (and trend) of climate-sensitive diseases

According to the Ethiopian Climate Resilient Green Economy document (7), the health impacts of climate change will be apparent in six mechanisms:

- morbidity and mortality through temperature extremes;
- increases in vector-borne diseases, such as malaria and bilharzia;
- increases in non-vector-borne diseases related to weather conditions (for example, diarrheal disease and cholera associated with both floods and drought);
- health problems associated with weather-related air quality;
- injury and mortality through floods and storms;
- impacts of climate-related influences on food and water supply (for example, malnutrition).

According to an estimate by McMichael and colleagues, about 36,000 lives were lost each year across Eastern Africa (including Ethiopia) because of climate change (27). The 4th IPCC report calculates that

the greatest future health risks associated with climate change in 2030 will be flooding, followed by malaria, diarrheal disease, malnutrition, and cardiovascular diseases (2)

Vector-borne diseases

Changes in climate are likely to lengthen the transmission period of major vector-borne diseases and to alter their geographic range. Studies have suggested that climate change could expose an additional 2 billion people to dengue transmission by the 2080s (28). Climate change is projected to significantly widen the area where the snail-borne disease schistosomiasis occurs (29). The 4th report of the IPCC stated that by the 2050s malaria will have entered into the highland areas of Ethiopia and that by 2080 conditions will be highly suitable for malaria transmission (2).

The National Adaptation Programs of Action (NAPA) also reported that climate change is projected to cause encroachment of malaria from lower altitudes in the Somalia and Afar regions to higher altitudes in Tigray and Amhara (15). In 1990 it was estimated that 6,508, 530 people, in areas of Ethiopia where the climate is more than 75% suitable for proliferation of malaria-transmitting mosquitoes, were at risk for endemic malaria. Several reports found that an increase in global mean temperature has created conducive ecological conditions for vector breeding and spreading of vector-borne diseases such as malaria. Limited research currently available on Ethiopia indicated that a positive association exists between climatic variability and infectious diseases such as malaria. Malaria is seasonal and unstable in Ethiopia, with the peak malaria transmission season ranging from September to December and coinciding with the major crop-harvesting season; thus, economic losses could be aggravated. Malaria is the top leading cause of outpatient visits, accounting for 12% of the total outpatient morbidity in 2007-2008 (30). It poses a significant economic burden on rural households and individuals both through increased out-of-pocket payments and person-days lost (31).

Using parasite survey data in conjunction with one climate model, Tanser and colleagues (32) estimated a 5-7% potential increase (mainly altitudinal) in malaria distribution. They also found that malaria-free highland areas in Ethiopia, Kenya, Rwanda, and Burundi could experience modest changes to malarial conditions by the 2050s, with conditions for transmission becoming highly suitable by the 2080s.

The 2007 MIS report estimated that parasite prevalence in Ethiopia as measured by microscopy was 0.7% and 0.3%, for *P.falciparum* and *P.vivax,* respectively, in regions below 2,000 meters altitude. The MIS 2011 draft report showed that 1.3% of children under age of 5 years tested positive for malaria using microscopy and 4.5% tested positive using rapid diagnostic tests. *P. falciparum* accounted for 77% of these infections. The 2011 MIS survey demonstrated a remarkable demarcation of malaria risk at an altitude of 2,000 meters, with thirteen-fold higher malaria prevalence at lower altitudes compared to higher elevations. Essentially no *P. falciparum* was detected by microscopy among persons surveyed within households with measured elevations above 2,000 meters in the MIS 2011 report (33).

According to the World Health Organization, 68% of Ethiopians are already living in areas at risk for malaria, where transmission is unstable and characterized by large-scale epidemics (17). For example, in 2003 large-scale epidemics resulted in 2 million confirmed malaria cases and 3000 deaths.

Based on an analysis using malaria morbidity data from the late 1980s until the early 1990s from 50 sites across Ethiopia, malaria epidemics were associated with high minimum temperatures in the preceding months(34). A more recent study in Jimma found that during the previous ten years (2000-2009), a fluctuating trend of malaria transmission was observed, with *P. vivax* becoming the predominant species (35). Monthly minimum and maximum temperatures and monthly total rainfall, at one month lagged effect, were significant meteorological factors for transmission of malaria in the study area (35).

A study in southern Ethiopia showed that *P. falciparum* malaria incidence models were linked to meteorological data while the observed variability in the models was principally attributed to regional differences, and no single model was found to fit all locations (36).

The 2010 WHO Ethiopia Country office reported that due to population movement, immune suppression (due to HIV/AIDS, malnutrition, etc.), and climate changes, the Leishmaniasis disease was observed to have spread to new localities in Ethiopia over the previous 5 years, including Libo and Fogera in Amhara, Tahtay Adiabo in Tigray, and Imey in Somali regional states (37).

A study in Boricha, Sidama found a positive association between malaria incidence and temperature in March, May, and the months between July and October; and between malaria incidence and rainfall fromJanuary to April and in the months of September and November. There was also a pattern of dramatic decrease and increase in malaria cases before and after the peak rainy season in May, respectively (38).

Climate change-induced malaria has also been reported in the Afar region (21). In South Omo, the rate of flooding has also increased and a large area has come under permanent flooding, triggering the infestation of bush and mosquitoes (malaria) (39).

Soil-transmitted Helminthiases (STHs) STOPPED HERE

After malaria, soil-transmitted helminthiases (STHs) account for the highest burden of parasitic disease worldwide (40). Most of Ethiopia already has conditions suitable for the transmission of STHs, and as a result the country has the third largest hookworm-infested population in sub-Saharan Africa, the second largest population infected with ascariasis, and the fourth largest population infected with Trichuriasis (41). A large number of those affected are children. These parasites can cause abdominal pain, gastrointestinal problems, and anemia, and can also hinder growth in children (42). In addition, these parasites can increase the risk of other diseases, including HIV/AIDS, malaria and tuberculosis (40).

Because STHs require specific climatic conditions to thrive, climate change could have a significant influence on their abundance and distribution. Soil temperature, humidity, and precipitation all effect the

biological development of the STHs. Weaver at al. described STHs' fluctuations around endemic areas as well as transmission to new regions (40).

Water-borne diseases in general

Increasingly variable rainfall patterns are likely to affect the supply of fresh water. Lack of safe water can compromise hygiene and increase the risk of diarrheal disease, which kills 2.2 million people every year globally. In extreme cases, water scarcity leads to drought and famine. By the 2090s, climate change is likely to widen the area affected by drought, double the frequency of extreme droughts, and increase their average duration six-fold (43). Floods are also increasing in frequency and intensity. Floods contaminate freshwater supplies, heighten the risk of water-borne diseases, and create breeding grounds for disease-carrying insects such as mosquitoes. They also cause drowning and physical injuries, damage homes, and disrupt the supply of medical and health services (44).

Numerous researchers found that temperature, precipitation, and humidity have been among the most important determinants for diarrheal disease in different parts of the world (45-48)Increased ambient temperatures are often correlated with waterborne disease outbreaks (46, 49). Pathogens that cause water-borne diseases are generally temperature-dependent, whereby rising water temperatures result in increased growth of bacteria in water (50), leading to increased rates of diarrheal diseases (51).

Climate change-induced flooding results in the disruption of drinking water sources and pollution, leading to outbreaks of water-borne diseases, especially diarrhea (52). Floods transport pathogens into drinking water sources, increasing the risk of exposure to these water-borne pathogens. Seasonal variation of water quality has been described in various studies (52, 53) and the concentration of parasites was found to be significantly higher in water samples taken following heavy rainfall (54).

In another context, declining rainfall and accelerated evaporation may reduce runoff, threatening the availability of fresh water for human and industrial consumption. Drought conditions can concentrate contaminants in smaller volumes of water and affect hygiene practices that control the spread of infectious diseases (55). The decrease in rainfall amount will be exacerbated by higher evaporation rates associated with increasing temperatures (55). In several studies, maximum temperature and extreme rainfall days were strongly related to diarrhea-associated morbidity(56, 57). A strong association was also observed between daily mean temperature and precipitation with the incidence of hospitalization due to acute diarrhea in Thailand, resulting in a distinct spatial pattern in the seasonal pattern of diarrhea in that country (58). The impact of these changes has been significant among children (59, 60).

Water-borne diseases in Ethiopia

Few studies have examined the association between climate change and water-borne disease at the local level in Ethiopia. However, the available reports indicate possible linkage. Based on the recent EDHS, diarrhea has been most common among children age 6–23 months, and the prevalence was highest among children residing in households that drink from unprotected wells and those residing in

rural areas (EDHS, 2011). Thirteen percent of children under age five years were reported to have had diarrhea, and 3 percent had diarrhea with blood in the two-week period before the survey. Moreover, the prevalence of diarrhea varies seasonally (EDHS, 2011). An epidemic of cholera following extreme floods in 2006 led to widespread illness and loss of life (61).

There have been reports from nine regions and two city administrations of acute watery diarrhea (AWD) from some affected areas of Ethiopia since April 2006 at different times. In 2006, a total of 51,201 cases and 558 deaths (CFR 1.1%) were reported from 146 woredas in 8 regions. The outbreak continued in 2007 and affected 317 woredas in all regions and city administrations. During this period, 49,511 cases and 775 deaths (CFR 1.3%) were reported. Similarly, in 2008 and 2009 a total of 3,870 cases and 23 deaths (0.6%), and 31,509 cases and 434 deaths (1.38%) were reported from 55 and 130 woredas, respectively. These outbreaks were linked to lack of basic sanitation and safe water supply in the locality of investment farms and religious gathering places, as well as to the high sensitivity of diarrheal pathogens to variations in climatic variability (62).In addition, prevention and treatment strategies for water-borne disease are not well established and therefore, climate change is likely to greatly impact the already poor efficacy of the strategies (63).

The FMoH understands that AWD is not only a health problem but also a challenge to overall development. This burden is further exacerbated by an unclean water supply, inadequate sanitation, and poor hygiene practices of many. However, the response to this burden was unsatisfactory because of the lack of a control strategy(62).

With this understanding the FMoH has developed the AWD Prevention and Control Strategy, with the goal of an AWD-free Ethiopia by the end of 2015. The general objective of the program is twofold: 1) to prevent and control AWD occurrence through comprehensive preventive and promotional approaches to protect citizens from the consequences of AWD; and 2) to contribute to the promotion of sustainable growth and transformation of the country with strategies of coordination and collaboration, health promotion and communication, prevention activities, case managements, public health surveillance, emergency preparedness, response and recovery, capacity building, and the implementation framework of the program(62).

Zoonotic diseases in general

Climate and environmental change could be associated with many emerging and re-emerging zoonoses that can be transmitted from animals to humans and from humans to animals, and may be acquired or spread through the air, by direct contact, by contact with an inanimate object that harbors the disease, by oral ingestion, and by insect transmission(64). An estimated 75% of emerging infectious diseases in humans have evolved from exposure to zoonotic pathogens (65, 66). These emerging diseases are new infections resulting from the evolution or change of an existing pathogen or parasite resulting in a change of host range, vector, pathogenicity or strain, or the occurrence of a previously unrecognized infection or disease.

Climate change may also cause an increased risk of food contamination, increased environmental survival of pathogens, changes in prevalence of pathogens in animal reservoirs, and changes in host–parasite ecology, which may enhance the risk of food borne disease (67). It could also potentially shift boundaries for spatial distributions, host–parasite assemblages, demographic rates, life-cycle phenologies, associations within ecosystems, virulence, and patterns of infection and disease (68). For example, an increase of a few degrees in environmental temperatures may lead to marked increases in cercarial emergence from snails (69).

Climatic variation also creates new ecological niches for vectors, hence altering temporal and spatial distribution of disease (70). It also influences the epidemiology of zoonotic diseases primarily by inducing changes in reservoir and vector dynamics (71). Therefore, any changes in the ecological conditions influencing wildlife diseases are also likely to have potential direct impact on human health (72).

Zoonotic infections are on the rise and pose significant additional threats to human health (73), where the problem is worsened due to the complexity of the different organisms involved, the difficulties posed by the numerous and changing biotic and abiotic factors influencing their epidemiology and transmission, and the huge challenges they pose for control (74). According to the report compiled by Grace and Jones (75) in low-income countries zoonoses or diseases recently emerged from animals are responsible for one-fifth of infectious diseases, contributing to the burden of human sickness and death (75).

Zoonotic diseases in Ethiopia

In a meta-analysis of zoonotic diseases worldwide, Grace et al. looked at 56 major zoonoses and determined that these diseases account for 2.7 million deaths and 2.5 billion cases of sickness each year (42) . Ethiopia was identified as a "hotspot" for zoonotic disease events and was ranked as the number one hotspot for leptospirosis, fourth greatest hotspot for Q fever and Trypanosomosis, and tenth for tuberculosis (42). The same author assessed the global burden of disease for zoonoses and determined that 68% of the burden is distributed among only 13 countries, with Ethiopia having the 4th highest burden (42). These data indicate an already existing burden of zoonotic disease in the country, and this burden has the potential to be exacerbated by the effects of climate change.

Although only a limited number of studies have examined the effect of climate change and zoonotic disease in Ethiopia, the current existing conditions seem suitable for the occurrence of climate-induced zoonotic disease. In an attempt to assess the burden of leptospirosis in Ethiopia, Yimer et al. conducted a pilot study in Wonji hospitals to test patients for the condition and found that almost half of all patients tested for leptospirosis were positive for the illness (76). Researchers have identified an association between outbreaks of leptospirosis and extreme rainfall and flooding in a wide range of countries with different ecologies (77). Transmission of leptospirosis can occur through direct exposure to infected livestock, contamination of water sources from flooding, and/or poor sanitation conditions. Additionally, higher temperatures are linked to increased incidence of the condition (77). Ethiopia's large livestock population, in conjunction with predicted increases in both temperature and flooding and an established

burden of disease, suggests that climate change may greatly increase incidences of leptospirosis in the country.

In addition to the changing climatic variability, there has been rapid deforestation and degradation of land resources, mainly due to population increases in Ethiopia. This affects the ecological niches of various diseases which favor their transmission and leads to environmental changes that can contribute to transmission of waterborne diseases through grazing lands (78). The country's forest areas have been reduced from 40% a century ago to an estimated less than 3% today (79). Ethiopia possesses one of the largest livestock populations on the African continent (80) and 90% of rural households own farm animals (81). Sharing of the house with animals is common ((80) and can expose inhabitants to various zoonotic diseases.

Since the consequences of climate change have strong associations with poverty and social inequality, its impacts will be felt in different ways and severities by different communities and social groups in Ethiopia. It is well recognized that the most vulnerable and marginalized communities and groups are those who will experience the greatest impacts (4), and are in the greatest need of support and adaptation strategies. At the same time, it is the vulnerable and marginalized who lack, or have the least access to, information, technology, or opportunity to adapt to current climate variability and sufficiently prepare for future changes in the climate system. More specifically, climate change poses a significant challenge to the reduction of poverty and social inequality for the rural poor, especially women, the marginalized, the disabled, and those living with HIV/AIDS, who will suffer disproportionately from its multifaceted and growing impacts.

Meningitis in general

Meningococcal infection has been recognized as a serious public health problem for almost 200 years worldwide, and over 80% of bacterial meningitis can be traced to three disease causing agents: Neisseria meningitides, Streptococcus pneumonia, and Hemophilus influenzae Type B. The disease can occur as a sporadic case, an institution-based focal outbreak, or a large epidemic year (82). Without treatment, bacterial meningitis kills up to 50% of those people it infects. Even if the disease is diagnosed early and treated with appropriate drugs, the case fatality rate remains 5-10%. As many as one out of five survivors will suffer from neurological after-effects such as deafness or mental retardation (83). The highest burden of meningococcal disease occurs in sub-Saharan Africa, which is known as the "Meningitis Belt", an area that stretches from Senegal in the west to Ethiopia in the east. This hyper-endemic area is characterized by social habits and a particular climate (82).

