MADAGASCAR
HEALTH AND POLLUTION ACTION PLAN

Accelerating the Implementation of Actions to Reduce Pollution-Related Illness

MINISTERE DE L'ENVIRONNEMENT ET DES FORETS

Ministère de la Santé Publique

GAHP
GLOBAL ALLIANCE ON HEALTH AND POLLUTION
Partnering to rid the world of toxic hotspots

UNIDO

European Commission

Acknowledgements

Leadership
The Health and Pollution Action Plan process was led by the Madagascar Ministry of Environment, Ecology, and Forests, the Madagascar Ministry of Public Health, and by Facilitators from Pure Earth, serving as the Secretariat of the Global Alliance on Health and Pollution.

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- Madagascar Ministry of Public Health
- Madagascar Ministry of Water, Sanitation and Hygiene
- Madagascar Ministry of Foreign Affairs
- Madagascar Ministry of Agriculture and Animal Husbandry
- Madagascar Ministry of Energy and Hydrocarbons
- Madagascar Ministry of Transportation and Meteorology
- Madagascar Ministry of Mines and Petroleum
- Madagascar Ministry of Industry and Private Sector Development
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About the Global Alliance on Health and Pollution

The Health and Pollution Action Plan (HPAP) program is an initiative of the Global Alliance on Health and Pollution (GAHP). GAHP is a global collaborative body that assists low- and middle-income countries to take concrete action to reduce the impacts of pollution on health. GAHP members include more than 40 national ministries of health and environment, development banks, United Nations organizations, other bilateral and multilateral groups, universities and non-governmental organizations. The Ministry of Environment, Ecology and Forests of the Republic of Madagascar is a member of GAHP. The current GAHP Secretariat is the New York-based non-profit organization, Pure Earth. More information about GAHP is available at www.gahp.net.

Abbreviations

AQ – Air quality
BLL – Blood lead level
DALY – Disability Adjusted Life Year
GAHP – Global Alliance on Health and Pollution
GBD – Global Burden of Disease
GDP – Gross Domestic Product
GNI – Gross National Income
HPAP – Health and Pollution Action Plan
MEEF – Ministry of Environment, Ecology, and Forests
MPH – Ministry of Public Health
PM – Particulate matter
PCB - Polychlorobiphenyl
POP – Persistent Organic Pollutant
TSIP – Toxic Sites Identification Program
UNDP – United Nations Development Programme
UNICEF – United Nations Children's Fund
UNIDO – United Nations Industrial Development Organization
USAID – United States Agency for International Development
WASH – Water, Sanitation and Hygiene
WHO – World Health Organization

Purpose and Use of this Document

The Madagascar Health and Pollution Action Plan (HPAP) has three core elements: 1) a description of the process used to prioritize issues and create the Plan; 2) descriptions of pollution challenges and associated health impacts that were identified as priorities through the consultative and analytical process; and 3) brief recommended actions, programs, and projects that would reduce the impacts on public health from priority pollution issues.

The HPAP document is not an exhaustive review of all pollution challenges facing Madagascar. Rather, it is a concise summary of key issues that are prioritized because they either have a significant impact on public health, or are severely understudied and represent gaps in our knowledge or response.

Attached to this HPAP document are concept notes that can be used to guide the development of proposals and programs to addressi priority pollution issues. These are outlines that require further consideration before a full proposal is developed.

Finally, the HPAP document contains vital data on the severity and impacts from pollution that can and should be used to elevate pollution both internally within government decision-making processes and externally in discussions with development partners. International experience shows that national pollution challenges are unlikely be tackled at scale until the issue is recognized as a priority by senior political leadership and is mainstreamed in national and international planning processes.

Executive Summary

Nearly one in three people in Madagascar die prematurely as a result of exposure to pollution. Exposures to contaminated air, water and soil are now the country's leading risk factors contributing to death and disease. The Health and Pollution Action Plan (HPAP) is a joint program between relevant national ministries in Madagascar and the Global Alliance on Health and Pollution (GAHP) to analyze pollution challenges and advance concrete actions to reduce impacts on public health.

Goals and Outputs of the Health and Pollution Action Plan

The HPAP program assists governments of low- and middle-income countries to develop and implement concrete actions to address pollution-related health challenges. The HPAP program aims to:

1. Assist governments to identify, evaluate and prioritize existing pollution challenges based on health impacts
2. Establish pollution as a priority for action within national agencies and development plans
3. Define and advance concrete interventions to reduce pollution exposures

HPAP Process in Madagascar

The Ministry of Environment, Ecology, and Forests (MEEF) is a longstanding member of GAHP. In 2016, MEEF requested assistance from GAHP for pollution analysis and action planning in the form of an HPAP. In April of 2017, MEEF and GAHP hosted HPAP Inception Meetings in Antananarivo, presided over by the Minister of Environment, Ecology and Forests, and formed a national Working Group comprised of representatives from nine ministries to oversee and guide the HPAP process with GAHP Facilitators. The Working Group met six times during the HPAP process to discuss priorities and solutions, and to provide inputs to the HPAP drafts. In September of 2018, the Working Group and GAHP Facilitators presented a draft HPAP document to the relevant ministries and other stakeholders for comment and validation.

Economic Costs from Pollution in Madagascar

Diseases resulting from pollution are estimated to have cost Madagascar between US $117M and $166M in 2015 due to lost productivity, the equivalent of 1.2% to 1.7% of the country's Gross Domestic Product. This percentage is higher than Sri Lanka (0.26% to 0.30%), a lower-middle income island state with a similar population size, and Mozambique (0.83% to 1.1%), a lower income country with a similar population size and Madagascar's closest neighbor.

In Madagascar, the welfare damages from pollution-attributable diseases equaled US $873M, or 8.6% of the Gross National Income for 2015. These

figures underestimate the true total cost from pollution because they do not include the costs of healthcare services associated with caring for people who are sick due to pollution-attributable diseases. To once again put these figures in context, welfare damages from pollution-attributable diseases represented just 5.8% of GNI in Sri Lanka and 6.8% in Mozambique for the same year. National data on direct healthcare spending used to treat pollution-attributable diseases is not available in Madagascar. However, just 0.12% of the country's health budget goes towards disease prevention more generally, which would include addressing environmental risk factors. This percentage falls far below the average of 30% among Libreville Convention signatories who reported this figure.

Health Impacts from Pollution in Madagascar

Polluted air, water and soil cause more death and disease in Madagascar than any other risk factor. In 2016, diseases resulting from exposures to contaminated air, water, and soil were responsible for 31.3% of all deaths nationally. The next leading risk factors were malnutrition, responsible for 22.9% of deaths, and metabolic risks, responsible for 17.5%. Among pollution issues, household (indoor) air pollution was responsible for 10.7% of all deaths, outdoor air for 4.3%, unsafe water for 8.1%, unsafe sanitation for 7.4, lead exposures for 0.5%, and occupational exposures to carcinogens for 0.4%. However, the health impacts caused by exposures to chemical contamination are poorly understood. Burden of disease data is not available for exposures to heavy metals beyond lead, nor for persistent organic pollutants or other chemicals. It is reasonable to assume that the total rates of death and disease from chemical pollutants are several times greater than the estimates for lead.