The distribution of epidemics is dependent on a wide variety of factors including immunological susceptibility, bacterial strain, demographic and socioeconomic factors, environmental factors, and the presence of other infections(83). The IPCC 4th assessment report indicated that climate change and variability have an impact on the epidemiology of meningitis, especially in countries within the 'Meningitis Belt' in semi-arid sub-Saharan Africa where they experience the highest endemicity and epidemic frequency of meningococcal meningitis (2). Climate change affects both weather (heat, humidity, wind) and the environment (extent of vegetation or desertification); it intensifies those factors

that most determine meningitis outbreaks, particularly humidity (drought) and dust levels for areas that will become more arid.

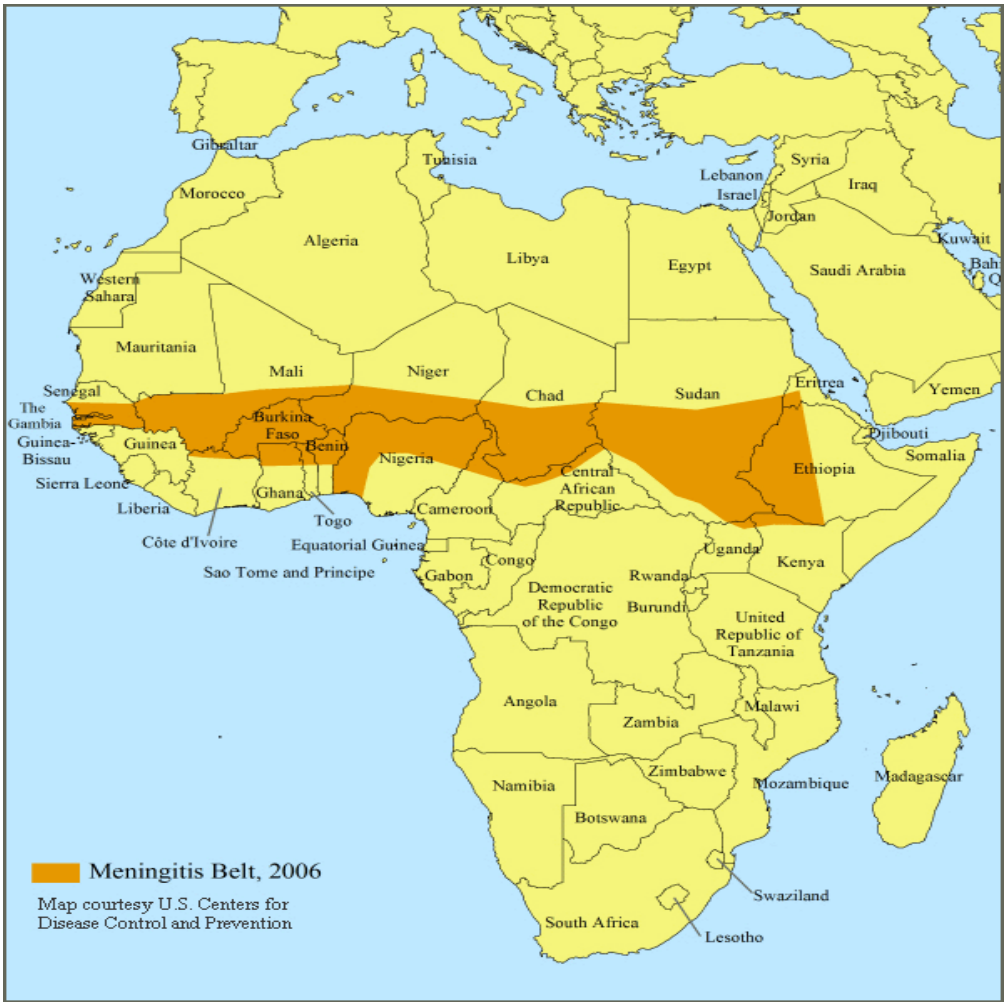

Figure 4. African Meningitis Belt. Source: World Health Organization (84).

Several studies have addressed the seasonality of meningitis. Gessner et al. found that similar to meningococcal meningitis, pneumococcal meningitis was seasonal, occurring primarily in the dry season (85). Obikar also concluded that climate factors are important for both the distribution and the seasonality of meningococcal disease; the distribution of sero-groups causing meningococcal disease (A, B, C, Y, W-135) varies over time and by geographic location and the spatial distribution of the disease indicates a close linkage with weather climatology (82). Large epidemics occur during the dry season, between December and June, in the meningitis belt area (82). This pattern has been attributed to effects of dust winds and upper respiratory tract infections, due to cold nights, on the local immunity of the pharynx, thereby increasing the risk of meningitis. An analysis using climate/environmental models to predict the probability of occurrence of meningitis epidemics in Africa's meningitis belt revealed that

anomalies in annual meningitis incidence at the district level were related to monthly climate anomalies. Significant relationships were found for both estimates of rainfall and dust in the pre-, post- and epidemic seasons. While present in all land-cover classes, these relationships were strongest in savannah areas (86).

Recent analysis of reported epidemics indicate that there appears to be a southward shift in the distribution of epidemics over time, with newly affected areas south of the current meningitis belt consistent with changes in the region's climate/environment in many areas (83). A predictive model based on all known meningitis epidemics occurring before 2000 in African countries revealed that epidemics of meningococcal meningitis occur in areas with particular environmental characteristics. Absolute humidity, dust and rainfall profiles, land-cover type, and population densities were independently associated with the location of epidemics. However, it was found that the absolute humidity profile and land-cover type were the best predictors in the final multivariable model (87).

Meningitis in Ethiopia

Ethiopia is within the meningitis belt, and is cyclically affected by epidemics of meningitis. Since the first reported outbreaks of meningitis in 1901, there have been repeated occurrences: 1935, 1940s, 1950s, 1964 and 1977, followed by the largest epidemics in 1981 and 1989, each affecting almost 50,000 people (88)). SNNPR and Oromiya have been most severely affected in the past, with Amhara, Gambella, and Tigray also seeing significant impact (89).

Recent studies indicate that there has been expansion of certain sero-groups of meningitis in Ethiopia beyond the areas traditionally included in the meningitis belt (90), mainly consistent with changes in the region's climate/environment in Southern Province in Ethiopia (83). A 2013 press release by the Federal Ministry of Health stated that a meningitis outbreak occurred in some parts of the Southern Nations, Nationalities, and Peoples State. It is also stated that outbreaks of meningococcal meningitis often occur during the dry season, particularly from December to June when dusty winds and respiratory infections are present (91).

Local studies which relate meningitis with environmental and climate variation are lacking in Ethiopia. However, a recent retrospective study by Ahmed (92), based on cases of bacterial meningitis in Gondar University Hospital, found a marked effect of seasonal variation, with more cases occurring in the summer months. Almost 35% of the cases of bacterial meningitis at Gondar were recorded in the months of May and June. Culture-specific results show that this variation was most pronounced in meningococcal disease in which almost two-thirds of the cases (67%) occurred in the dry season during the second quarter of the year, i.e., April to June. Among the various agents of bacterial meningitidis, Streptococcus pneumoniae was the most common organism identified in the CSF cultures of 35 patients (35.3%). Next were Neisseria meningitides from 27 cases (27.3%) and Haemophilus influenza from 9 cases (9.1%)(92) .

Air Quality

The Ethiopian Climate Resilient Green Economy document (7) identifies air quality as an area that will likely be adversely affected by climate change. The main factors that could impact air quality are air pollution and changes to seasonal/regional allergens. These threats will likely be exacerbated by increases in temperature and rainfall variability.

Air Pollution in general

Air pollutants such as particulate matter (PM) and ozone have been found to have negative health effects including decreased lung function, asthma, and chronic respiratory diseases, as well as increased risk for heart attack. The effects of air pollution tend to be intensified with high levels of heat (93). Studies have suggested that excess heat increases morbidity and mortality from cardio-respiratory disease in those exposed to ozone and PM, with greater risk associated with the elderly or those with pre-existing vulnerabilities (84).

Many air pollution models have indicated that temperature is the strongest meteorological variable affecting concentrations of ozone in polluted areas, with an increase in temperature correlated to high levels of ozone (94). Additionally, periods of drought have been associated with increased airborne dust, thus increasing levels of PM.

Air Pollution in Ethiopia

Air pollution in Ethiopia has not been extensively researched. Etyemezian et al. (95) conducted a pilot study in 2004 to assess the ambient air quality in Addis Ababa. The authors determined that ambient outdoor PM_{10} and $PM_{2.5}$ levels approached, if not exceeded, standards set by the Ethiopian EPA(96). These findings indicate that temperature increases associated with climate change have the potential to greatly impact air quality, especially during a period of drought.

As of 2006, lower respiratory infections were the leading cause of death in Ethiopia (42) as a result, outdoor and indoor air pollution is a major concern in the country. A study looking at indoor air pollution in rural Butajira found seasonal and ecological variations in indoor air pollution concentrations. Considering the spatial-temporal variation of the monthly mean nitrogen dioxide (NO_2) concentrations, there are clear variations, although the highest concentrations of NO_2 appear to be in the main rainy season, from June-September (97). These findings suggest that seasonal and ecological variability has the potential to affect indoor air pollution levels.

Fires

Wildfires caused by drought and extreme temperatures have the potential to serve as a major source of PM. For example, in 2003 a heat wave was associated with a record number of wildfires and poor air quality attributed to PM and ozone in Europe (94).

In some parts of Ethiopia, pastoralists are suspected of starting fires to maintain their land. Although technically illegal, such fires are said to increase growth of vegetation for grazing, decrease the prevalence of ticks or other pests, and decrease predator attacks (98). With increased temperatures or seasonal drought, such fires have the potential to grow out of control. In 2000, The Foreign Agricultural Service reported outbreaks of forest fires throughout southern Ethiopia. Due to the extended drought, these fires, which were attributed to pastoralists, burned about 250,000 acres of forest and 10-15% of Nechi Sar National Park.

Around the world, respiratory disease has been attributed to outbreaks of wildfires(93). Fires burning out of control not only pose a risk to air quality, but also to the physical safety of those nearby, as well as the threat of property loss.

Allergens

Allergens are likely to be affected by seasonal changes in climate. Although no studies have explored the role that allergens play in respiratory health in Ethiopia, a number of studies have been conducted exploring this concept worldwide.

Patterns of airborne pollens, fungal spores, and mold will likely be altered with changes in seasonal climate, rainfall and humidity levels. Increases in temperature and high concentrations of carbon dioxide (CO_2) have been associated with increased pollen production of plants and longer pollen seasons (99). Increases in humidity have been associated with the production of fungal spores linked to hospital admissions for (100)asthma.

Pollutants such as PM and ozone have been shown to exacerbate allergy and asthma symptoms when allergens are present (101). The combination of air pollutants and changes in allergens due to climate change are anticipated to worsen allergic disease and asthma, particularly in children(101).

Nutrition and related impact

Overview

Climate change affects nutrition through various causal pathways that impact food security, sanitation, water and food safety, health, maternal and child health care practices, and many socioeconomic factors, and will increase the risk of hunger and under-nutrition over the next few decades; it challenges the realization of attaining human rights for health and adequate food . Climate change also has an impact on water availability and quality, sanitation systems, and food safety, and on water-borne, food-borne, vector-borne and other infectious diseases which eventually both increase nutritional needs and reduce the absorption of nutrients and their utilization by the body (102).

A study in the West-Arsi zone in Ethiopia which examined local climatic trends and their impacts on livelihoods shows that the trend of gradual and extreme weather change is particularly negative for the livelihood of people in the midlands and lowlands. On the other hand, drought, rain delay, erratic

precipitation, and heavy and unseasonal rain are challenges to the livelihood of the whole region. These conditions force the community to save, diversify, change the growing season, increase mobility, and sell wood and livestock, as well as adopt social interconnectedness as coping strategies (103).

With a likely change in the patterns of climate-related extreme events, such as heat waves, droughts, storms, heavy precipitation and floods and increased risks of disasters, vulnerable communities and households will suffer serious setbacks with regard to food and nutrition security (102). The fourth assessment report (AR4) of the Intergovernmental Panel on Climate Change (IPCC) concluded that under-nutrition linked to extreme climatic events may be one of the most important consequences of climate change due to the very large numbers of people that may be affected (4).

Nutrition and related impact in Ethiopia

A study which assessed the prevalence of rural and urban food energy deficiency in selected African countries showed that Ethiopia ranks as the fourth most food insecure country in the sample using FAO data, but the most food insecure country using household data (104). In addition, low agricultural yields and average farm sizes, land degradation and deforestation, and chronic problems with food security are already evident in Ethiopia (105). Climate change is projected to reduce yields of the wheat staple crop by 33%, further contributing to poverty in Ethiopia(15).

The impacts of climate change on nutrition and health will further aggravate the effects of the HIV pandemic, reducing the workforce dedicated to agriculture and the food supply (106). This is a great concern considering that most of the populations affected by HIV depend on agriculture for their livelihoods. Climate change will also put a further strain on the already heavy workload of women, with negative impacts on their ability to provide proper care to infants and young children, heightening the risk of under-nutrition (106).

In Ethiopia and Kenya, two of the world's most drought-prone countries, children aged five or less are, respectively, 36 and 50 percent more likely to be malnourished if they were born during a drought. For Ethiopia, that translated into some 2 million additional malnourished children in 2005 (61).

Recent vulnerability mapping reports also confirmed Ethiopia's high vulnerability to climate change with the least capacity to respond(26). The same study argues that climate change will be a major challenge to the country's efforts t security and environmental sustainability.

In areas of Ethiopia where drought is more frequent, such as Shinile and Borena, pasture and water scarcity are leading to low conception rates and poor health of lactating animals. This has an adverse implication on the availability of milk and milk products for home consumption (23). It has been concluded that higher temperatures and increased rainfall unpredictability, combined with increasing land degradation and bush encroachment, will result in increased food insecurity and nutritional deficits, unless pastoralists switch to better-adapted livestock species. The impact of food insecurity and malnutrition is more severe on poor households, who usually do not have the financial capacity to modify their herd composition (23).

Unless health services, which are currently very poor in Shinelie and Borena, are improved in the coming years, increased food insecurity and malnutrition are likely to decrease labor productivity and human resistance to diseases, and increase human

mortality (23). In Afar, among the indirect impacts of climate change-related exposure on human health are food insecurity, malnutrition, and poor child growth and development (21).

Mental health

Displacement or property damage due to flooding, economic losses due to drought, and loss of life due to illness will likely take a toll on the mental health and well-being of a population. Worldwide there have been numerous studies examining the impact that extreme weather events, such as hurricanes or typhoons, have on the mental health and well-being of those affected. The losses from such events may lead to post-traumatic stress disorder, anxiety, and depression. Increased risk of suicide and issues with substance abuse are also common. These mental health consequences of extreme weather events have potential consequences for physical health, as they have been linked to medical problems such as heart disease, hypertension, and diabetes (107).

Agriculture

Ethiopia's economy and the social wellbeing of its population are already subject to climate variability and weather extremes. Agriculture, primarily rain-fed and highly sensitive to fluctuations in rainfall, forms the basis of the economy, providing approximately 46% of GDP and jobs for 80% of the working population. Chronic food insecurity affects 10% of the population and even in average rainfall years, these households cannot meet their food needs: they rely partly on food assistance. Droughts can result in sharp reductions in agricultural output and related productive activity and employment, with multiplier effects on the economy. Floods regularly cause crop and infrastructure damage and widespread suffering and hardship; for example, in 2010 several tens of thousands of people were displaced and over ten thousand hectares of cropland were inundated in the Afar and Amhara regions.

The close links between climate and Ethiopia's economy are reflected in the strong relationship between GDP growth rate and rainfall variability. Because Ethiopia's economy and the well-being of the Ethiopian people are closely linked to agriculture and the use of natural resources – water, land, forests, biodiversity, and fisheries – adaptation and action towards climate resilience will come in part through focusing on improving performance and management in these areas with future climate change in mind.

Generally, the livelihood of pastoralists and agro-pastoralists, who are highly dependent on natural resources for livestock-keeping, cropping, fishing, beekeeping and hunting, is very sensitive to climate change. However, because of differences in wealth, power, social values, and natural resources within the communities, their vulnerability and ability to adapt to climate change also vary in time and space. The range of vulnerability within the pastoralist community can be broadly classified as follows (39):

- The most vulnerable to climate change are usually elderly men and women and children.
- The poor with fewer livestock and less voice in decision-making in the community are more vulnerable; women heads of household are usually classified as poor.

- Minorities within the clans and sub-clans, engaged in fishing, beekeeping and hunting, are more vulnerable than the majority and more powerful, who are engaged in keeping livestock.
- Those who rear mainly cattle and sheep are more vulnerable than those rearing camels and goats, which are more resistant to drought.
- People living in critical areas such as flooded regions and who are bounded by different conflicting ethnic groups are more vulnerable than people in other locations.
- Agro-pastoralists with limited mobility are more vulnerable to climate change than are nomadic pastoralists.

In Ethiopia, agriculture remains by far the most important sector and it directly supports about 85% of the population with regard to employment and livelihood. This sector contributes about half of the country's gross domestic product (GDP). Agriculture is particularly sensitive to climate change. Greater total or more intense rainfall across the country may increase soil erosion and the occurrence of crop damage. Ethiopia is particularly vulnerable to accelerated soil erosion because of existing pressures and degradation on its land area, 79% of which has a slope of greater than 16%, with 25% having a slope of greater than 30%. Changes are also expected to occur to production system viability; cropland area and cropping patterns; pest and disease frequency and distribution brought about by changes in seasonality; timing and distribution of rainfall; higher evapotranspiration; and drought and flood damage.

As noted earlier there are no country-wide, methodologically consistent, climate impact studies for Ethiopia. Agricultural studies show a diverse set of impacts, including decreases in suitable rain-fed land areas and potential cereal production, but also some positive impacts on growing-season length by the 2080s (108). Livestock yields will be impacted directly through temperature effects on annual growth, milk and wool production and reproduction; and indirectly by changes in the quantity and quality of pasture, forage, grass, and disease and increases in parasites. The negative impacts of climate change may be particularly experienced by pastoralist communities. The interactions between these problems and potential benefits of greater CO_2 'fertilization' are largely unknown.

Crops

Agriculture is dominated by rain-fed small-scale farming, primarily based on traditional technologies. Modern inputs, in particular fertilizers, are comparably low, at an average of 81 kg/ha (109). Small-scale subsistence farming accounts for 95 percent (about 8 million peasant households) of the total area under crops, and more than 90 percent of total agricultural output. Although the arable area has expanded slightly in recent years, population growth has outpaced this expansion. Average landholding per household has dropped to below 1 ha. Average yields remain low, at only 2.1 t/ha for maize, 1.7 t/ha for wheat, 1.4 t/ha for teff and 1.25 t/ha for barley (110). Although the importance of agriculture, as measured in terms of its contribution to GDP, has decreased in recent decades, the overwhelming majority of the population is still mainly rural and depends heavily on agricultural income.

Conway and Schipper (111) used the 'Livelihoods, Early Assessment and Protection' (LEAP) software platform to simulate changes in yield of the five main staple crops in Ethiopia under the full range of climate model projections of dry (-19%), average (+1%) and wet (+19%) rainfall for the 2020s. The crops

simulated were maize, teff, barley, and sorghum with a short and long maturity cycle. The effects of climate change were calculated as differences between the period with observed data (1995-2008) and the same period with rainfall adjusted according to the climate model projections. Higher rainfall produced modest effects on yield, not always consistent, with increases in most years and very small decreases in some years. Lower rainfall had greater impacts on yield for all five crop types and produced more consistent reductions in yield in nearly all years.

Changes in crop yield were used to calculate changes in LEAP, the estimated number of beneficiaries needing food assistance, and the consequent livelihood protection costs in areas where the Productive Safety Net Programme (PSNP) operates (using algorithms from 2008). Figure 5 shows the effects of changes in crop yield under future rainfall conditions, on the estimated total number of beneficiaries, expressed as a percent change from the baseline period average. The scale shows percent changes because the relationships used to calculate the index are provisional and still under development. The full line shows results, with observed rainfall having notably high values between 1999 and 2002, 2004 and reflects the major drought in 2002. The effect of the dry rainfall scenario (short dash) leads to an average increase of 32%, in the total number of people needing assistance across all years. The higher rainfall leads to an overall average reduction of 11% in beneficiary numbers. The multi-model average change in rainfall (not shown) gives results very close to those estimated for the present day.

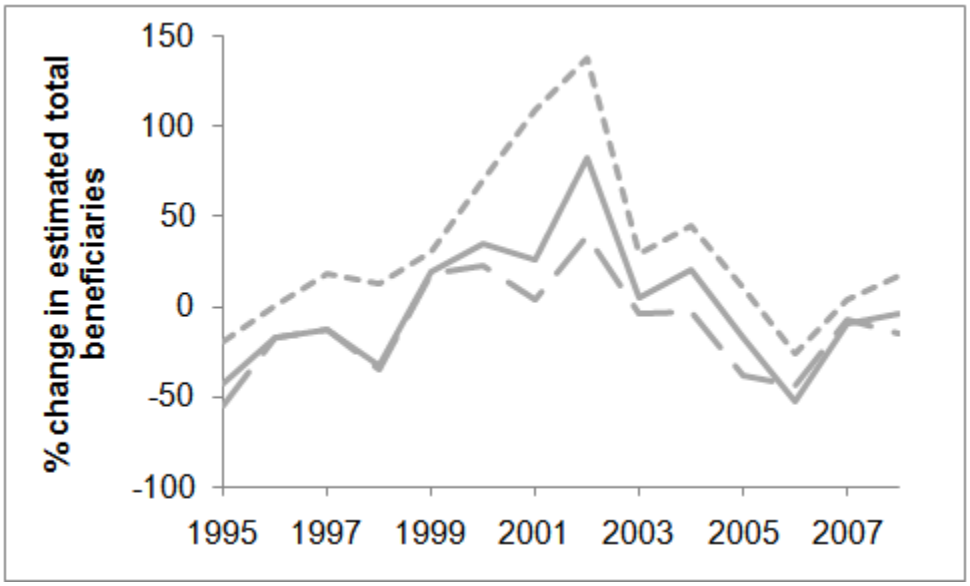

Figure 5: Per cent change from long-term average (1995-2008) in total beneficiaries in the PSNP under different climate change projections for the 2020s. Grey solid line 100% rainfall, long dash wet extreme, short dash dry extreme.

Livestock

Ethiopia has the largest livestock population in Africa and the tenth largest in the world. Livestock is an integral part of the farming systems in the country, and the source of social and economic values such

as food, power, fuel, cash income, security, and investment. The livestock sector is estimated to contribute approximately 12 to 15 percent to total GDP and about 25 to 30 percent to agricultural GDP (112).

Jones and Thornton (113) assessed livelihood transitions to 2050 in Africa due to climate change and found that changes in the frequency and severity of extreme climate events could have significant consequences for livelihoods, natural resources, food production and food security. Increasing frequency of heat stress, drought, and flooding events are projected to have adverse effects on crop and livestock productivity, in addition to changes in mean climate. Thornton et al. (2009) reviewed the impacts of climate change on livestock and livestock systems in developing countries and considered knowledge gaps. They highlighted key issues around the quantity and quality of feeds, changes in atmospheric CO_2 concentrations, and temperature impact on growth rates. They noted that climate change could have many indirect and unpredictable impacts on infectious animal diseases throughout Africa; for instance, combinations of drought followed by high rainfall have led to wide-spread outbreaks of diseases such as Rift Valley Fever and bluetongue in East Africa. Finally, droughts may force people and their livestock to move, potentially exposing them to environments with health risks to which they have not previously been exposed (114).

Transport

Although improvements have been made to Ethiopia's transport infrastructure, in 2008 the road network was 56,113km long, of which 85% was unpaved. Improvement and maintenance of transport links between urban centers, to and from ports of export and import, and in particular to rural areas are pre-requisites for economic development. Transport links -- both paved and unpaved roads -- are highly vulnerable to the increases in rainfall and temperature which are projected for Ethiopia, with heavy rainfall washing out roads and high temperatures damaging road surfaces.

A World Bank study (115) projects that climate change will increase the maintenance costs of the country's road network by between $10 million to $21 million annually, depending on the climate model used. These costs will be reduced and transport links maintained if road drainage and bridge designs are adapted to the expected climatic conditions. Maintenance costs of unpaved roads are also high, and extending the network of paved roads is likely to be economically beneficial.

Industry

Ethiopia's economic development will require an expansion of industrial activities. Some of the industrial sectors, such as textile and leather, will allow increases in exports; others, such as cement and steel, will expand largely for domestic infrastructure development. While the growth of Ethiopia's industrial sectors has the highest priority, challenges relate to greenhouse gas (GHG) emissions caused by these activities. Ensuring the transfer of modern and resource efficient technologies is therefore an important component of Ethiopia's growth plans.

Water

River flows tend to increase

Recent studies of river basins in East Africa, including Ethiopia, using a range of climate model results, show a tendency for higher river flows due to higher rainfall (increases in rainfall large enough to offset greater losses to evaporation). A minority of models (less than half those used for IPCC 2007) still show decreases in rainfall and river flows.

Flooding may increase

Although no studies have directly considered changes in flood characteristics, it is very likely that flood frequency and magnitude will increase under higher rainfall conditions.

River flows are highly sensitive to rainfall changes

Modeling studies of the Awash and Abay (Blue Nile) show that both rivers have high sensitivity to climate change. A set of modeling studies for the region show that most hydrological systems are more sensitive to changes in rainfall than to changes in temperature/evaporation.

Lake Ziway Watershed Water availability

Abraham (116) applied the changes in rainfall and temperature to the Lake Ziway Watershed using one climate model to a hydrological model to simulate future flows and concluded the following:

- Except during the 2001-2025 period, the total average annual inflow volume might decline significantly by up to 19.47% and 27.43% for different scenarios.
- This inflow volume reduction is likely to drop the lake level about 0.66m.
- The surface area might shrink by 25.3 $km^{2.}$

Energy

The vast majority of Ethiopia's national energy needs are met by fuel wood, crop and animal waste, and human and animal power. Only 5% comes from electricity and 95% of this is generated by hydro-power. Much of Ethiopia's hydro-power potential has yet to be developed. This energy mix greatly increases the country's vulnerability to climate change. For example, Ethiopia's reliance on fuel wood and charcoal brings widespread land degradation, exposing bare soil to erosive rainfall and gulley erosion. As the impact of climate change increases, there is likely to be a higher reliance on forest products for livelihoods.

Energy generated by hydropower is also vulnerable to fluctuations in rainfall, temperature, and evaporation. For example, reduced power production during drought years already takes a significant toll on the economy. In 2002/3, the power supply was lost one day a week over four months because of

drought, causing a sustained reduction in economic productivity. Loss of electricity also has an impact on basic services, especially in schools and hospitals.

Ethiopia plans to increase its hydroelectric power production significantly to satisfy its own growing needs and to supply its neighbors. While these plans offer huge potential to power low carbon growth in Ethiopia and beyond, they need to be carefully considered for implications of future climate change so that benefits can be sustained and conflicts with other water users can be avoided.

Impacts of Climate Change on the Economy

Ethiopia has experienced strong economic growth in recent years. With real GDP growth at or near double-digit levels since 2003/04, the country has consistently outperformed most other countries in Africa. Official figures show real GDP growth averaged 11.2 percent per annum during the 2003/04 to 2008/09 period, putting Ethiopia among the fastest growing economies in sub-Saharan Africa. Although IMF estimated growth rates around 7.5 percent in 2010–11 (117) lower than government estimates of 11.4 percent, this growth performance is still in excess of the population growth rate and the 7 percent rate required for attaining the MDG goal of halving poverty by 2015 (118).

To assess the impacts of climate change, it is necessary to estimate the impacts and costs of climate/weather events on socio-economic activities, based on observations. In many countries information (qualitative and quantitative) on costs is not readily available, because it is rarely recorded in a consistent manner over time, is difficult to estimate, and --where it does exist -- is often in a form that requires additional work to be useful for the type of work required here. The main climate hazards in Ethiopia are associated with rainfall extremes – droughts and floods - and variations in the timing of rainfall (onset and breaks in the rains). These are the events that we analyze in detail and it is through changes in their frequency and magnitude that climate change is likely to be manifest and most significant in socio-economic terms. Gradual warming will bring the slow onset of change throughout the country, and although of heat waves will occur with increased frequency, there is very little information on their effects in Ethiopia at present.

Quantifying economic impacts

Until recently very little work had been done to quantify the economic effects of climate variability or extremes in Ethiopia, despite the high profile and significant impacts that droughts have had. In fact, this is the case globally – although this is now being addressed, particularly since the Stern review, but also since earlier work by the World Bank, (119). The earliest empirical economic analysis for Ethiopia was commissioned as part of the World Bank water strategy paper (120).

Conway and Schipper (111) highlight sensitivities within the economy, such as effects on GDP, consequences for the external sector, and prices. The effects are clear in the major drought years of 1984 and 2001; however, in other years, the relationship between a national estimate of rainfall and economic performance/behavior is not systematic and relationships cannot be readily identified. This

gap has implications for estimating economic effects of future climate change because such projections need to be based on robust and stable relationships that can be used for future climate conditions.

Modeling the links

Robinson et al. (121) simulated the economic impacts of climate change for 2050 using a multi-sectoral regionalized dynamic computable general equilibrium model. The researchers concluded that climate change would reduce Ethiopia's GDP in the 2040s up to 10 percent, with greater negative effects on the poorer households. The results suggested that with support from developed countries, suitably scaled adaptation measures could restore aggregate welfare to baseline levels.

Deressa and Hassen (122) analyzed the economic impact of climate change on crop production in Ethiopia and concluded that climate, household, and soil variables have a significant impact on the farmers' net revenue per hectare. Their results also suggested that both rising temperature and declining precipitation are damaging to Ethiopian agriculture. The net crop revenue impact of predicted climate scenarios from three models (CGM2, HaDCM3, and PCM) for the years 2050 and 2100 indicated a reduction in crop net revenue per hectare by the years 2050 and 2100. On this basis, they concluded that increasing temperature marginally during winter and summer reduces the net revenue per hectare by US$997.85 and US$1277.28, respectively. Their results also indicated that reduction in the net revenue per hectare will be greater in the year 2100 than 2050 under all scenarios. They suggested that different agro-ecological zones are not uniformly affected by future changes in climate.

The World Bank (5) analyzed the economic impacts from climate change and potential adaptation policies in Ethiopia using a dynamic Computable General Equilibrium (CGE) model calibrated to the 2001/02 social accounting matrix. The results indicated that as the climate shocks become more negative, the impact would be much more serious and result in an average decline in average annual real GDP growth rate over a 25-year simulation horizon.