Priority Pollution Issues and Concept Notes

Priority pollution issues for Madagascar were selected because of their known impacts on health or because there are significant gaps in the current understanding or response. The following priority pollution issues were identified by HPAP Working Group:

1. Reducing health impacts from household air pollution

2. Reducing health impacts from ambient outdoor air pollution

3. Reducing health impacts from contaminated sites and exposures to chemicals

Concept notes describing potential projects to address each of these issues are included in this report. These concept notes can serve as the foundation for full proposals for national or international funding.

Public Policy and Political Leadership Recommendations

The HPAP includes a number of recommendations on public policy and political leadership that are aimed at increasing the financial and technical resources available for pollution control. The highest priority recommendations include:

1. A clear statement from the President to the Cabinet and the public that pollution is a leading cause of death and disease in Madagascar and a national priority that will be mainstreamed into decision-making in all relevant ministries.

2. The inclusion of pollution as a national priority in internal development plans as well as national development strategy documents created for international development partners and other aid donors.

3. Giving clear responsibility and the necessary resources to a specific body for monitoring pollution challenges, advising on actions, and reporting on progress.

Conclusions

Public health risks are changing rapidly in Madagascar. Whereas malnutrition and communicable diseases once dominated the public health agenda, pollution is now a key driver of death and disease. To combat this trend, policy-makers must recognize and prioritize pollution challenges and incorporate pollution control into national development plans, policies and programs.

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Global Developments in Pollution and Health

Sustainable Development Goals

Global attention to the impacts of pollution has increased in recent years. In 2015, pollution was specifically included in the United Nations global development goals for the first time. The 2030 Agenda for Sustainable Development includes 17 Sustainable Development Goals (SDGs). Within Goal 3 on Healthy Lives, Target 3.9 aims to “by 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination” (United Nations General Assembly, 2015).

Climate Change and Health

Growing concern over the implications of climate change, including its impacts on public health, is reflected in recent global commitments like the Paris Agreement and the United Nation’s New Urban Agenda. While not the focus of the current report, there are certainly links between climate change and the environmental health issues identified through the HPAP process, both globally and for Madagascar specifically. For example, air pollution has been identified as a key area of climate-related health risk in Madagascar, and is also a priority concern in the HPAP (WHO & World Bank, 2018). This convergence provides further impetus to address these issues holistically and in a timely manner.

Global Burden of Disease Data

Part of the increased attention on pollution is due to improved data about pollution’s impacts on public health and economic development. Agencies such as the World Health Organization (WHO) and the Institute for Health Metrics and Evaluation (IHME) have conducted increasingly sophisticated studies of the Global Burden of Disease (GBD). These studies show that pollution is now responsible for between nine million and thirteen million deaths annually, and is one of the leading risk factors causing premature death in the world (Landrigan et al., 2017). The percent of deaths attributable to pollution across all countries is captured in Figure 1. The HPAP analysis of health impacts in Madagascar relies primarily on data from the IHME GBD study (IHME, 2016).

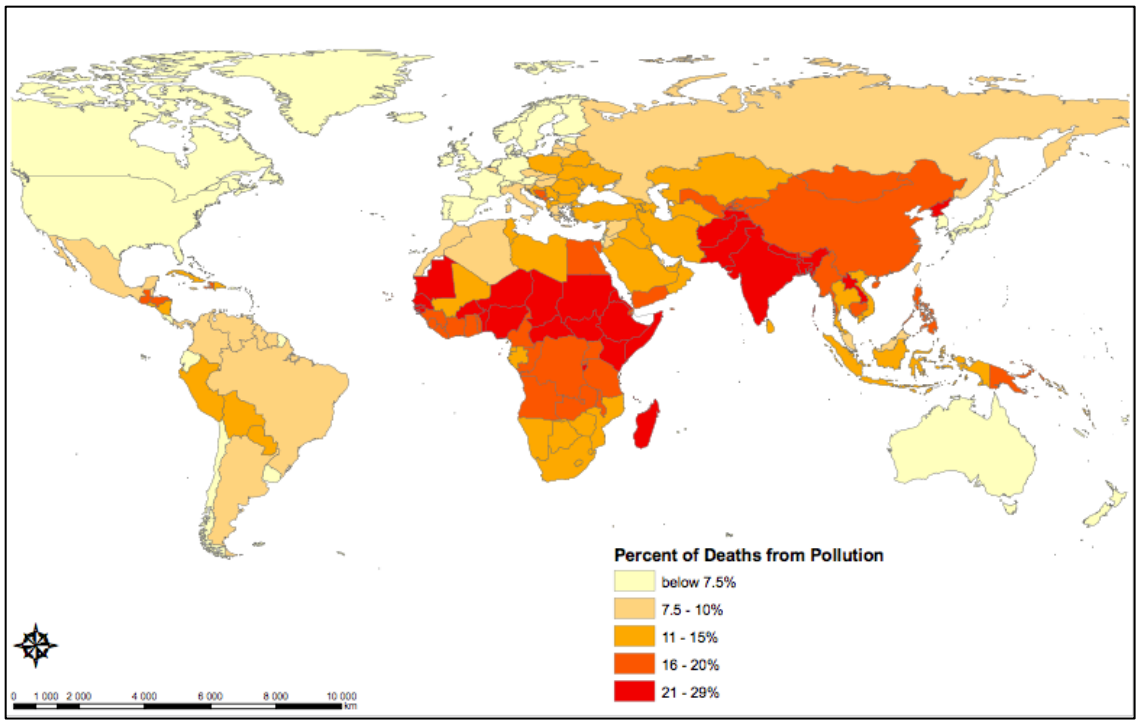

Figure 1. Percentage of all deaths in 2015 that were caused by pollution (IHME, 2016).

Lancet Commission on Pollution and Health

A 2017 report in the medical journal The Lancet presents the findings of an international Commission on Pollution and Health (Landrigan et al., 2017). The Commission finds that pollution is now one of the biggest drivers of death and disease in the world, causing 16% of all deaths globally. The overwhelming majority of the disease burden from pollution (92%) falls on people in low- and middle-income countries. Pollution's impacts are felt most acutely by communities that lack the capacity to address the problem. Pollution has severe implications for sustainable development, because it exacerbates the poverty cycle, harms the environment and biodiversity, causes lifelong disability, and holds back economic growth.

There is also strong evidence that pollution is not an inevitable outcome of development. Well-tested solutions, as well as new, cost-effective and alternative technologies can prevent, mitigate and remediate pollution problems and reduce toxic exposures. Many middle-and high-income countries and industrial sectors have successful experiences and expertise with best available technologies and best environmental practices aimed at preventing and combating air, water and soil pollution. Countries can take decisive action to prevent and clean up pollution, without sacrificing economic growth.

Use of Health Metrics for Pollution Prioritization

For too long, pollution has been viewed largely as an environmental problem, to be analyzed and addressed by environmental agencies, when in reality the drivers and consequences extend beyond this sector. The health effects of pollution contribute to growing social and economic inequities and poverty. As reported by the Lancet Commission, pollution-related diseases disproportionately affect the poor (Landrigan et al., 2017). The occurrence of these diseases results in lost income and increased healthcare costs, thus placing an additional economic burden on poor communities and perpetuating intergenerational poverty.

Approaching pollution narrowly as an environmental problem has not been successful. Pollution levels and associated health impacts in low- and middle-income countries have increased. As long as pollution is addressed only by ministries of environment, countries will struggle to address the issue at scale and rates of disease and death will continue to climb.

Recent data about pollution's impacts on health make it clear that pollution is a public health challenge that requires a dedicated, interdisciplinary response from agencies responsible for public health, transportation, agriculture, industrial development, resource extraction, and many others. The most rational common metric to analyze and prioritize pollution issues across all of these sectors is health outcomes. This is done by measuring and monitoring the reductions in disability and premature deaths that can be achieved by different interventions in the sectors.

Origin of the HPAP Program

GAHP has received requests from more than 20 low- and middle-income country governments to help to address pollution challenges by facilitating research, prioritization, planning, project selection and design, and by supporting the development of funding strategies. GAHP is not a funding agency but the expertise and experience of its member organizations can be highly valuable for countries where national institutions face limitations related to funding and technical capacity. In response to these requests for assistance, the GAHP Secretariat and other member organizations developed the Health and Pollution Action Plan program—a pollution prioritization and planning process that can be tailored to the needs of an individual country. The HPAP Program aims to identify, prioritize and accelerate national interventions to reduce pollution-related illness and death that are directly related to wider development challenges such as economic losses, inequity, and poverty.

HPAP Program Goals and Process

The Health and Pollution Action Plan (HPAP) program is designed to assist governments of low- and middle-income countries to develop and implement solutions to pollution-related health challenges.

The HPAP program is facilitated by the Global Alliance on Health and Pollution (GAHP) and brings together relevant national ministries (Environment, Health, Production/Industry, Transport, Energy, Mining, Agriculture, etc.) to advance concrete pollution actions. In countries where a National Environmental Health Action Plan (NEHAP) has already been developed with the support of WHO, the HPAP is intended to support the practical implementation of the key priorities.

The HPAP differs from other planning process in that it is structured to bring together different agencies and parties that may not frequently work closely together. It is intended to promote collaboration, and have well-defined and practical outcomes Among these outcomes is the commitment by all the participants, including international partners and donors, to undertake specific short- and medium-term actions to improve environmental health.

The goals of the HPAP program are to:

1. Assist governments to identify, evaluate and prioritize existing pollution challenges based on health impacts
2. Establish pollution as a priority for action within national agencies and development plans
3. Define and advance concrete interventions to reduce pollution exposures and related illnesses

Depending on the national context, the scope of the HPAP may include indoor and outdoor air pollution, unsafe water and inadequate sanitation, chemical contamination, and occupational exposures to pollutants.

The HPAP process is flexible and tailored to the needs of each country, but generally includes the following steps:

PHASE 1. Collection, compilation and analysis of available information

PHASE 2. Inception meeting to prioritize pollution issues and define next steps

PHASE 3. Preparation of a draft Health and Pollution Action Plan

PHASE 4. Consultation and finalization of an agreed Action Plan

PHASE 5. Dissemination, promotion, outlining the investment case, fund raising, implementation, monitoring and regular updating of the HPAP

HPAP Process in Madagascar

The Ministry of Environment, Ecology and Forests (MEEF) of the Republic of Madagascar is a long-standing member of GAHP. In 2016, MEEF requested assistance from GAHP to help prioritize pollution challenges and develop plans to reduce pollution's impacts. MEEF agreed to co-host a national HPAP program with facilitators from the GAHP Secretariat, Pure Earth. The HPAP development process in Madagascar followed the five-step process outlined above.

In 2016, GAHP facilitators and MEEF representatives began collecting relevant reports and data on pollution issues specific to Madagascar and on the associated impacts to public and occupational health. With assistance from MEEF, GAHP facilitators developed a background report summarizing the national pollution situation to inform the HPAP process and its participants.

The core stage of the collaborative HPAP process began in Madagascar in the spring of 2017, with the convening of a multi-stakeholder Technical Workshop and High-Level Inception Meeting in Antananarivo on April 4 and April 6, respectively. The meetings were hosted jointly by MEEF and GAHP.

The Technical Workshop sought inputs from technical staff from relevant ministries, non-governmental organizations, and international development agencies. The invitees were chosen based on their familiarity and expertise working on specific pollution issues in Madagascar. The output of this meeting was an initial list of priority pollution challenges and potential solutions.

A subsequent High-Level Inception Meeting was chaired by MEEF during which the outputs of the Technical Workshop were shared with decision-makers. Participants from nine ministries agreed that Madagascar should pursue the HPAP program as outlined and focus on the identified priority pollution issues, as described below.

Subsequently, in May of 2017, a National Working Group composed of officials from nine relevant Ministries was established. The Working Group was directed jointly by MEEF and the Ministry of Public Health (MPH). The Working Group was tasked with analyzing specific priority issues identified during the meetings; collecting and reviewing relevant data on pollution sources, contamination levels and health impacts; and analyzing potential interventions and policy options; as well as reviewing draft text for the HPAP document. The Working Group worked in close collaboration with GAHP and convened six times between May 2017 and September 2018.

The outcome of the HPAP process in Madagascar is this concise Action Plan for the Government of Madagascar to review, validate and implement, with ongoing facilitation from GAHP members. The plan should lead to a financial analysis and planning process on the part of the government.

Pollution Context and Trends in Madagascar

Current Context of Pollution Challenges and Government Response

A number of efforts have been put in place by the Government of Madagascar and its partners to counter pollution, of which the main one is the Décret MECIE (Mise en Compatibilité des Investissements avec l'Environnement), a law on environmental impact assessment of all activities that could harm the environment. However, the lack of human and financial resources, as well as competing demands, have constrained real progress. More than three quarters of the population of Madagascar lives below the international poverty line (purchasing power parity of 1.9 USD) (World Bank Group, 2018a). The country has faced frequent cycles of political instability, disrupting economic growth and the provision of public services (World Bank, 2015).

Despite the Décret MECIE and other sectoral efforts in the context of sustainable development, actions to address pollution have not progressed much beyond the creation of standards and regulations. Present approaches are, at best, reactive to problems rather than proactive and preventative. Thus far, the activities under the Décret MECIE have been limited to large industries and have not addressed smaller but highly polluting activities. Furthermore, the focus has been on environmental impacts and the implementation of Environmental Management Plans, without specifically considering effects on health. The efforts to date have not been sufficient to reduce the growing health burden from pollution. Cooperative and integrated efforts across ministries would elevate pollution control as a priority and allow the implementation of comprehensive strategies.