Gebreegziabher *et al*(123) used a dynamic CGE model to grasp the economy-wide effect of climate change-induced shocks in agriculture on Ethiopia's economy. The study found that over a fifty-year period the projected reduction in agricultural productivity may lead to reductions in average income of about 30%, compared to what would have prevailed in the absence of climate change. The study also found that in those parts of the moisture-sufficient highlands where cereal production currently dominates, overall productivity is projected to increase until approximately 2030 because of climate change, but to decline sharply thereafter. In the drought prone highlands, the situation is somewhat different. Land productivity in crop production is expected to decline because of climate change more or less continuously throughout the period.

Zenaye (124) studied the impact of climate change on household poverty in Ethiopia using a dynamic micro-simulation approach and concluded that climate change will negatively affect production and consumption in the countryby 2050. However, the impacts are not uniform across the different agro-ecological zones. An exception is in the areas of the pastoralist households where there in an increment in income and consumption of households up to the 2040s. The households in the drought-prone areas

will be the hardest hit and are projected to sustain declines of household consumption expenditure by 30.3 percent. In urban and rural non-farming areas, climate change in 2050 is forecasted to bring a fall in household consumption between 14 and 15 percent. At the national level, total consumption of poor households will decline by 21.4 percent while the consumption of non-poor households will decline by 17.0 percent. The results further indicate that climate change will negatively affect the country's target of poverty reduction. According to the results of the analysis, poverty and inequality will be exacerbated by the effect of climate change in 2050. The impact of climate change raises the national poverty prevalence from 29.6 percent in 2010/11 to 45.15 percent in 2050. Poverty will be worsened in both rural and urban areas, causing the total number of poor people in the country to rise significantly. Climate change will also increase the inequality among households from its level of 29.8 percent in the base year to 33.2 percent in 2050. Hence, different adaptation and mitigation measures are vital if the country is to achieve its growth and poverty reduction targets.

Solomon (125) examined the impact of climate change on agricultural production until 2050 using the DCGE model and concluded that the overall economy could worsen through changes in agricultural productivity. The reduction in total agricultural crop production will also affect the industry, leading to higher losses in vegetable products (29.6 percent), grain mill products (27.6 percent), and prepared food (24.9 percent) by 2050, as compared to the baseline. With regard to the service sector, trade is projected to decline by 33.9 percent, while hotel service will decrease 24.3 percent by 2050. Climate-change-induced higher national food prices will lower overall Ethiopian GDP growth, factor income, and decrease real household incomes and consumption. The poor rural households will be more affected than urban and rural non-farming households, and the value of exports and imports will fall by 35.7 and 32 percent in 2050, respectively.

You and Ringler (126) simulated the period 2003–50 in Ethiopia using a multimarket model to analyze the effects of changes in water constraints, food damage, and fertilization on economic indicators such as agricultural GDP growth, overall GDP growth, and poverty. Based on this simulation, they concluded that the incremental variability of precipitation, which translates as fluctuating rainfall, reduces the availability of a stable water supply and increases the risk to the food supply. They concluded that climate change is expected to intensify the already high hydrological variability and frequency of extreme events with a significant negative effect on the development of the agricultural sector and on the Ethiopian economy as a whole. Droughts impair agricultural productivity and may lock subsistence farmers into poverty traps, whereas recurrent flooding can have long-term negative effects on agricultural GDP by directly damaging crops and by destroying roads, thereby exacerbating the inadequacy of transport infrastructure and consequently limiting access to markets.

Policy, Adaptation and Response to Climate Change

Policy

The Ethiopian Government has already put in place a number of policies, strategies, and programs aimed at enhancing the adaptive capacity and reducing the vulnerability of the country to climate variability and change. Such programs include the Plan for Accelerated and Sustainable Development to

End Poverty (PASDEP), the Environmental Policy, and the Agriculture and Rural Development Policies and Strategies. The Environment Policies of Ethiopia (EPE) and Conservation Strategy of Ethiopia (CSE) are the two umbrella instruments concerning environmental management in Ethiopia. These instruments were approved in 1997 and responded to the then-apparent environment and development challenges of the country. Most policy recommendations contained in the EPE and CSE are very much relevant to climate change mitigation and adaptation (127).

In 2005, Ethiopia formulated its five-year MDG-based Medium-Term Development Plan entitled “A Plan for Accelerated and Sustained Development to End Poverty (PASDEP 2005-2010)” (128). PASDEP I has clearly identified that atmospheric pollution and climate change are the causes of considerable environmental and socio-economic problems (PASDEP, 2005). The impacts of climate change and atmospheric pollution include weather variability, loss of pastureland, droughts, flood and thus food insecurity, and other environmental related health problems. Proposed intervention measures includedeveloping a federal strategy, standards, and laws to improve urban air quality; developing a national strategy to enhance coping mechanisms regarding the adverse impacts of climate change; and launching environmentally sound investment and other programs that foster cleaner development mechanisms, including emissions trading. Ethiopia’s Growth and Transformation Plan (GTP) was recently prepared (2010/11-2014/155) with the objective of building a carbon-neutral and climate-resilient economy (129). Enforcement of the existing environmental laws is a priority in connection with environmental conservation and climate change. The formulation and implementation of climate change adaptation and mitigation program are highlighted as priority activities.

Building on the positive trajectory of growth during the last ten years in Ethiopia, the Growth and Transformation Plan (GTP) -- the main government policy instrument that guides the major economic and social development efforts of the country -- sets a goal for achieving double digit growth that will elevate the country to that of middle-income country level by 2025, while at the same time becoming climate-neutral. The Government of the Federal Democratic Republic of Ethiopia has initiated the Climate-Resilient Green Economy (CRGE) initiative to protect the country from the adverse effects of climate change and to build a green economy that will help realize its ambition of reaching middle income status before 2025. Following the Bali Road Map and the Copenhagen Accord, Ethiopia is preparing itself to tackle climate change involving two concurrent approaches: Mitigation (actions that tackle the causes of climate change, such as reducing greenhouse gas emissions), and Adaptation (actions that minimize the consequencesof actual and expected changes in the climate).

National Adaptation Program of Action (NAPA)

The government of Ethiopia recognizes the impact of climate change on health, and has developed a Climate Change Adaptation Program Plan for Health for the years 2011-2015, with the anticipation that this strategic plan will help overcome the health risks of climatic change that the people of Ethiopia have been facing for many years (130). The document outlines how climate change affects human health directly through increasing morbidity and mortality as a result of temperature extremes, increasing vectors of infectious diseases, proliferation of non-vector borne infectious diseases, declining air quality, more frequent floods and storms, and indirectly through impacts on food supply and water resources

(130). Climate-sensitive diseases such as malaria, trypanosomiasis, onchocerciasis, schistosomiasis, and Leshmaniasis are already common in Ethiopia, and climate change may worsen their impact (130).

In response to the UNFCCC calls for the specific needs and special situations of less developed countries (LDC) to be addressed in the form of Climate Change National Adaptation Programs of Action (NAPA), Ethiopia has prepared "Climate Change National Adaptation Program of Action (NAPA) of Ethiopia in 2007" (15). Central to the NAPA process is the integration of climate change adaptation activities with national development policies to ensure their effective implementation. The NAPA process in Ethiopia identified arid, semi-arid, and dry sub-humid areas of the country as the most vulnerable to drought; agriculture was identified as the most vulnerable sector; and, with regard to livelihoods, small-scale rain-fed subsistence farmers and pastoralists are identified as those most at risk. The NAPA process has identified and prioritized eleven project areas that address the immediate climate change adaptation needs in the country, focusing on human and institutional capacity building, improving natural resource management, enhancing irrigation agriculture and water harvesting, and strengthening early warning systems and raising of awareness. Implementation of NAPA activities, however, is not progressing as expected due to financial constraints.

The Climate-Resilient Green Economy (CRGE)

The country's objective is to identify green economy opportunities that could help Ethiopia reach its ambitious growth targets while keeping greenhouse gas emissions low. The government intends to attract development partners to help implement this new and sustainable growth model and to become a "green economy front-runner".

The CRGE initiative follows a sectoral approach and has so far identified and prioritized more than 60 initiatives, which could help the country achieve its development goals while limiting 2030 GHG emissions to around today's 150 Mt CO_2e – about 250 Mt CO_2e less than estimated under a conventional development path. Implementing the initiatives would also offer important co-benefits such as improved public health through better air and water quality, and would promote rural economic development by increasing soil fertility and food security. The green economy plan is based on four pillars.

The four pillars of the green economy plan are:

1. Improving crop and livestock production practices for higher food security and farmer income while reducing emissions;
2. Protecting and re-establishing forests for their economic and ecosystem services, including as carbon stocks;
3. Expanding electricity generation from renewable sources of energy for domestic and regional markets;
4. Leapfrogging to modern and energy-efficient technologies in transport, industrial sectors, and buildings.

Nationally Appropriate Mitigation Action (NAMA)

In response to the call of the Copenhagen Accord for the Non-Annex I Parties to prepare and implement Nationally Appropriate Mitigation Actions (NAMAs), Ethiopia has prepared and submitted its NAMA to the UNFCCC secretariat (EPA, 2010a). Key mitigation technologies and practices include the following.

Key mitigation Technologies and Practices in the Ethiopia's NAMA by sectors:

- **Renewable energy,** including10 hydro power plants with a total of 5,632 MW that will be completed between 2010 and 2015, 11 under study with a total capacity of 8,915 MW; 7 wind power projects with a total of 764 MW to be completed by 2013; and 6 geothermal projects with a total of 450 MW to be completed by 2018.
- **Bio-fuel Development** to produce 63.36 million liters of ethanol and 621.6 million liters of biodiesel for the market starting from 2010 up to 2015.
- **Electricity Generation from Renewable Energy for Off-grid use and direct use of renewable Energy** including 150,000 solar home systems, 65,000 Small Hydro Projects, 600 wind or solar pumps, 3,000 institutional PV, 3,000,000 solar Lanterns, 3,500 solar water heaters, 10,000 solar cookers, 9,110,000 improved stoves, l25,000 household biogas digesters and 1,000 institutional biogas digesters starting from 2010 up to 2015.
- **Transport**: Construction of 9 national railway routes covering 4,885 KMs to be completed by 2020.
- **Forestry:** reforestation of 21,440 km^2 degraded lands, lands affected by gullies and slopes, managing 28,736.7 km^2 natural forests, 4,390.96 km^2 deciduous forest, 60,360 km^2 of national parks, and 19,817 km^2 non-timber forests; establishing 52,695 km^2 production forests; and managing 51,496 km^2 wetlands.
- **Agriculture: Composting** 80,000 km^2 of agricultural land and 261,840 km^2 of practicing agro-forestry.
- **Waste management:** Landfill methane recovery from 9 landfills from a total of 43 million m^3 of deposited waste.

Ethiopia's Program of Adaptation to Climate Change (EPACC)

Ethiopia's Program of Adaptation to Climate Change (EPACC) is one of action to build a climate-resilient economy through adaptation at sectoral, regional, and local community levels. The EPACC updates and replaces Ethiopia's National Adaptation Program of Action (NAPA) which was formulated in 2007 and submitted to the UNFCCC Secretariat. The May 2010 report of the UNFCCC's Least Developed Countries Expert Group encouraged the updating of NAPAs, suggesting that a more programmatic approach could be more effective than the NAPAs' the project approach. In line with this suggestion, Ethiopia has reformulated its adaptation program. Ethiopia's NAPA contained detailed descriptions of some larger adaptation projects, but the formulation of those projects was not as ambitiously participatory as that of the present EPACC.

The sectoral ministries and all of the Regional Governments are expected to jointly mobilize all the stakeholders down to the local community at the village level in formulating and implementing their responsibilities. About 20 problems and the actors responsible for their solutions have been identified in the areas of health, agriculture, forestry, land management, water, energy, waste, transport, industry, infrastructure, municipalities, and disaster management at various levels (131).

Priority actions to be taken for implementing adaptation measures to climate change

- Identifying the risks posed by climate change and mapping the areas likely to suffer;
- Establishing a simple and practical information network;
- Creating/strengthening a vibrant early warning system;
- Mainstreaming into development and service activities;
- Integrating adaptation to climate change into educational curricula at all levels;
- Enhancing integrated research and development activities on climate change; and
- Accessing financial resources and technologies for the implementation of climate change adaptation.

Institutional Capacity Building

Various GOs, NGOs, and international institutions are engaged in climate change research and advocacy. The major government institutions include the Environmental Protection Authority (EPA), the National Meteorological Services Agency (NMA), Addis Ababa University (AAU), the Ethiopian Institute of Agricultural Research (EIAR), and the Ethiopian Development Research Institute (EDRI). Among the NGOs, the Forum for Forum (FfF), Climate Change Forum (CCF), African Climate Change Resilience Alliance (ACCRA), and Pastoralist forum are worth mentioning, as are UNDP, WFP, WB and Ethiopian Consumers Protection Association (ECPA) among the International institutions.

The Ethiopian Government has established the Environmental Protection Authority (EPA) as the responsible institution to ensure the implementation of the UNFCCC and its Kyoto Protocol in a coordinated and yet decentralized manner. Recognizing the urgency and inter-sectoral nature of the environment, it has also established the Environment Council (EC) by proclamation to provide overall leadership in environmental policy and regulatory systems and to provide high-level oversight of environmental standards and directives. It is chaired by Ethiopia's Deputy Prime Minister, and its members are Federal Ministries, all Regional State presidents, representative of trade unions, environmental NGOs, and the Ethiopian Chamber of Commerce. It is the highest-level decision-making body in government for the environment. The Environmental Protection Authority is the secretariat of the EC.

These and other national policies are geared towards accelerating growth and transformation to lift the country out of the cycle of poverty and to meet the national vision of a middle-income Ethiopia. In light of this national interest, climate change provides both a challenge and an opportunity to reconfigure the country's development strategies so as to realize sustainable development.

Gap analysis

This review shows that much has been accomplished and there is recognition of the significance of climate change for Ethiopia at the highest levels of government. Yet gaps are evident. Climate change-related health outcomes have not been adequately studied in Ethiopia to guide the development and implementation of adaptation and mitigation strategies. Therefore, the main gaps identified through this SANA are presented below.

Organizational gaps

The SANA has identified various national organizations working on climate change-related activities in Ethiopia, including the Environmental Protection Authority (EPA), and the Ministries of Health, Agriculture and Water Resource. The EPA of Ethiopia has been mandated to coordinate the national response to climate change in the country. It has recently launched an ambitious Climate Resilient and Green Economy (CRGE) strategy including the Nationally Appropriate Mitigation Action (NAMAs) plans and the National Adaptation Plan (NAP). There have been various barriers, however, that impede the implementation of different strategies adopted on climate change by the organizations. The main gaps related to organization include:

- Lack of a well-organized structure in the regional branch offices of the EPA, and merging of the EPA and regional land administration offices.
- Lack of inter-sectoral collaboration among the organizations working on climate change-related activities. The poor linkages between the organizations such as the National Meteorology Agency (NMA), the Ministry of Health, and the Ministry of Agriculture with the academic and research institutes have been recognized.
- Although the impact of climate change has been identified by the various organizations, there are no strong specific units in each institution that can lead and organize the climate change-related activities. Though the PHEM at the MOH is responsible for 24 reportable diseases with potential outbreaks related to climate change, the regional health bureaus are not self-sufficient to handle the outbreaks. The regional health bureaus usually expect a national-level response for such problems.
- Poor coordination and communication exist among the various stakeholders on climate change and health.
- The involvement of the private sector in the endeavors of climate change and health is highly limited.

Training gaps

- Staff currently working on climate change and related outcomes in the various organizations are inadequately trained in the specific relevant techniques relating to climate change and health.