To change the trend of increasing disease and death from pollution, the current approach must change to a collaborative, inter-ministerial strategy that includes all relevant actors and stakeholders. In other countries, such a paradigm shift has often required a clear expression of interest and intent by senior political leaders.

The MEEF is presently inadequately resourced and has established only limited cooperation with other ministries in dealing with pollution priorities. The HPAP process tries to provide a new perspective for all the parties involved and to promote an integrated model of pollution management, tailored to Madagascar's situation, where all parties contribute in their specific area of authority and expertise.

Health and Environment Framework in Madagascar

In 2008, Madagascar signed the Libreville Declaration, which represents a common framework for the implementation of health and environment priority actions in African countries. Poor air quality, chemicals, new toxic substances, and industrial and household-related risks are among the factors highlighted in the Declaration, providing the basic justification for tackling these issues.

Madagascar convened a Working Group on health and the environment (“Groupe de travail sur la santé et environnement" or GTSE), to implement national actions under the Declaration. With input from the relevant stakeholders, the GTSE produced a Situational Analysis and Needs Assessment (“Analyse situationnelle et estimation des besoins" or ASEB) in 2010. As of 2015, Madagascar was one of 22 countries that had completed the ASEB process, out of 52 total signatories (WHO & UNEP, 2015). The ASEB identified environmental risks resulting from natural events and human activities, and presented the relevant government entities, regulations, and surveillance systems.

Following the ASEB, the government adopted a National Policy on Health and Environment (“Politique nationale en santé et environnement”) in 2011 to serve as a comprehensive framework for actions taken in this area. The policy aimed to synergize implementation of a number of national policies and regulations, as well as international agreements.

This policy was then translated into a Joint National Action Plan (“Plan National d’Actions Conjointes en Santé et Environnement" or PNAC), developed by the GTSE. The PNAC lays out priority actions, required resources, costs and a timeline.

The joint actions identified were:

- Establish a formal Strategic Alliance
- Strengthen the legislative and regulatory linkages between health and environment
- Implement educational and communications programs
- Expand relevant research
- Create or expand monitoring systems for health and for pollution
- Strengthen capabilities of participants involved in joint actions
- Reinforce activities for prevention and response

The key steps required to make progress in addressing health and environment, including pollution, have therefore been well identified and discussed. However, the lack of funding for the implementation process is the main limitation of efforts to implement the Libreville Declaration framework. In the context of a country with very constrained resources and many competing priorities, substantive progress has been limited.

Synergies and Overlap between HPAP and other Relevant National and Regional Programs

Beyond the Libreville Declaration described above, Madagascar has committed to a number of international agreements relevant to the contents of the HPAP, including the Basel, Stockholm, Rotterdam and Minamata Conventions. Furthermore, Madagascar has adopted the comprehensive framework of the Strategic Approach to International Chemicals Management (SAICM).

In 2016, an analysis conducted under the Africa ChemObs project identified the status and needs of chemical and waste management in Madagascar (MEEF & Ministère de Santé Publique, 2016). While the country has a national chemicals management policy, relevant legislation, and information exchange mechanisms, Madagascar does not currently compile or assess information on diseases caused by chemicals. This data would provide important insight into the true impact of chemical contamination and facilitate more detailed prioritization approaches.

There may also be opportunities in the future to integrate pollution into related national strategies. For example, Madagascar has validated a National Policy and Strategic Plan against Non-Communicable Diseases ("Politique et Plan National Stratégique contre les maladies non transmissibles"). Pollution was not included within its scope, despite growing recognition of its contribution to non-communicable disease mortality.

Overview of Health Impacts from Major Pollution Challenges

The Madagascar Health and Pollution Action Plan is based on studies and inputs from national agencies, as well as national and international data on pollution sources and impacts. The analysis relies heavily on data on deaths and Disability Adjusted Life Years (DALYs) from GBD studies conducted by the IHME and the WHO.

What Is A Disability Adjusted Life Year (DALY)?

The DALY is a measure of overall disease burden, expressed as the number of years lost due to ill-health, disability or early death. The DALY is increasingly used in the field of public health. It extends the concept of years of life lost due to premature death, to include equivalent years of healthy life lost due to poor health or disability. In so doing, mortality and morbidity are combined into a single, common metric.

Background information from national and international sources was synthesized into a National Situation Report summarizing the current status of pollution and attributable disease in Madagascar. The HPAP team used the findings of this report to prioritize pollution issues, analyze possible interventions and ultimately identify recommendations to reduce pollution-attributable death and disease.

Annual Death and Disease Rates from Pollution

The following table, presented to the Technical and High-Level meetings for discussion, summarizes the scale of annual deaths from pollution.

Table 1. Summary of annual deaths from pollution in Madagascar (IHME, 2016).

Pollution Type	Annual Deaths	Rate (per 100K)	As % Of All Deaths
Air			
Household air	21,146	85	10.7%
Outdoor air	8,500	34	4.3%
Total Air	**29,646**	**119**	**15.0%**
Water			
Unsafe sanitation	14,505	58	7.3%
Unsafe water	15,923	64	8.1%
Total Water	**30,428**	**122**	**15.4%**
Chemicals			
Lead	933	4	0.5%
Mercury	Unknown	Unknown	Unknown
POPs	Unknown	Unknown	Unknown
Other Chemicals	Unknown	Unknown	Unknown
Occupational Carcinogens	791	3	0.4%
Total Chemicals	**1,724**	**7**	**0.9%**
Total – All Pollution	**61,798**	**248**	**31.3%**

Pollution's Impacts Compared to Other Causes of Disease and Death

Polluted air, water and soil cause more death and disease in Madagascar than any other risk factor. Pollution is accountable for 31.3% of all annual deaths, followed by malnutrition at 23% (IHME, 2016). The contribution of pollution is higher in Madagascar than the sub-Saharan region as a whole, where 23.0% of deaths are attributable to pollution exposures.