- Lack of training on special skill development, e.g., carbon trade negotiation, geospatial analysis, and hazard mapping, is a reality.
- Most authorities and other staff in the various organizations lack proper awareness of and knowledge about climate change and health activities.

Research gaps

- There has been inadequate research on climate change-related health outcomes in Ethiopia. As a result, polices and strategies related to climate change and health are not based in a body of evidence specific to Ethiopia.
- Lack of research capacity among experts and equipment limitation to carry out relevant research linked to development are concerns.
- Lack of baseline information on basic climate change indicators, e.g., carbon release of the industrial sector, is a major gap.
- Lack of laboratories relevant for carrying out climate change and health-related research is a serious challenge.
- There is a shortage of funds for research on climate change and health.
- There is a lack of specific training that is required for enabling the research activities, e.g., climate change modeling and longitudinal data analysis.

Institutional capacity

- There is a serious lack of technologies that fit the local setting, as well as and shortage of capital to adopt the new technology. The MOA has identified climate change as a development threat as its impact is evident with the changing pattern of rainfall in the last 3-4 decades, reoccurrence of droughts, and a resulting reduction in GDP. The CRGE strategy was set in 2011 and a case team composed of seven staff was formed to coordinate activities related to the strategy. However, it has not been carried out due to lack of a collective vision and the high cost required for implementation at different levels.
- A number of governmental and non-governmental organizations are working on climate change adaptation and mitigation activities, but their activites are not properly coordinated.
- There is a lack of trained personnel and experts on climate change and health in the organizations, regional offices, and academic and research institutes. Multidisciplinary approaches among the professionals of health, agriculture, climate, and water resources are weak, resulting in fragmented activities with little output.
- A very long and inefficient procurement system exists at many of the organizations.

Financial capacity

- Due to the long-term aspects of climate change, financial capital has been identified as a constraint; this is particularly a challenge for the EPA to implement and realize plans and strategies.
- Even if the funds were available, the absorption capacity in some organizations could present a problem.

Policy gaps

- Policies and proclamations on climate change and health are lacking, and those that do exist are not up-to-date.
- Strategies set for climate change and health, such as the climate change adaptation program plan for health (2011-2015) by the MOH, have not been properly advocated and communicated to the general public, relevant stakeholders, and organizations.
- Policies and strategies are adopted mainly based on international evidence and not on findings related to local climate change and health.
- Climate change was not recognized as a public health threat in the 1994 health policy of the country.
- The existing policies do not address the gender dimensions of climate change.

Monitoring and evaluation

- No proper monitoring and evaluation of the climate change situation and its impacts is currently being undertaken.
- The data on climate change sensitive diseases and other health outcomes are not aligned with climate change.

Needs assessment

Organizational needs

- Financial and technical support to implement plans and strategies on climate change and health.
- Well-organized structures in the regional branch offices at the various levels.
- Strengthening Strong inter-sectoral collaboration among the organizations working on climate change-related activities.
- Strong communication and exchange of information among different stakeholders on climate change and health.
- Encouragement and advocacy for involvement by the private sector in the endeavors related to climate change and health.

Training needs

- Train experts on climate change and health through short- and long-term courses. There need to be improved incentives and salary for the experts.
- Create awareness among the community about climate change and health issues.
- Develop curricula on climate change and health should be developed and instituted in undergraduate and graduate programs.
- Train personnel trained specifically in climate change-related science.
- Training personnel on special skill development, e.g., carbon trade negotiation, geospatial analysis, and hazard mapping.

Research needs

- Coordinate implementation of research on climate change and health.
- Strengthen individual and organizational research capacity at various levels, including academic and research institutes.
- Strengthen collaboration between the academic and research institutes and the NMA and other organizations.
- Foster international collaboration between the Ethiopian organizations and academic/research institutes to identify and implement research issues linked to development.
- Retain the trained personnel and experts on climate change and health.
- Establish climate change and health research centers in collaboration with national and international organizations.
- Establish baseline data on critical indicators related to climate change and health.

- Establish and strengthen laboratories necessary for carrying out research on climate change and health.
- Mobilize adequate funding to carry out relevant research on climate change and health that impacts on development.
- Strengthen the research capacity on climate change and health, particularly on climate change modeling and other relevant data management systems.

Institutional capacity needs

- Trained personnel specifically on climate change-related science at relevant institutions.
- Proper coordination and collaboration among the organizations at various levels, with personnel properly trained on climate change and health.
- Provide for appropriate locally sensitive technologies for the organizations that can be applicable at institutional and community levels.
- Promote multidisciplinary approaches among professionals of health, agriculture, climate and water resources.
- Improve the capacity and efficiency of the organizations to utilize meager resources effectively.

Financial capacity needs

- Mobilize adequate financial resources to properly implement climate change and health activities.
- Improve the utilization of financial systems and governance at different organizations.
- Strive for the effective and efficient utilization of meager financial resources.

Policy needs

- Update the existing policies and develop new policies and strategies in line with international and national needs, and including the gender dimensions of climate change.
- Strengthen the collaboration among various organizations to implement the existing policies and strategies effectively.
- Work towards the availability of relevant data for decision making on climate change and health.
- Make climate change part and parcel of the health policy of the country.
- Put in place clear and operational climate change adaptation and mitigation policies and strategies.

Monitoring and evaluation needs

- Establish and strengthen proper monitoring and evaluation systems on climate change and health at various levels in the organizations.
- Work towards the availability of super computers for climate and health data management and processing.
- Work towards the alignment of climate data with health data.
- Publish climate change and health information for the wider dissemination to the global scientific community.
- Establish websites for a wider dissemination of climate change and health information.
- Establish and strengthen scientific and local community forums.

CONCLUSIONS

- Climate change currently represents one of the greatest human development challenges, particularly in low-income countries like Ethiopia.
- The potential impact of climate change on health in Ethiopia has been recognized, but the specific actions and responses have been overlooked. Some of the current impacts of climate change on the country have been manifest in the form of repeated drought, floods, malnutrition, extreme temperature events (extreme heat and cold), and the re-emergence of climate-sensitive diseases. The impact of climate change could also be reflected in the form of increased environmental survival of pathogens and the creation of new ecological niches for vectors, hence changing the epidemiological distribution of diseases.
- Climate impact studies can illustrate the sensitivity of particular systems (e.g., health, agriculture, and water) and the possible direction and magnitude of change in the future. The current stage for research on climate change and health is rudimentary: research findings and other activities tend to appear largely through fragmented, less organized efforts. As a result, no spatially detailed, methodologically consistent climate impact studies are available for the country.
- Poor collaboration among various organizations on planning and executing activities related to climate change and health has been identified, pointing to the need for a better multidisciplinary approach.
- A concern has been identified that the continued climate warming throughout Ethiopia will lead to rainfall irregularity, resulting in poor outputs of rain-fed agriculture. This will be followed by food insecurity and malnutrition.
- This report has clearly documented a lack of trained personnel and expertise on climate change and health in the organizations, regional offices, academic, and research institutions.

Multidisciplinary approaches among professionals in the fields of health, agriculture, climate, and water resources are weak, resulting in fragmented activities with minimal output.

- Lack of well-organized structures in the various organizations and poor inter-sectoral collaboration among them on activities related to climate change and health were identified through this report. Poor coordination and communication among different stakeholders on climate change and health have been recognized.
- Policies and strategies adopted in the country were mainly based on international evidence without taking into consideration local climate change and health-related evidence, and there was a lack of recognition of climate change as a threat to public health. The existing policies and strategies fail to address the gender and community dimensions of climate change.
- The monitoring and evaluation components of climate change and health in various organizations have been identified as weak.

Priority needs for intervention

- Increasing community awareness and knowledge on climate change and health through proper media and dissemination forums.
- Increasing the number of trained personnel on climate change and health at the various relevant organizations.
- Strengthening the research capacity on climate change and health through training and technical support for various organizations, including academic and research institutes.
- Establishing climate change and health research centers equipped with adequate laboratory facilities.
- Developing and strengthening national and international research collaborations to carry out relevant research linked to development.
- Updating existing policies and developing new policies and strategies in line with current international and national standards.
- Mainstreaming of climate change and health units at various organizations and academic/research institutes.

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ANNEXES

Annex 1. Key Informants background for GEOHealth Hub SANA

Name of organization	Name of informant	Position of key informant	Phone no.
FMOH	Ato Mebratu Maetsentu	Planning officer	NA
FMOH	Ato Chanyalew Tadesse	Consultant, National WaSH coordinating	0911566994
FMOH	Ato Dagne Tadesse	M&E Officer	0911389541
EPA	Mehari Wondmagegne	Monitoring and Evaluation Directorate Director	0911689132
EPA	Dereje Agonafir	Environmental Units Program Directorate Director	0911416684-M 0116476499-O
FMOA	Ato Sertse Sibuh	CRGE coordinator	0912734713
FMOWE	Ato Alemayehu Tafesse	Head, EIA and Sustainable Development Office	0911413311
FMOWE	Ato Sahele Tamiru Fekede	Senior Energy Analyst and Director of energy study and development follow-up directorate	0116627368 0912425094
PHEM	Ato Abel Yeshaneh	Public Relation Officer	0911453054
NMA	Ato Tesfaye Gisilla	Metrological Research and studies directorate director	0911071486

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Annex 2. Climate Change-Related Policies and Programs of Ethiopia Policy /Strategy

Climate Change Related Policies and Programs of Ethiopia Policy /strategy	Climate change relevant components in the policy/Strategy
1. Environmental Policy (1997)	• Provide overall guidance in the conservation and sustainable utilization of Et environmental resources • Promote environment monitoring programs • Foster use of hydro, geothermal, solar, and wind energy to minimize emissio greenhouse gases • Provide coordination and leadership support in conserving and managing er resources • Consider climate change as a cross-cutting and important environmental, so development challenge that needs to be tackled
2. EPACC (Ethiopian Program of Adaptation to Climate Change)	• Adequately captures the growing threat of climate change in Ethiopia and cl the need to mainstream climate change in all spheres of development policy planning at all phases and stages of the planning and implementation proce • Clearly states the urgency of taking practical adaptation and mitigation actio various social and economic sectors. • Role of non-state actors in the planning, design and implementation of activi in the work program is not clearly spelled out.
3. Ethiopian NAMA	• Pays special attention to unleashing the huge potential of the country's wate and geothermal energy resources for the purpose of generating electricity fo transport and household consumption, and managing urban wastes. • Fails to include important mitigation actions in land-use planning, energy effi incentives, and traffic management regulatory policy measures.
4. CRGE (Climate Resilient Green Economy) strategy	• Recommends the use of low carbon solutions to leapfrog other economic realizing the ambitions set out in the country's Growth and Transformation P • Presents an overarching framework to marshal a coherent response to clima generate both innovative thinking and a course of actions to meet the challe associated with the transfer of climate-friendly technologies and finance for t construction of a climate resilient green economy in Ethiopia.
5. GTP (Growth and Transformation Plan)	• Climate change is recognized as a huge threat and opportunity for Ethiopia. • Both climate change adaptation and mitigation issues are considered. • It stipulates the country's ambition to build a climate resilient green economy
6. RDPS (Agricultural and Rural Development Policy Strategies)	• Sustainable Land Management Program (SLMP) as a tool to reduce rural vu and building ecosystem resilience • Environmental rehabilitation • Watershed development for environmental adaptation • Harnessing the multiple benefits of water resources • Integrated disaster risk monitoring and early warning • Use of improved agricultural inputs and modern technologies
7. Energy policy & Biofuels strategy	• Supports energy diversification and the development of modern (renewable) sources • Advocates for hydro-power generation • Recommends biofuel development as important strategy for energy secur change mitigation • However, focuses on hydro- and bio-energy sources

8. Water Policy	• The water sector policy instruments do not factor climate change as a major affecting the amount, distribution, and quality of water resources. But they s important: • Water harvesting and management measures • Flood management • Promotion of equitable water for multiple use
9. Women's Policy (1993)	• Recognizes the critical role and contribution of Ethiopian women to poverty sustainable development • Fails to address the gender dimensions of climate change
10. Health Policy (1994)	• Focuses on health promotion and disease prevention, curative and rehabilit and public health emergency preparedness • Prioritizes the prevention of environmental pollution with hazardous chemic the development of environmental health • Focuses containing and controlling malaria • Does not consider climate change as a major public health threat
11. Climate Change Adaptation Program Plan for Health – (2011-2015)	• Helps to overcome the health risks of climatic change, which the population facing for many years while dealing with health problems raised from climati

Source: from the document entitled "A Climate Change Country Assessment Report for Ethiopia Submitted to Forum for Environment (on behalf of ECSNCC) by *Epsilon* International R&D (132); August 2011, Addis Ababa".

Annex 3: Health effects of Climate Change

	Prediction	General Effects	Specific to Ethiopia
Temperature	Likely to increase	Urban heat island effect, heat stroke/exhaustion, increased risk of cardiovascular disease, with children, elderly and those with preexisting conditions most at vulnerable.	Increased temperatures po to the health of humans an as well as land degradatior likely be exacerbated by pe drought.
Floods	Frequency and intensity likely to increase	Contaminate freshwater supplies, increased risk of water-borne diseases, causes physical injuries, damage homes and infrastructure	Periods of flooding are corr outbreaks of diarrhea, chol dengue, malaria, and other borne diseases.
Droughts	Frequency and intensity likely to increase	Food insecurity, malnutrition, increase in water scarcity, exacerbated by increased temperatures	By the 2090s, drought is ex affect a larger area and occ often and last 6x as long (4
Air Pollution	With a "business as usual" level emissions of ozone and PM, increased temperatures are likely to exacerbate the effects of air pollution.	PM and ozone have been found to have negative health effects, including decreased lung function, asthma, chronic respiratory disease, and increased risk for heart attack	*Studies pertaining specifica Ethiopia are not yet availab*
Wild Fires	Likely to increase with periods of drought and extreme heat	Wildfires will likely be a source air pollution (PM), threaten the safely of humans and livestock, and destroy property/infrastructure.	*Studies pertaining specifica Ethiopia are not yet availab*
Allergens	Suggested that climate change will impact regional allergens from airborne pollens, fungal spores, mold	Possible respiratory effects, allergic airway air pollutants and changes in allergens due to climate change are suspected to worsen allergic disease and asthma.	*Studies pertaining specifica Ethiopia are not yet availab*
Vector Born Disease	Likely to increase transmission seasons and geographic distribution.	Malaria, cholera, Dengue, parasites (STHs)	Malaria will move to highlar 2050 (IPCC). Extreme wea will exacerbate the problem
Zoonotic Diseases	May alter vector dynamics, temporal/spatial distribution, and prevalence	Disease transmission directly or indirectly via contaminated water, food, meat, milk etc. Flooding exacerbates the possibility of disease transmission.	Ethiopia identified as a "hot zoonotic disease events (7
Mental Health	Likely to increase with traumatic climate events	Increase in stress disorders, substance abuse, suicide risk anxiety, and depression.	*Studies pertaining specifica Ethiopia are not yet availab*

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Section IV

Situational Analysis and Needs Assessment:

POLICY, REGULATORY, AND ORGANIZATIONAL FRAMEWORKS IN ETHIOPIA

Establishing a GEOHealth Hub for East Africa

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Summary

Background

The purpose of this theme, Policy, Regulatory, and Organizational Frameworks, is to examine and identify gaps in national policies, regulations, and organizational arrangements that govern Ethiopia's ability to prevent and mitigate the health impacts of air pollution, occupational hazards, and climate change. The report also reviews the capacity of organizations with the mandate to engage in the above areas.