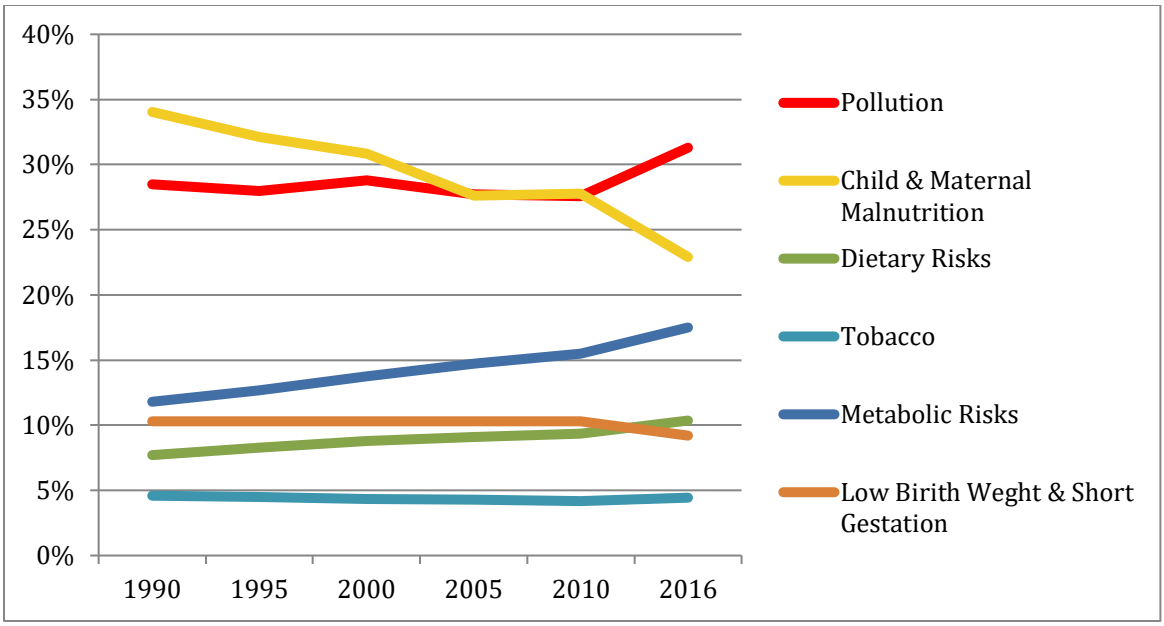

Figure 2. Percentage of all annual deaths in Madagascar caused by leading risk factors (IHME, 2016).

An analysis of the morbidity and mortality in Madagascar shows that great progress has been made on reducing deaths from communicable diseases between 1990 and 2016. This has contributed to an increase in life expectancy at birth of nearly 15 years in the period since 1990 (World Bank Group, 2018b). This improvement is due in large part to efforts by the government, with support from partners, to tackle well recognized problems such as malaria and diarrheal diseases.

What is a Risk Factor?

A risk factor is any attribute, characteristic or exposure of an individual that increases the likelihood of developing a disease or injury. Some examples of important risk factors are unsafe sex, malnutrition, tobacco and alcohol consumption, and exposures to toxic chemicals.

As death rates from communicable diseases have fallen, an increasing proportion of deaths are attributable to non-communicable diseases, such as those caused by exposures to pollution (Figure 3). If current trends continue, deaths from non-communicable diseases will overtake those from communicable disease within ten to fifteen years.

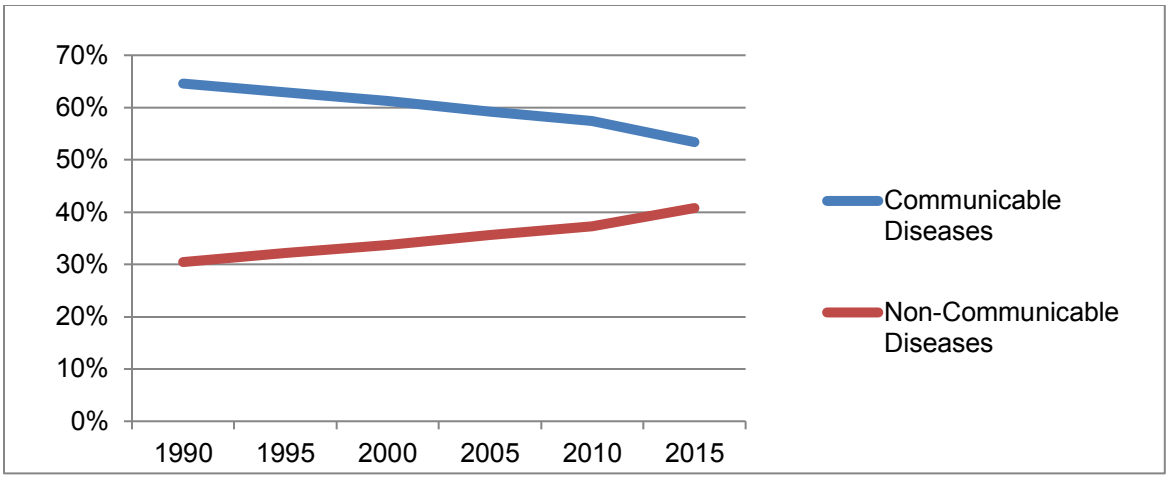

Figure 3. Percentage of total annual deaths attributable to communicable and non-communicable diseases in Madagascar (IHME, 2015).

The same trend is seen in the percentages of annual disability adjusted life years (DALYs) attributable to communicable and non-communicable diseases (Figure 4).

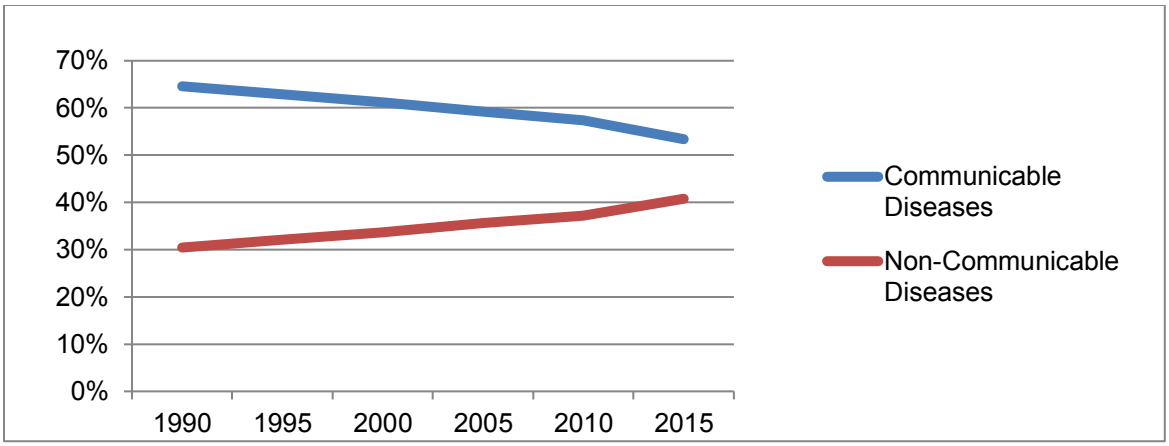

Figure 4. Percentage of total annual DALYs attributable to communicable and non-communicable diseases in Madagascar (IHME, 2015).

Available National and Regional Data

There are limited local data available on health and pollution links in Madagascar and no comprehensive national or sub-national database that would allow these links to be examined in greater detail. Pollutant-specific data has been collected for persistent organic pollutants (POPs) and mercury to generate reports to fulfill obligations under international agreements, however these reports and data set generally do not provide information about exposures to pollution or health outcomes associated with exposures. Peer-reviewed literature provides additional, although piecemeal, data on certain environmental health issues. As a result, very little is known about burden of disease associated with chemicals.

Known contaminated sites

As part of the needs assessment conducted for the Libreville Declaration, a list of known contaminated sites in Madagascar was compiled (Table 2), drawing on Pure Earth's Toxic Sites Identification Program (TSIP) data, industry, and national focal points for international conventions. The list is not considered comprehensive.

Table 2. Locations and characteristics of selected contaminated sites in Madagascar (MEEF & Ministère de Santé Publique, 2016; Pure Earth: Blacksmith Institute, 2014).

Site name	Source of contamination	Primary pollutant	Population at Risk
Ilafy – Analamanga region and other regions	Stockpile of used transformers, capacitors, and oil contaminated by PCBs	PCBs releases and soil contamination	Surrounding urban population
Maromaniry in Antsiranana II - Diana region	Contaminated site by chromium from an old tannery	Chromium	Population living around the contaminated site.
Akiembe Bas in Toliary I and Caron in Mahajanga I – Boeny region	Release of tank flushing water by a former oil company	Hydrocarbon	Population who built on the contaminated soil
Anjeva tannery in Antananarivo	Dumping ground of skin waste treated with chromium (which is no longer used by the Anjeva tannery). No corrective measures to address the possibility of chromium contamination of the surroundings where there is agricultural land, residential areas, and a river.	Chromium	Surrounding population eating agricultural products and drinking water from the river
Andasibe	Abandoned contaminated site	Creosote	
Vatovavy Fitovinany (Source: NFP of Mercury Convention)	Metal production: extraction of gold with mercury amalgamation (new practice to be forbidden)	Mercury	Local population
Ambato-Boeny	Misuse of pesticides, Rinsing spray devices in the river	Pesticide	Population that drinks water from river
Analamanga Region and Alaotra-Mangoro	Improper disposal of products containing mercury in open dumps	Mercury	Population living next to the open dump
Toamasina	Abandoned site of ZEREN (former fertilizer factory)	Ammonia	Local population

Mercury

When annual mercury emissions were normalized by population size and compared across countries, Madagascar had a moderate-to-high quantity per capita, based on 2011 data (Table 3).

Table 3. Mercury releases normalized by population (Rothenberg, Mgutshini, Bizimis, Johnson-Beebout, & Ramanantsoanirina, 2015).

Mercury (Hg) releases to air, water and land for Madagascar and other nations.

	Hg releases (tons/year)[a]	Population[b]	Hg emissions (g/capita)
Yemen	0.80	26,052,966	0.000031
Pakistan	10.8	196,174,380	0.000055
Panama	0.40	3,608,431	0.00011
Dominican Republic	2.1	10,349,741	0.00020
New Zealand	1.4	4,401,916	0.00032
Australia	24.6	22,507,617	0.0011
Ecuador	76.3	15,654,411	0.0049
Burkina Faso	2.60	17,812,961	0.145
Cambodia	14.9	15,205,539	0.980
Madagascar	98.5	22,599,098	4.36
Mexico	1560	116,220,947	13.4
Philippines	1670	105,720,644	15.6

[a] Maximum annual amount of Hg released to air, water, and land from UNEP (2011).
[b] Population statistics from CIA (2014).

The Final Report on the Initial Evaluation of the Minamata Convention included a national inventory, completed in 2017, that laid out estimates of quantities of mercury released by source and by environmental media.

Table 4. Quantity of mercury released by source and by route in 2015-2016 in Madagascar, reported in kg Hg (MEEF, 2017).

	Air	Water	Soil	Byproducts and impurities	General waste
Extraction and use of combustibles and energy sources					
Other coal combustion	1.8	0	0	0	0
Extraction, refining and use of oil	144.96	24.98	23.05	0	0
Extraction and use of other combustibles	83.03	0	0	0	0
Biomass power plants and energy production	1549.34	0	0	0	0
Primary production of metal					
Extraction of gold and silver with amalgamation processes using Hg	1755	304.2	280.8	0	0

	Extraction and transformation of gold by other processes	0.06	0.01	0.01	0	0
Production of other minerals and materials containing Hg impurities						
	Cement production	15.26	2.65	2.44	0	0
	Pulp and paper production	0.06	0.01	0.01	0	0
	Lime production and lightweight aggregate kilns	17.5	3.03	2.8	0	0
Consumer products containing Hg						
	Thermometers containing Hg	81.11	121.67	81.11	-	121.67
	Transmitters with electronic/electric relays	183.9	0	245.2	-	183.9
	Lamps containing Hg	1.63	0	1.63	-	2.17
	Batteries containing Hg	1675.75	0	1675.75	-	3351.5
	Polyurethane with mercury catalyst	26.27	13.13	52.53	0	39.4
	Biocides and pesticides	34815	6034.6	5570.4		
	Paints	26.27	13.13	52.53	0	39.4
	Antiseptic in pharmaceutical products	514.28	27.95	16.77	-	0
	Cosmetic products and their derivatives	0	1852.5	97.5	-	0
Products with intentional use of Hg						
	Dental amalgams and fillings	2.56	42.44	0	81.29	49.08
	Manometer and blood pressure monitors	185.16	255.97	171.38	0	253.12
	Chemistry laboratories and equipment	164.16	28.45	26.27	0	0
Waste incineration						
	Incineration of medical waste	135.63	23.51	21.7	0	0
	Informal waste incineration	11635.52	2016.82	1861.68	0	0
Burying of waste and treatment of wastewater						
	Informal discharge of waste	383.14	383.14	3065.12	0	0
	Wastewater system and treatment	0	2645.82	0	0	0
Crematoriums and cemeteries						
	Crematoriums	0.21	0	0	-	0
	Cemeteries	0	0	1000	-	0
Total, kg Hg (%)		**53371.21 (67)**	**11135.05 (14)**	**10615.94 (14)**	**81.29 (0)**	**3961.44 (5)**

As Table 4 highlights, the majority of mercury is released to air (67%). The largest contributor to mercury releases in all media (air, water and soil) is biocides and pesticides. Other large contributors are informal waste incineration (open-air burning), mercury-containing batteries, informal discharge of waste, and wastewater treatment.

According to the National Synopsis of Mercury in ASM in Madagascar, the use of mercury in artisanal mining did not become prevalent until 2015 (MEEF, 2018). The national inventory, based on data from 2015-2016, attributes the release of 2,340 kg Hg per year to this activity. The National Synopsis, released in 2018, generated a much higher estimate of 13,367 kg Hg per year from this sector.

Fortunately, in the one study identified that examined mercury exposure in Madagascar—in this case through the consumption of rice—the average daily

mercury dose from rice was two orders of magnitude below the most conservative international reference dose (Rothenberg et al., 2015). This assessment was based on methylmercury concentrations in rice samples and average values for ingestion rate and body weight.