Methods

The assessment includes a comprehensive literature review of peer-reviewed publications and reports and in-depth interviews with key stakeholders. Literature was identified through electronic searches; when necessary, hard copies of past reports were accessed to review. A semi-structured guideline was used to conduct the in-depth interviews aimed at strengthening the situational analysis and identifying gaps.

Findings

Air Pollution

Air pollution relevant policies are incorporated into national constitutional, health, and environmental law. The Constitution of the Federal Democratic Republic of Ethiopia, for example, gives all persons the right to a clean and healthy environment (Article 44/1) and mandates the government to ensure that right (Article 92/1). Federal health policy also addresses prevention of environmental pollution from hazardous chemical wastes (Article 5/3) and calls for cost-effective interventions to prevention land, air, and water pollution using cost-effective strategies (Article 2/2/f).

Proclamation No. 300/2002 of Environmental Pollution Control, Sub-Article 6/1/b, specifies ambient air quality standards and allowable emissions for both stationary and mobile air pollution sources. The 11 regional states in the country are mandated, under Article 15 of the Environmental Organs Establishment Proclamation No. 295/2002, to establish an independent regional environmental agency, or designate an existing agency, for environmental management. Accordingly, each of the regional states has either formed an independent bureau responsible for environmental matters or created a department for the environment in one of their bureaus. However, enforcing mechanisms are almost nonexistent.

Climate Change and Health

In 2011, the federal government initiated the Climate-Resilient Green Economy (CRGE) initiative to protect the country from the adverse effects of climate change and to build a green economy that will help Ethiopia realize its ambition of reaching middle-income status before 2025. However, the only legal provisions in Ethiopia focusing on climate change and associated issues consist of limited content within the country's environmental policy document.

The Ethiopian environmental policy 1997(3/9/a) recognizes the country's sensitivity to climatic variability and promotes a climate monitoring program. Article 3/9/d of the policy document emphasizes the need to actively protect the ozone layer, recognizing the vulnerability of the Ethiopian highlands (which already have a thin protective atmosphere) to potential suffering due to agricultural losses and adverse health effects from additional exposure to ultraviolet rays.

Institutionally, at the federal level there is a ministerial steering committee chaired by the Prime Minister Counselor and hosted by the Natural Resource Management Department in the Ministry of Agriculture. This institutional structure has not yet extended to the regions and other lower administrative levels although there are designated officials in the regional capitals.

Occupational Safety and Health

No national occupational health and safety policies exist. However, article 2/2 of the National Health Policy of 1993 states that emphasis will be placed on the promotion of occupational health and safety in industries and production sectors. The policy also calls for intersectoral collaboration to develop facilities and mechanisms for workers' health and safety in the production sectors (Article 3/9). With regard to the health and safety of workers, the Labor Proclamation No. 377/2003 gave the Ministry of Labor and Social Affairs (MOLSA) the powers and duties to determine and enforce standards and measures, and to collect, compile, and disseminate information.

Labor Proclamation No. 377/2003, under Sub-Articles 1-8 of Article 92, identifies the occupational safety, health, and working environment conditions that should be ensured by the employer and employees to safeguard workers.

Institutionally, the Ministry of Labor and Social Affairs (MOLSA) and its counterparts in the regional states coordinate all aspects of the labor administration system according to the provisions of existing labor laws. They also co-operate directly with other corresponding centers of power in the federal and regional governments.

Acronyms and Abbreviations

AAU	Addis Ababa University
COP	Conference of Parties
CRGE	Climate Resilient Green Economy
DFID	Department for International Development
EPA	Environmental Protection Authority
FDRE	Federal Democratic Republic of Ethiopia
GHG	Green House Gases
IPCC	Intergovernmental Panel on Climate Change
IRI	International Research Institute
LDC	Least Developed Countries
MOH	Ministry of Health
MOLSA	Ministry of Labor and Social Affairs
MRV	Monitoring Reporting and Verification
$MtCO_2e$	Million Metric Tons of Carbon Dioxide equivalent
NAPA	National Adaptation Program of Action
NMA	National Meteorology Agency
OSH	Occupational Safety and Health
UNDP	United Nations Development Program
UNFCCC	United Nations Framework Convention on Climate Change

1. Introduction

International commitments on the environment, development, and health have been observed since the Rio Declaration in 1992 which focused on consequences and potential hazards of the environment-development interaction to human beings (1). The Libreville Declaration on Health and Environment in Africa signed by 52 member countries clearly spelt out the impact of environmental risks on the health of populations and related vulnerabilities. It also provided broad regional directions for mitigating the impact of environmental risks in member countries (2).

Anchored in the Libreville Declaration, a country-specific Situational Analysis and Needs Assessment (SANA) was conducted revealing the importance of inter- linkage between health and the environment as a fundamental shift in thinking. Ethiopia produced its Environmental Health SANA report in 2010. The report highlighted the need for a paradigm shift in understanding and dealing with health and environmental issues, which are often viewed as separate entities. Existing policies and strategies were fragmented, compounded by major gaps, lack of capacity, inability to reach implementers, and lack of harmonization in organizational frameworks (3).

We followed the SANA approach to analyze and present findings of Theme IV: Policy, Regulatory and Organizational Frameworks.

Theme IV examines and identifies gaps in national policies, regulations, and organizational arrangements that govern Ethiopia's ability to prevent and mitigate the health impacts of air pollution, occupational hazards, and climate change. Theme IV also reviews the capacity of organizations with the mandate to engage in the above areas.

Identification and analysis of national policies and regulatory frameworks were identified through a situational analysis and a needs assessment. Resources such as trained personnel, financing, materials/equipment, research laboratories, and physical space were evaluated through interviews and site visits. Gaps in national, regional, and local capacity and the concerns of major stakeholders were identified. This report lists and prioritizes policy development and implementation needs based on overlaps between the findings of the SANA and the cross-cutting nature of the needs. The prioritization in this report is based upon the responses of experts from ministries and the document reviews.

2. Methods

Prior to implementing the SANA effort, the research team discussed and reached consensus on carrying out the activities. An orientation for research assistants (RA) outlined the objectives of the Global Environmental and Occupational Health (GEOHealth) project and trained the principal investigators and RAs in the SANA protocols. A time schedule was designed and each research team member was responsible for his or her assigned tasks.

Data collection for the SANA involved two approaches: a comprehensive literature review and semi-structured interviews with key stakeholders. The comprehensive literature review focused on the collection of all available documents. Due to lack of published documents related to any of the GEOHealth themes, much of the literature reviewed was in the form of unpublished reports accessed directly from ministries and other organizations. Electronic searches were carried out, and, when appropriate, hard copies of reports were accessed.

In-depth interviews were used to strengthen the findings from the literature review for the situational analysis and to identify gaps and/or needs not met by current activities and/or capacity. Interviews were conducted with key leaders or program staff within the ministries and other organizations or agencies based on their role and significance in addressing air pollution, climate change, or occupational health and safety (Table 2). A semi-structured guide was used by the interviewers to conduct the interview.

Once information from the literature review was prepared and the in-depth interviews were conducted, the data were synthesized and the gaps and needs were identified.

3. Assessment Findings: Situational Analysis and Needs Assessment

3.1. Situational Analysis

The following analysis resulted from the literature review and in-depth interviews with key persons at various ministries or agencies:

3.1.1. Air Pollution

Policy

The Federal Democratic Republic of Ethiopia (FDRE) Constitution is the basis for all development-related policies, legal provisions, and related outcomes within the country. Article 44/1 of the Constitution gives all persons the right to a clean and healthy environment, while Article 92/1 states that the government has the duty to ensure this right. Article 92/2 of the Constitution requires that the design and implementation of development programs and projects do not damage or destroy the environment (4).

In addition to the Constitution, federal health and environmental policies address environmental health issues. Article 5/3 of the health policy provides guidelines and directives for prevention of environmental pollution resulting from hazardous chemical wastes (5). The FDRE environmental policy lists the following pollution prevention measures (6) as its main objectives:

- 2/2/f. Prevent the pollution of land, air, and water in the most cost-effective way so that the costs of preventive measures do not outweigh the benefits.
- 3/5/g. Recognize that water resources play an important role in meeting Ethiopia's energy demand and that, and that, by generating power, cause no pollution to the environment;

- 4/8/b. Promote training and improve the working conditions of researchers so that they become technically competent.

Regulatory Framework

The regulatory framework for air pollution control in Ethiopia is provided through two key articles that describe the process of setting environmental air quality standards. Sub-Article 6/1/b of the Environmental Pollution Control Proclamation No. 300/2002 specifies ambient air quality standards and provides emission limits for stationary and mobile air pollution sources (7). Sub-Article 6/4 states that national regional states may, based on their specific situation, adopt environmental standards that are potentially more, but not less, stringent than those determined at the federal level (7).

Institutional Framework

Article 5/1/b of the federal environmental policy calls for multilevel coordination among responsible management bodies (federal to local) to ensure sectoral and cross-sectoral planning and implementation. These bodies include concerned ministry commissions, authorities, and bureaus, including relevant federal executive organizations, as well as regional and municipal governments; elected councilors; non-governmental organizations; community representatives; representatives of professional or other environmental associations; and the private sector (6).

The federal Environmental Protection Authority (EPA) was established by Proclamation No. 9/1995. The Environmental Organs Establishment Proclamation Number (No.) 295/2002 expanded the mandates of EPA and further established it as an autonomous organization. The Proclamation decentralized the original central structure of environmental management (8, 9). Article 15 of the Proclamation calls for each of the 11 national regional states to establish an independent regional environmental agency, or designate an existing agency to lead environmental management. In accordance with this directive, each of the regional states has either formed an independent bureau responsible for environmental matters, or created a department for the environment in one of their bureaus. These regional environmental agencies have important functions with regard to monitoring and enforcing environmental legislation (8). The proclamation also stipulates that all government ministries or agencies should establish an environmental unit to ensure that their activities comply with the environmental standards and laws of the country (8). These units are also expected to promote coordination of environmental matters among ministries and agencies. EPA is responsible for participating in the negotiations of international environmental agreements and to ensure their domestic ratification.

Article 7 of the Environmental Pollution Control Proclamation No. 295/2002 established a specialized body, the Environmental Inspectorate, to enforce existing environmental standards in Ethiopia (7). The Inspectorate has a broad mandate to conduct continuous monitoring and surveillance. Environmental

inspectors are empowered to ensure compliance with environmental standards and related requirements. Critics have challenged this mandate as a violation of the right to privacy as guaranteed by the Constitution.

Strategy

The implementation and specific modalities for the realization of the objectives set by the Constitution and environmental proclamations are yet to be formulated. There are no documents outlining the national or regional strategies that ministries and agencies should adopt to translate existing policies, legal provisions, or guidelines for air pollution into practical programs.

Guidelines

Ambient environmental quality standards are set with a goal of safeguarding public health and protecting the environment (Table 1).

Table 1: Guideline standards for priority ambient atmospheric pollutants (10)

Compound	Guideline value ($\mu g/m^3$)	Average time
Sulphur dioxide	500	10 minute
	125	24 hours
	50	1 year
Nitrogen dioxide	200	1 hour
	40	1 year
Carbon monoxide	100000	15 minutes
	60000	30 minutes
	30000	1 hour
	10000	8 hours
Ozone	120	8 hours
Suspended particulate matter		
PM_{10}	50	1 year
	150	24 hours
$PM_{2.5}$	15	1 year
	65	24 hours
Lead	0.5	1 year

Capacity

The presence of a strong environmental policy in the country provides a key starting point to bring about changes to air pollution and other types of environmental contamination. To implement the policies, however, research, laboratory settings and equipment, training facilities, and technically competent professionals are required. Currently no report describes the number and the capacity of such resources in the country. Several research institutions are engaged in environmental research, including the Ethiopian Health and Nutrition Research Institute, Ethiopian Institute of Agricultural Research, Institute of Biodiversity Conservation (Biotechnology and Bio-safety Department), Armauer Hansen Research Institute (AHRI), Harar Rural Technology Research Centre, Mekelle Appropriate Technology Research Center. There are also laboratories available at the Addis Ababa City Environmental Protection Authority Laboratory and within universities, such as the laboratory at Jimma University.

System Capacity

Strong coordination is lacking among implementers throughout the country to act synergistically on the common problems. More clarity is needed regarding the responsibilities of, and relationships among, federal agencies and regions, and among regions themselves (11). None of the agencies involved in air pollution control have a structural framework that reaches the lower administration levels or even to the regions.

Institutional Capacity

Institutional capacity building in the field of environmental protection is urgently needed. In particular, institutions at the regional level do not have trained/skilled manpower or adequate financial resources to realize their environmental obligations (6, 11). The comprehensive environmental legislation currently in place involves complex and multi-sectoral issues and requires efficient institutional mechanisms to support its implementation (6, 11). Except for one laboratory and the few instruments in the Addis Ababa regional Environmental Protection Authority, there are no research institutions and laboratory set-ups for measuring air pollution levels and other environmental contaminants. Lack of funding is the other major capacity limitation faced by the institutions, constraining their ability to effectively measure and control air pollution.

Individual Capacity

Few qualified air pollution professionals are available in Ethiopia, and the ministries responsible for air pollution control have no trained staff.

3.1.2. Climate Change and Health

Policy

Similar to air pollution, climate change is addressed in Ethiopia's environmental policy through regulations and institutional and programmatic mechanisms. Article 3/9/a of the policy document emphasizes the need for a climate monitoring program as the country is highly sensitive to climatic variability. Article 3/9/c recognizes Ethiopia's environmental, long-term economic interests, and energy interests with regard to the will and ability to minimize atmospheric inputs of greenhouse gases. For example, the energy sector is committed to harnessing hydro-, geothermal, and solar energy, none of which produce significant amounts of pollutant gases. Article 3/9/d of the policy document emphasizes the need to actively protect the ozone layer, recognizing the vulnerability of the Ethiopian highlands (which already have a thin protective atmosphere) to suffer agricultural losses and adverse health effects from additional exposure to ultraviolet rays (6).

Regulatory Framework

The federal environmental policy provides the only legal framework focused on climate change in the country. There are no strategic research plans or policy enforcement mechanisms for its implementation.

Institutional Framework

At the federal level, emphasis is given to climate change and its dynamic, cross-sectoral nature. An inter-ministerial steering committee has been established, chaired by the Prime Minister Counselor and hosted by the Natural Resource Management Department within the Ministry of Agriculture. The

committee also includes representatives from the Ministries of Health, Industry, Water and Energy, and Mines, along with the Environmental Protection Authority. The Department of Natural Resource Management also has technical teams assigned to deal with issues concerning climate change. While the federal structure has not yet extended to the regions and other lower administration levels, there are climate-related focal persons at the regional level.

In addition to the federal government, there are a number of other organizations working on climate change in the country, including Climate Change Forum Ethiopia, Farm Africa, the Norwegian Embassy, the U.K. Department for International development (DFID), the European Union, the United Nations Development Program (UNDP), and others.

Strategy

Ethiopia is already experiencing the effects of climate change, including increases in average temperature and changes in rainfall patterns. This presents the necessity -- and opportunity -- to switch to a new, sustainable development model. The Government of the FDRE has initiated the Climate-Resilient Green Economy (CRGE) initiative to protect the country from the adverse effects of climate change and to build a green economy that will help the country realize its ambition of reaching middle-income status before 2025 (12). The CRGE was developed in 2011 and launched at the 17th United Nations Framework Convention on Climate Change (UNFCCC) in Durban, in 2011 (13). It follows a multi-sectoral approach and has so far identified and prioritized more than 60 initiatives, which could help the country achieve its development goals while limiting 2030 Green House Gases (GHG) emissions to 150 Mt CO_2e – around 250 Mt CO_2e less than estimated under a conventional development path.