The following sites were identified as being contaminated with mercury as of 2016:

- gold mining in the Vatovavy Fitovinany Region, Ikongo District, Manampatrana Commune and Manampatrana Fokontany, Bezamana, Amboanjombe Center, and Manambato;
- the controlled discharge of municipal waste in the Analamanga Region, District of Antananarivo Avaradrano, Ambohimangakely Commune, Andralanitra Fokontany;
- the use of permanent mercury thermometers in industry in Ambatovy, Alaotra-Mangoro Region, Moramanga District, Moramanga Commune, Ampitanimbe Fokontany.

Lead

No comprehensive overview of lead pollution in Madagascar was identified. However, several sources were examined independently. The concentration of lead in particulate matter (PM) was observed to decrease between 2002 and 2008, following the prohibition of the use of leaded gasoline in 2006 (Rasoazanany et al., 2013).

Elevated levels of lead were observed in wastewater from discharge pipes of textile factories in Antananarivo (Rasoazanany, Andriambololona, Andrianarivo, & Randriamanivo, 2007). The maximum concentration observed was 251 μg/L, which exceeds the “national norm” of 200 μg/L.

Finally, drinking well pumps have been implicated as a source of lead in drinking water. These hand pumps provide water at the household level in areas where public utilities are not feasible or reliable. However, certain components of these pumps typically contain lead, often reclaimed from used car batteries. The lead can leach into the water being pumped. This has been highlighted as an issue particularly in coastal areas in eastern Madagascar. In a recent study in Tamatave, 67% of water samples taken under first-draw conditions (after a pump has been inactive for 1 hour) exceeded the WHO provisional guideline of 10 μg/L (Akers, Maccarthy, Cunningham, Annis, & Mihelcic, 2015).

Akers et al. noted that users should be educated in the practice of flushing the pump before collection, as this reduced, but did not eliminate, lead in the water. Replacing lead components with those made out of iron was highlighted as a more effective intervention. While blood lead levels (BLL) were not taken in Tamatave, biokinetic modeling indicated that reducing the concentration of lead

in household water from 23.5 µg/L (90th percentile under first-draw conditions) to 3.95 µg/L (10th percentile) may reduce the risk of elevated BLL from about 40% of children to about 15% (Akers et al., 2015).

Chromium

Information on heavy metals beyond lead and mercury is even more limited. One study examined the concentration of chromium in wastewater discharged from a tannery (Rasoazanany et al., 2007). The concentration of 2712.1 µg/L exceeded the "national norm" of 2000 µg/L.

POPs

MEEF generated an inventory of POPs, published in 2015. The investigation looked specifically at the organochlorine pesticides lindane, endosulfan, alpha- and beta-hexachlorocyclohexane, and chlordecone. There is no evidence that these chemicals are currently imported. Chlordecone was never used in Madagascar, the use of alpha- and beta-hexachlorocyclohexane was abandoned in 1985, lindane was banned in 2006, and endosulfan was banned in 2011. These chemicals were not identified during site visits to places of use or storage of pesticides.

Still, the authors note some gaps in this analysis. While the site visits covered areas known for pesticide use, some regions in the country may have small stocks of these chemicals. Secondly, the methodology for the inventory did not include any environmental sampling, which would have allowed the authors to explore existing soil contamination.

In addition to pesticides, the inventory examined the uses of PBDE, a class of organobromines which are used as flame retardants. Potential sources in Madagascar are electronic and electric equipment and components within vehicles. Contaminated sites were not identified as there are no official sites for the production, use or disposal of PBDE-containing products. The report indicates that such products, like end-of-life electronics and vehicles, are generally kept in households or institutions, rather than disposed of through official channels.

To identify potential sources of polychlorinated biphenyls (PCBs), MEEF conducted an inventory of all identified electrical transformers. Through extrapolation, it was estimated that, across the country, transformers held a total of 1354 metric tons of PCB-containing oil. Investigators classified sites as contaminated when they identified leaks in the transformers or when an area was used for the repair of transformations, although environmental sampling was not conducted to confirm. The potential for such sites to impact human health is highlighted by an analysis discussed in the ChemObs report (MEEF & Ministère

de Santé Publique, 2016). PCBs were detected in the urine of individuals living in areas where contaminated oil, transformers and capacitors are stored.

The number of industries identified in Madagascar that used perfluorooctanesulfonic acid (PFOS) was limited. It was found that a supplier of textile chemicals sold 70,000 L of a product containing PFOS, which has stain-repellent properties, to a fabric manufacturer between 2008 and 2010. PFOS was also identified as being used in fire-fighting foam and in minimal quantities in aviation hydraulic fluids. The report speculates that sites for fire-training exercises are likely contaminated with PFOS.

Dioxins and furans are considered non-intentional pollutants as they are released as byproducts from combustion or industrial processes, or from contamination by precursor chemicals like PCBs. The POPs inventory highlighted the following activities as potential sources of dioxins and furans:

- Incineration of biomedical waste
- Open-air burning of biomass and waste, industrial fires
- Thermal production of non-ferrous metals (nickel and cobalt)
- Generation of central electricity from fossil fuels and biomass
- Generation of heat and cooking with fossil fuels and biomass
- Motors (4- and 2-stroke, diesel)
- Production of cement, lime, bricks, and ceramics
- Asphalt mixing processes
- Textile factories
- Leather processing
- Drying of biomass
- Crematoriums
- Smoke houses
- Drycleaners
- Cigarette smoking
- Leachate from waste
- Waste discharge in water
- Composting
- Disposal of used oil
- Equipment containing PCBs
- Kaolin or clay extraction sites

However, due to the unavailability of data, only emissions from the generation of electricity and heat were quantified; as of 2010, 2,479 gTEQ/a were emitted to air and 1,308 gTEQ/a were emitted in residues. Toxic equivalency (TEQ) values are “a weighted quantity measure based on the toxicity of each member of the dioxin and dioxin-like compounds category relative to the most toxic members of the category” (United States Environmental Protection Agency, 2016).

Non-POP pesticides

Insecticides used in malaria control efforts were detected in the soil and groundwater in south-eastern Madagascar (Solonomenjanahary, Ratsimbasoa, Rafarasoa, & Rasoloariniaina, 2018). Organophosphorus, sprayed in homes, was found in high concentrations in soil in an area constructed as a storage sump for insecticides. Pyrethroid insecticides are incorporated into mosquito netting; this netting may be washed in waterways or misused as fishing nets, introducing the chemical into waterways and potentially contaminating food sources.