The government's green economy plan is based on four pillars (12):

1. Improving crop and livestock production practices to improve food security and raise farmer income while reducing emissions.
2. Protecting and re-establishing forests for economic and ecosystem benefits, including as carbon stocks.
3. Expanding electricity generation from renewable sources of energy for domestic and regional markets.
4. Leapfrogging to modern and energy-efficient technologies in transport, industry, and building design.

Implementing these initiatives would offer important co-benefits. For example, public health would improve through better air and water quality and increased soil fertility, while food security would promote rural economic development (9).

In addition to the CRGE strategy, the National Meteorology Agency (NMA) designed the National Adaptation Program of Action (NAPA), a program within the UNFCCC designed to help Least Developed Countries (LDCs), including Ethiopia, identify their priority adaptation needs and to communicate these needs to the Conference of Parties (COP) of the UNFCCC and other concerned

bodies (14). The Intergovernmental Panel on Climate Change (IPCC) identified the main country determinants of adaptive capacity as economic wealth, technology, information and skills, infrastructure, institutions, and equity. For public health, the current health status and pre-existing disease burdens must be considered (15). NAPA provides a mechanism for LDCs to seek immediate and urgent support to build these capacities and start adapting to the current and projected adverse effects of climate change (14).

Cognizant of the impact climate change can have on the health of citizens in Ethiopia, the federal Ministry of Health has also prepared a "Climate Change Adaptation Program Plan for Health, 2011-2015." This plan provides the foundation for a systematic response across all health systems at national, regional, zone, woreda, and kebele levels (15). The following are response measures identified for the climate change adaptation program (15).

- Develop and disseminate reliable information about potential climate change impacts, vulnerabilities, adaptation options and tools, good practice examples and advantages of adaptation, potential tradeoffs, synergies and conflicts with mitigation, and existing policies to decision makers, stakeholders, and the larger public to raise their awareness.
- Initiate training for health professionals and researchers on the health effects of climate change; ensure that systems are in place to detect and track climate change induced health problems; and make the necessary preparations to respond to, and manage, climate change associated risks.
- Enhance infrastructures specifically designed to reduce vulnerability to climate variability (e.g., flood control structures, air conditioning, building insulation, and stringent building codes) and general public health infrastructures (e.g., sanitation facilities, waste water treatment, water supply systems, and laboratory buildings).
- Build capacity in education, awareness-raising, and the creation of legal frameworks, institutions and an environment that enables people to make well-informed, long-term, sustainable decisions.
- Develop a forward-looking, strong, and unifying vision of health care, as well as an understanding of the problems posed by climate change.
- Train individuals skilled at recognizing, reporting, and responding to health threats associated with climate change, as well as researchers with backgrounds in epidemiology and laboratory sciences to provide a sound basis for surveillance and response.
- Train skilled public health managers, who understand surveillance and diagnostic information, to mobilize the appropriate response.
- Train individuals in the operation, quality control, and maintenance of the public health infrastructure, including laboratory equipment, communications equipment, and sanitation, wastewater, and water supply systems.
- Develop new arrangements and collaborations among institutions to address risks effectively, thereby enhancing adaptive capacity. Nations and international organizations, such as WHO,

can cooperate in coordinating surveillance and response activities to address disease threats more effectively.

- Increase collaboration between the public and private sectors.
- Gain better knowledge of the processes of adaptation decision-making; roles and responsibilities in adaptation of individuals, communities, nations, institutions and the private sector; conditions that stimulate or act as a barrier to adaptation; and what level of certainty is needed for public health decision-makers to act.
- Conduct research on barriers and opportunities for enhancing adaptive capacity in order to protect human health.
- Focus and prioritize response measures to address the groups most vulnerable to climate change during development and execution of policies, strategies, and programs.

Guidelines

There are no guidelines or related documents available concerning climate change.

Capacity

System Capacity

The federal Environmental Protection Authority oversees the major responsibilities related to climate change, although a number of other institutions are involved. There are, however, no specific documents available that state how the various institutions should communicate and cooperate as they undertake various climate change-related actions. Based on our interviews, we found that:

- The National Meteorology Agency, for example, indicated that there is interaction or communication between the agency and the EPA, MOH, International Research Institute (IRI), insurance agencies, and the Ministry of Transportation. Previously a taskforce organized between MOH and NMA was actively engaged in activities related to climate change and health issues.
- The Water and Energy Minister collaborates with Ministries of Agriculture, Finance and Economic Development, Mines, Trade, Transportation, and Education, as well as the Ethiopian Light and Power Agency, Addis Ababa University, and the Science and Technology Institute on climate change and developmental activities. Communication and coordination at the lower administration level, however, is very poor. Consequently, there is inadequate capacity to exchange information among NMA and NAPA project staff and with implementers of the action plans.

Institutional Capacity

No ministry or institution has the capacity to translate the intervention mechanisms into practice on the ground, as there are no laboratory settings or research institutions that deal with climate change. There are, however, some older instruments that may be used to monitor meteorological events and one laboratory is set up in the Addis Ababa Regional Environmental Protection Authority. The capacity limitation is not only restricted to laboratory set-up and research institutions: financial constraints also challenge the work of implementers.

Individual Capacity

The documents reviewed and interviews conducted revealed few highly trained professionals and limited capacity associated with climate change, whether with regard to implementing intervention activities, carrying out research, or providing training. There is no qualified professional at any level of government -- federal, regional or lower administrative levels in any of the ministries -- with expertise in issues related to climate change.

3.1.3. Occupational Safety and Health (OSH)

Policy

In addition to the environmental rights granted by the FDRE Constitution noted above, Article 42/2 guarantees workers the right to a healthy and safe work environment. Under Proclamation No. 4/1995, MOLSA is given the power to determine standards and measures for the safety and health of workers and to follow up on their implementation; and to collect, compile and disseminate information on safety and health of workers (16). There is, however, no national OSH policy outlining how occupational safety and health should be handled nationally or at lower governing levels as required by the international Occupation Safety and Health and Working Environment Convention No. 155/1981, of which Ethiopia is a signatory. There are, however, other policies that have some relevance to the promotion and necessity of OSH services development (17).

The national health policy of 1993, for example, has clearly indicated principles that directly deal with OSH issues. Article 2/2 states that emphasis will be made to promote OSH in the industry and production sectors. Article 3/9 states that inter-sectoral collaboration is required to develop facilities and mechanisms for workers' health and safety in the production sectors (5, 17).

Currently an occupational safety and health policy is under consideration for approval by the House of People's Representatives that accounts for Ethiopia's obligations under international conventions and other OSH-related agreements.

Regulatory Framework

Occupational safety, health, and workplace regulations are available in two proclamations. The Food, Medicine and Health Care Administration and Control Proclamation No. 661/2009 article 23/1 states that any employer shall ensure the availability of occupational health services to his/her employees. Article 23 sub-article 2 of the same proclamation states that the executive organ shall issue appropriate directives on occupational health and use of machinery (18). Labor Proclamation No. 377/2003, under Sub-Articles 1-8 of Article 92, describes the following occupational safety, health, and working conditions (19):

> An employer shall take the necessary measure to safeguard adequately the health and safety of the workers; he shall in particular:
>
> 1. Comply with the occupational health and safety requirements provided for in this Proclamation;
> 2. Take appropriate steps to ensure that workers are properly instructed and notified concerning the hazards of their respective occupations and the precautions necessary to avoid accident and injury to health; ensure that directives are given and also assign safety officer; establish an occupational, safety and health committee of which the committee's establishment, shall be determined by a directive issued by the Minister;
> 3. Provide workers with protective equipment, clothing and other materials and instruct them of its use;
> 4. Register employment accident and occupational diseases and notify the labor inspection of same;
> 5. Arrange, according to the nature of the work, at his own expense for the medical examination of newly employed workers and for those workers engaged in hazardous work, as may be necessary.
> 6. Ensure that the work place and premises do not cause danger to the health and safety of the workers;
> 7. Take appropriate pre-executions to insure that all the processes of work shall not be a source or cause of physical, chemical, biological, ergonomical and psychological hazards to the health and safety of the workers;
> 8. Implement the directives issued by the appropriate authority in accordance with this Proclamation.

Institutional Framework

According to the provisions of existing labor laws, the Ministry of Labor and Social Affairs and its counterparts in the regional states coordinate all aspects of the labor administration system (17). The Minister provides the political and executive leadership, while the State Minister and heads of the Occupational Safety, Health and Working Environment Department, as well as employment services, provide technical leadership and oversee the appropriate implementation of the law under the scope of their responsibilities. They propose policy and legislation-related instruments, undertake studies, and monitor how the system is operating in all matters of labor administration (17).

They also cooperate directly with other corresponding centers of power in government, namely other lead agencies such as the MOH, the Ministries of Agriculture and Rural Development, Finance and Economic Development, Education, and Justice, as well as the Supreme Court, the EPA, the Radiation Protection Authority, and the Quality and Standardization Authority (17).

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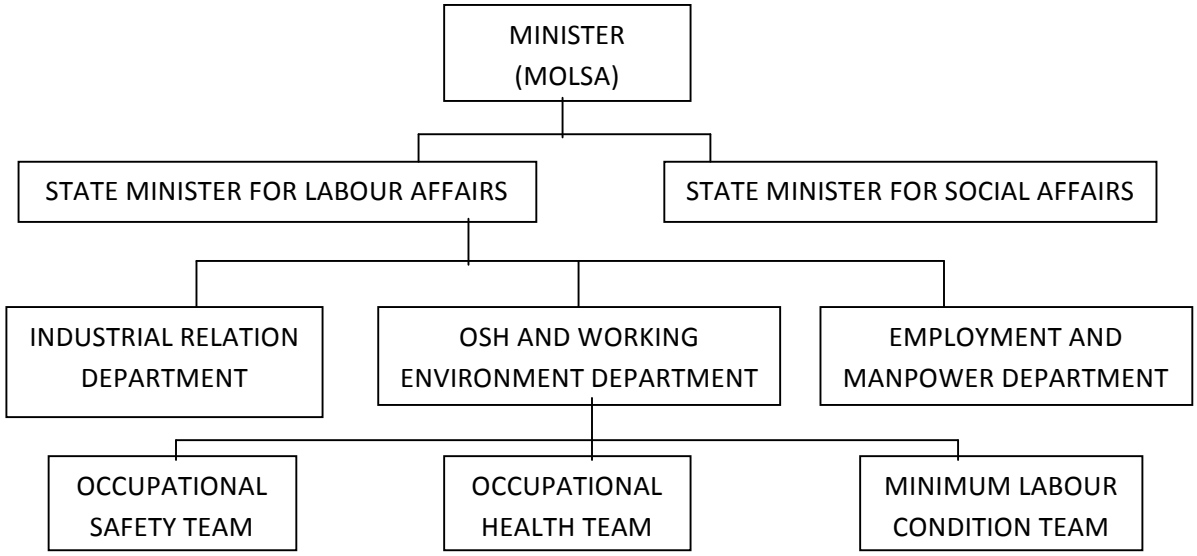

Source: Solomon Yimer and Chris Keil, Ethiopian Occupational Health and Safety Regulatory Environment

Figure 1: Federal level organizational structure of the Ministry of Labor and Social Affairs

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Strategy

With regard to OSH, only directive documents are available, which, according to the experts interviewed, require revision to account for current developments and associated new technologies, and health outcomes.

Guidelines

There are no existing guidelines to monitor and evaluate the safety and health of the occupational environment.

Capacity

System Capacity

While there are no guidelines regarding how various sectors or ministries should communicate and share their responsibilities, MOLSA officials indicated that they co-operate directly with other corresponding centers of power within the government (17).

Institutional Capacity

Documents regarding the availability and capacity of research institutions and laboratories established to address OSH-related issues are lacking. However, from the interviews conducted, there appears to be a wide gap in the availability of research institutions, laboratory settings, logistics, and financial resources to implement the required activities.

Individual Capacity

The Ministry of Labor and Social Affairs identified the lack of experienced and skilled professionals as the most significant problem in carrying out its duties. Most of the available inspectors are generally well-trained in basic sciences, but lack specialized OSH training (16). It was also established during the interview process that university training and other training opportunities are not yet targeting their needs and therefore inspectors are not able to use the measuring instruments appropriately to carry out their monitoring and evaluation responsibilities.

3.2. Identified Gaps

Based on the reviewed documents and interviews conducted with various ministry officials, gaps, constraints, and needs are identified and described according to each ministry or sector.

National Meteorology Agency

Gaps/Constraints

- Lack of technically skilled human power/ professionals.

- High turnover of those skilled professionals, either to employment abroad or to other organizations.
- Inadequacy of cross-sectoral links among ministries and departments.
- Lack of a strong coordination mechanism at both the federal and regional levels.
- Lack of inter-office links among those federal and regional sector offices involved in the environment and development.
- Lack of awareness regarding the concepts and advantages of related meteorological issues.
- Absence of well-organized research institutions involved with climate change adaptation and associated possible outcomes.
- Lack of efficient outreach mechanisms on the environment to local communities.

Ministry of Health

Gaps/Constraints:

- No clear understanding by the relevant groups of the difference between environmental health and environmental protection.
- Lack of coordination with assigning professionals to the appropriate environmental health activities; for example, pharmacists are currently recruited for the inspection of food and drinking establishments.
- Lack of political commitment to a strong department of environmental health; consequently, no department is responsible in the FMOH and the Addis Ababa City Administration. Within the ministry, attention to air pollution and climate change is deficient.
- No clear job descriptions, as the organizational structure of the department is already combined with other units or directorates.

Environmental Protection Authority

Gaps/Constraints:

- Capacity issues -- both human power and facilities -- present challenges at regional and lower levels.
- Moving down from the regional levels, environmental protection activities are carried out by various implementers, resulting in lack of clarity regarding responsibilities and leading to less emphasis on critical issues.
- There is an absence of indicators and standards.
- Lack of awareness and less attention to climate change issues is a problem at lower administrative levels.
- There has been no intensive research and monitoring on the status and trends of pollution in Ethiopia's major cities, including Addis Ababa.
- No local research has been carried out regarding climate change issues.

Ministry of Agriculture

Gaps/Constraints:

- Lack of awareness about climate change.
- Resource scarcity (logistics and financial) to carry out various interventions on climate change.
- Gaps in technology, including knowing what type of technology is required for the current conditions associated with climate change and the technical skills to choose and apply the knowledge.
- Poor inter-sectoral collaboration to address the complex nature of climate change.
- Absence of monitoring, reporting, and verification (MRV) mechanisms.
- Lack of integration with research institutions, as the research centers emphasize production but still need to incorporate climate change and related issues in their routine activities.
- Lack of opportunities to inform and share climate change information at conferences, meetings, symposiums, and else GEOHealth
- A scarcity of human resources at both the qualitative and quantitative levels, to deal with adaptation and mitigation as they relate to climate change.
- Lack of research carried out on climate change and related issues.

Ministry of Water Resources and Energy

Gaps/Constraints:

- Lack of skilled and experienced professionals.
- No baseline data or information on the amount of CO_2 released or discharged into the environment by various industries or factories.
- No research centers that conduct studies to evaluate different adaptation and mitigation activities.
- No indicators to determine carbon emission reduction.
- No indicators to determine the effectiveness of the intervention on efficient stove distribution and improved housing conditions, and its associated health improvements.
- Financial and logistic scarcities.

Ministry of Labor and Social Affairs

Gaps/Constraints:

- Lack of appropriately skilled professionals.
- Absence of monitoring and evaluation tools and therefore an absence of consistency and scientific rigor.

- Lack of training for professionals on the use and maintenance of the few available instruments.
- Overlap of responsibilities in some areas, as the advisory and inspection activities are carried out by the same individual.
- Lack of evaluation procedures even in circumstances governed by a current regulation.
- No systems for pre-employment health evaluations or occupational disease identification.
- Training gaps, as training at both university level courses and short-term instruction given by different agents are not need-based.
- Research gaps, as no relevant studies have been conducted on those sectors needing special attention, including the horticulture, mining, textile, and construction. Health hazards that could result from new construction associated with development should also be investigated.
- No evidence-based information regarding costs of health problems that result from work and work environments.
- Absence of an accident and emergency registration system or reporting mechanism.

3.3. Needs assessment

3.3.1. **Identified Needs**

National Meteorology Agency

Needs:

The following needs are fundamental to the mission of the NMA.

- There should be effective interaction between universities and NMA for research and training activities.
- There must be practice-based training at the universities so that their graduates acquire the required skills.
- There should be a mechanism to assist in retaining those professionals who might otherwise leave their employment and possibly Ethiopia.
- There is a need for establishing a national center for climate change adaptation and other associated factors.
- The training curriculum should include meteorological and climate concepts, with related basic education at the primary, secondary, and tertiary levels of the teaching sectors.
- Teachers with knowledge and training in meteorology and climate studies are needed at all educational levels.
- There is a need for NMA to avail itself of advanced technologies to measure air pollutants in the atmosphere and monitor meteorological events.

Needs:

- Establish a self-sufficient environmental health authority or agency to run the activities accordingly.
- Establish an organizational framework for environmental health that runs from the federal to the woreda levels.
- Assign duties, accountability, and responsibility to the ideal environmental health professionals.
- Provide research and training opportunities on data quality, program evaluation, and cause identification related to environmental health conditions.

Environmental Protection Authority

Needs:

- Establish certified external environmental auditing centers or consultancy institutions.
- Establish air pollution monitoring stations at various sites in Ethiopia's cities.
- Establish laboratories in different regions of the country.
- Conduct research that shows the status and trends of air pollution in Addis Ababa.
- Conduct research on control mechanisms and interventions.
- Conduct research on climate change and its associated health problems.
- Train professionals on issues relating to air pollution and to climate change.
- Create awareness in the communities about the hazards of burning of plastic waste and rubber.

Ministry of Agriculture

Needs:

- Create awareness of climate change and its associated outcomes at all levels.
- Build the capacity of the ministry in the areas of facilities and technological provision.
- Provide financial and logistic support.
- Conduct research on climate change and its related possible outcomes.
- Train professionals about climate change, adaptation, and mitigation.
- Provide efficient machines for energy production.

Ministry of Water Resources and Energy

Needs:

- Recruit knowledgeable, skilled, and experienced professionals.
- Provide various training opportunities on air pollution and climate change issues, at both the basic knowledge and technical capacity levels.
- Conduct baseline research, as baseline information on air pollution and climate change is lacking.
- Formulate indicators to measure change and achievement of interventions.
- Evaluate the impact of interventions to improve public health issues.

Ministry of Labor and Social Affairs

Needs:

- Improve the capacity of professionals by providing need-based training.
- Conduct need-assessment research to target need-based training.
- Conduct research at different institutions to evaluate the health conditions of the workers.
- Conduct baseline research on newly constructed developmental projects.
- Conduct research to evaluate the economic burden of health problems that result from poor work environments.
- Assign different professionals to advisory and inspection duties.
- Organize systems to evaluate pre-employment health conditions of workers and to identify occupational diseases by collaborating with ministry of health.
- Organize a country-wide registration system for work-related accidents and emergencies.

4. Priority Gaps

- There is a shortage of skilled human resources at all levels, including a lack of those with specific skills to operate equipment and manage problems related to occupational health and safety, climate change, and air pollution.
- There is a lack of evidence and research activities related to air pollution, climate change, and occupational health. Data are limited in all three areas. In the context of Ethiopia's growing industrialization, no baseline data or surveillance systems, other than a few studies of particular factories, are available.
- Coordination and integration among the different stakeholders is poor. The structure and the regulation between different ministries exist, but the implementation has been minimal at best.
- There is minimal awareness among the public, implementers, and decision makers of contemporary problems such as the health impacts of climate change, air pollution, and occupational and workplace hazards.
- Poor monitoring and documentation of activities persist. Documents and data are not available in most organizations, and monitoring and evaluation activities are limited.
- There is inadequate linkage between training institutions and skills required by the ministries. No forums are available for engaging universities and the different stakeholders in curriculum design and joint research activities.
- There is no budget allocated or facilities designated for laboratories, research, or surveillance.

5. Priority Needs for Intervention

Identified Needs

- Training professionals (both undergraduate and graduate) should be prioritized at the national level for instruction on occupational health, climate change, and air pollution.

- Align training curricula with the country's needs. The universities and stakeholder ministries should design need-based curricula together.
- Generate evidence and establish research and surveillance sites and control stations in various sites in Addis Ababa to monitor particulate matter, emitted gases, and other pollutants. Encourage industries/factories to establish their own stations and to document and report their findings to the concerned ministries.
- Increase awareness of the public and of decision makers regarding climate change, air pollution, and occupational health, and improve documentation of the related activities
- Set indicators for monitoring and evaluating climate change and occupational health and safety, and establish systems to implement policies and regulations.
- Establish mechanisms of accountability and systems of coordination at national and organizational levels.

6. Conclusions

Results of the situational analysis and needs assessment of the policies, regulations, and regulatory framework show a number of major common constraints in addressing air pollution, occupational health and safety, and climate change and health.

While many policies and regulatory provisions are already on paper, there is a lack of persistence in implementing the policies/strategies and effecting the regulatory provisions. Observation points to the lack of linkage among the various institutions charged with addressing the complexity of the problems and needs related to health, development, and the environment.

The results of the situational analysis indicate that there are cross-cutting gaps in the various sectors. Among these, shortage of skilled personnel is an urgent priority. Most of the stakeholders suffer from acute shortages of professionals and poor retention mechanisms.

Research activities to date in air pollution, occupational health, and climate change as related to health are minimal. Consequently, evidence based decision-making and monitoring and evaluation are hampered.

Each of the four themes in the SANA is defined by its complexity and multi-sectoral nature; however, mechanisms for coordination and integration are mostly on paper and nonfunctioning in reality. Lack of such mechanisms reduces the engagement of the different stakeholders mandated by the government.

The linkage between universities and concerned ministries indicates a mismatch between what the training institutions are producing and the specific skills required by the ministries, along with poor awareness among many sectors of the related challenges. Furthermore, poor documentation compounds minimal monitoring and evaluation activities.

Based on the findings of the situational analysis and needs assessment, the following are underscored:

- To design interventions focusing on capacity building, such as aligning curricula with specific needs of ministries and equipping professionals with the necessary technical skills.
- To build research capacity to improve evidence-based decision-making and enhance surveillance systems for monitoring and evaluation.
- To clarify implementation guidelines, procedures of accountability, and coordination mechanisms as required by existing policies and regulations.
- To develop mechanisms for raising awareness in the respective sectors, including policymakers and the public at large.

7. Strengths and Limitations

Strengths

This is the first attempt to address the macro level conditions of policies, regulations, and organizational frameworks for identifying gaps and needs at national level. The use of the SANA approach has helped in preparing the tools for future evaluations. It represents an international collaboration involving many national stakeholders, key professionals, and acclaimed researchers.

Limitations

Given the lack of related information available, regional governments were not addressed in the needs assessment.

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9. Annexes

Annex 1: Key informant Background for GEOHealth hub SANA interview

Name of organization	Name of informant	Position of key informant	Phone number	Remarks
MOH	Mebiratu	Monitoring and Evaluation Officer	0913070097	
MOH	Dagne Taddesse	Monitoring and Evaluation Officer	0911389541	
MOH	Chanie			
EPA	Mehari Wondmagegne	Monitoring and Evaluation Directorate Director	0911689132	
EPA	Dereje Agonafir	Environmental Units Program Directorate Director	0911416684-M 0116476499-O	
MOA	Sertse Sibuh	CRDE coordinator	0912734713	
WAEM	Alemayehu Tafesse	EIA and Social development Officer	0911413311	
WAEM	Sahile Tamiru	Energy Study and Development Follow up Directorate	0912425094	
NMA	Tesfaye Gissila	Meteorological research and Study Directorate Director	0911071486	
MOLSA	Fekade G/Michael		0911894373	
MOLSA	Mesfin Yilma		0911611884	
MOLSA	Fitsum G/Michael		0911916125	
PHEM	Abel Yeshaneh	Public Relation Officer	0911453054	

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Annex 2: Proclamations that have relation with environmental protection and environmental health

No	Proclamation/Regulation No and Date	Title	Sources
1	Proc. No. 9/1995	Proclamation to Provide for the Establishment of the Environmental Protection Authority	Federal Negarit Gazeta Of the Federal Democratic Republic of Ethiopia, 1st Year No.9 Addis Ababa-24th August, 1995.
2	Proc. No. 295/2002	Environnemental Protection Organs Establishment Proclamation	Federal Negarit Gazeta Of the Federal Democratic Republic of Ethiopia, 9th Year No.7 Addis Ababa-3rd October, 2002.
3	Proc. No. 299/2002	Environmental Impact Assessment Proclamation	Federal Negarit Gazeta Of the Federal Democratic Republic of Ethiopia, 9thYear No. 11 Addis Ababa 3rd December, 2002
4	Proc. No. 300/2002	Environmental Pollution Control Proclamation	Federal Negarit Gazeta Of the Federal Democratic Republic of Ethiopia, 9thYear No. 12 Addis Ababa3rd December,2002
5	Proc. No. 655/2009	Biosafety Proclamation	Federal Negarit Gazeta Of the Federal Democratic Republic of Ethiopia, 1st Year No. 63 Addis Ababa 9th September,2009
6	Reg. No. 159/2008	Prevention of Industrial Pollution Council of Ministers Regulation	Federal Negarit Gazeta Of the Federal Democratic Republic of Ethiopia, 15th Year No. 14 Addis Ababa 7th January,2009
7	Proc. No. 200/2000	Public Health Proclamation	Federal Negarit Gazeta Of the Federal Democratic Republic of Ethiopia, 6th Year No. 28 Addis Ababa 9th March, 2000
8	Proc. No. 661/2009	Food, Medicine, Health Care Administration and Control Proclamation	Federal Negarit Gazeta Of the Federal Democratic Republic of Ethiopia, 16th Year No. 9 Addis Ababa 13th January, 2010
9	Proc. No. 377/2003	Labor Proclamation	Federal Negarit Gazeta Of the Federal Democratic Republic of Ethiopia, 10th Year No. 12 Addis Ababa 26th F1ebruary 2004
10	Proc. No. 575-2008	Ethiopian Wildlife Development and	Federal Negarit Gazeta Of the Federal Democratic Republic of Ethiopia, 14th Year No 31. Addis Ababa 22nd May, 2008

		Conservation Authority Establishment	

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Annex 3: Guidelines for Air Quality: Compounds with Non-Carcinogenic Health Endpoints (7)

Compound	Guideline Value (GV) or Tolerance Concentration (TC) µg/m³	Averaging Time
Acetaldehyde	2 000 (TC)	24 hours
	50 (TC)	1 year
Acrolein	50 (GV)	30 min
Acrylic acid	54 (GV)	1 year
2-Butoxyethanol	13100 (TC)	1 week
Cadmium	5×10^{-3} (GV)	1 year
Carbon disulphide	100 (GV)	24 hours
	20 (GV) odour annoyance	30 min
Carbon Tetrachloride	6.1 (TC)	1 year
1,4 Dichlorobenzene	1000 (TC)	1 year
Dichloromethane	3000 (GV)	24 hours
Diesel exhaust	5.6 (GV)	1 year
Ethylbenzene	22 000 (GV)	1 year
Fluorides	1 (GV)	1 year
Formaldehyde	100 (GV)	30 min
Hydrogen sulphide	150 (GV)	24 hrs
	7 (GV) Odour annoyance	30 min
Manganese	0.15 (GV)	1 year
Mercury, inorganic	1 (GV)	1 year
Methyl Methacrylate	200 (TC)	1 year
Monochlorobenzene	500 (TC)	1 year
Styrene	260 (GV)	1 week
	7 (GV) Odour annoyance	30 minutes
Tetrachloroethylene	250 (GV)	24 hours
	8000 (GV) Odour annoyance	30 minutes
Toluene	260 (GV)	1 week
	1000 (GV) Odour annoyance	30 minutes
1,3,5 Trichlorobenzene	200 (TC)	1 year
1,2,4 Trichlorobenzene	50 (TC)	1 year
Vanadium	1 (GV)	24 hours
Xylenes	4800 (GV)	24 hours
	870 (GV)	1 year

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Annex 4: Guideline for Air Pollutants with Carcinogenic Health Endpoints (7)

Compound	Average ambient air concentration $\mu g/m^3$	Health endpoint	Unit risk $[\mu g/m^3]^{-1}$	cla
Acetaldehyde	5	Nasal tumours in rats	$(1.5\text{-}9) \times 10^{-7}$	
Acrylonitrile	0.01-10	Lung cancer in workers	2×10^{-5}	
Arsenic	$(1\text{-}30) \times 10^{-3}$	Lung cancer in exposed humans	1.5×10^{-3}	
Benzene	5.0-20.0	Leukaemia in exposed workers	$(4.4\text{-}7.5) \times 10^{-6}$	
Benzo[a]pyrene		Lung cancer in humans	8.7×10^{-2}	
Bis(chloromethyl)ether	No data	Epitheliomas in rats	8.3×10^{-3}	
Chloroform	0.3-10	Kidney tumours in rats	4.2×10^{-7}	
Chromium VI	$(5\text{-}200) \times 10^{-3}$	Lung cancer in exposed workers	$(1.1\text{-}13) \times 10^{-2}$	
1,2-Dichloroethane	0.07-4	Tumour formation in rodents	$(0.5\text{-}2.8) \times 10^{-6}$	
Diesel exhaust	1.0-10.0	Lung cancer in rats	$(1.6\text{-}7.1) \times 10^{-5}$	
ETS	1-10	Lung cancer in exposed humans	10^{-3}	
Nickel	1-180	Lung cancer in exposed humans	3.8×10^{-4}	
PAH (BaP)	$(1\text{-}10) \times 10^{-3}$	Lung cancer in exposed humans	8.7×10^{-2}	
1,1,2,2-Tetrachloroethane	0.1-0.7	Hepatocellular carcinomas in mice	$(0.6\text{-}3.0) \times 10^{-6}$	
Trichloroethylene	1-10	Cell tumours in testes of rats	4.3×10^{-7}	
Vinychloride	0.1-10	Hemangiosarkoma in exposed workers. Liver cancer in exposed workers	1×10^{-6}	

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Overall conclusions

The FOUR core sections shared same and consistent findings. The sectoral areas of GEOHealth, which includes air pollution, occupational health and safety, and climate change faced the following gaps and challenges

1. Organizational gaps: the capacity to accommodate adequate number and type of professionals
2. Research capacity: the ability of running independently researches
3. Training gaps: the present health professionals and experts do not fit to manage environmental exposure assessment
4. Limited capacity: this is in terms of accessing and using equipment and laboratory settings needed for environmental exposure assessment
5. Policy and regulatory gaps: although this is not as serious as the above ones, there is a need to have updated policy on OSH.
6. Monitoring and Evaluation gaps: there is limited and institutionalized monitoring of key indicators in the field of GEOHealth themes. Such key issues include ambient air monitoring, monitoring the level of hazards in occupational settings, and injury among industrial workers