Household air pollution

Household (or "indoor) air pollution contributes to 10.7% of all premature deaths in Madagascar (IHME 2016). More than 90% of households in the country use solid biomass, including charcoal, wood and crop waste, for cooking (Dasgupta, Martin, & Samad, 2015). Household sampling conducted by the World Bank between 2009 and 2010, revealed that the average concentration of $PM_{2.5}$ was 0.776 mg/m^3 in kitchens (Dasgupta et al., 2015). This value stands in stark contrast to the WHO Air Quality Guidelines for typical indoor exposures, which recommends a 24-hour average concentration of 0.010 mg/m^3. Similarly, the household sampling revealed CO concentrations of 28 ppm, whereas the recommendation is 6.1 ppm. The impact of these pollution levels and other exposures associated with fuels is reflected in health outcomes examined at the national level, including deaths from lower respiratory infections and chronic bronchitis (Dasgupta et al., 2015).

Ambient air pollution

Ambient (or "outdoor") air pollution is also a topic of concern, specifically in Madagascar's urban areas, and is responsible for 4.3% of annual premature deaths. Transportation is a significant driver of ambient air pollution. The combination of the importation of older, less efficient vehicles plus the use of low-quality fuel creates inefficient combustion and dangerous vehicle emissions (Schwela, 2012). A wide range of stationary sources also contribute to the degradation of ambient air quality. According to the World Bank Country Environmental Analysis, these sources include "a diesel run thermal power plant, boilers in industrial premises, brickyards, domestic sources, stone quarries, landfills and oil storage facilities" (Carret, 2013). The burning of agricultural fields and forests is a long-standing practice that is also known to generate particulates, which are transported by wind into urban areas (Carret, 2013).

Some efforts have been made to improve air quality and generate more comprehensive data in this area. The use of leaded gasoline was prohibited in 2006; this was reflected in a decrease in the concentration of lead in particulate matter (PM) between 2002 and 2008 (Rasoazanany et al., 2013). Furthermore,

there are air monitoring stations that measure PM, carbon monoxide, hydrocarbons, nitrogen oxides, and sulfur dioxide, but these are limited to Antananarivo. During a 2008 study in Antananarivo, concentrations of both $PM_{2.5}$ and PM_{10} exceeded WHO guidelines of 25 μg/m^3 and 50 μg/m^3, respectively (Rasoazanany et al., 2013). The authors speculated that these elevated levels of particulate were generated by vehicle traffic on market days.

Economic Costs of Pollution in Madagascar

Premature death and disease due to pollution impose great costs on national budgets and health-care spending, especially in industrializing low-income countries such as Madagascar. Diseases caused and exacerbated by pollution result in medical expenditures and in pain and suffering. Pollution-related disease can reduce labor force participation, labor market productivity, and economic output. Early life exposures to neurotoxic pollutants such as lead and mercury can impair cognition, diminish the ability to concentrate, and disrupt behavior, thus reducing lifetime earnings. Because pollution and pollution-related diseases disproportionately affect the poor, these impacts contribute to the intergenerational perpetuation of poverty.

Using data and approaches from the Lancet Commission on Pollution and Health, and relevant data from Madagascar, it is estimated that diseases resulting from pollution are estimated to have cost Madagascar between US $117 million and US $166 million in 2015 due to lost productivity—the equivalent of 1.2% to 1.7% of the country's 2015 Gross Domestic Product (GDP) . This percentage is higher than Sri Lanka, a lower-middle income island state with a similar population size, at 0.26% to 0.30%, and Mozambique, a lower income country with a similar population size and Madagascar's closest neighbor, at 0.83% to 1.1%. The welfare damages from pollution-attributable diseases equal US $873 million, or 8.6% of the gross national income (GNI) for the same year. Welfare damages from pollution-attributable diseases represented just 5.8% of GNI in Sri Lanka and 6.8% in Mozambique (Landrigan et al., 2017). A complete description of the cost estimate methodology is included in Annex A.

National data on direct healthcare spending used to treat pollution-attributable diseases is not available in Madagascar. However, just 0.12% of the country's health budget goes towards disease prevention more generally, which would include addressing environmental risk factors; instead the focus is on curative programs (WHO & UNEP, 2015). By way of comparison, an analysis of 22 Libreville Declaration signatories found that on average each country put 30% of its health budget towards disease prevention.

The costs of pollution-related disease are often overlooked and undercounted because they are associated with non-communicable diseases that appear and extend for many years after the initial exposure, are spread across the population and are not captured by standard indicators. The costs of pollution-related disease include: 1) direct medical expenditures; 2) indirect health-related costs, such as time lost from school or work, and needed investments in the health system; 3) diminished economic productivity in persons permanently damaged by pollution; and 4) losses in output resulting from premature death.

Pollution-related disease is responsible also for intangible costs, such as those of poor health in people made ill by pollution, disruption of family stability when a person of working age becomes disabled or dies prematurely as a result of pollution, and the loss in years of life to the people themselves. These costs are much more difficult to estimate than the costs of pollution control, which are usually tangible and concrete. Although the costs of pollution-related disease can have large impacts on expenditure in the health sector, they are typically difficult to isolate within overall figures.

Priority Pollution Challenges and Health Impacts

Priority Issues Identified in Working Group Meetings

The initial Working Group meeting included the presentation and general discussion of the overall health and environmental issues and of the IHME impacts data. This was followed by technical presentations on some of key issues were made by local specialists. Within the time available, a number of findings and recommendations for next steps were identified. These were refined in the course of further discussion within the Working Group and the HPAP team.

Indoor Air

- The pollutants of concern include particulates, carbon monoxide, aldehydes, etc. The main sources include cooking, lighting, smoking and household dust. Those most at risk are women, children, smokers and particularly the poor. Nearly 5 million households use wood fuel or charcoal.
- Current efforts include promotion of energy-efficient and cleaner stoves, and of the use of bioenergy such as ethanol, the National Policy and Strategic Plan against Non-Communicable Diseases, and promotion of green energy and of renewables.
- There is a need for a Strategic Plan for Household Air Pollution, public education and communication, upgrading access to cleaner and more efficient fuels for the majority of the population to achieve a transition to clean fuels.

Outdoor Air

- There are many pollutants of different types including gas, liquid and solid, affecting individuals throughout the population.
- Sources include second-hand cars and motorcycles, poor fuel quality, brickmaking, uncontrolled burning of wastes, factory level sources, slash-and-burn agriculture (in rural areas), as well as household air pollution that becomes outdoor air.
- Drivers include problems of technology and of low fuel quality standards, as well as weaknesses in the enforcement of regulations. There is a need for stronger inspection systems at all levels. Fuel imports should be upgraded to meet European standards. The new Law on Industrial Development needs to be strengthened.
- Outdoor air must be continuously measured and monitored to inform relevant decision making, as there are no specific data or statistics.

Contaminated Sites and Exposures to Chemicals

- Attention was focused on chemical contamination. This includes water quality issues that are not in the scope of ongoing programs of the Ministry of Water, Sanitation and Hygiene (Ministry of WASH). HPAP work should be complementary.
- Pollutants include PCBs/PBDEs/pesticides/mercury/other metals, as well as industrial wastes and medical wastes from various sources. MEEF is addressing some of these under existing UN Environment programs.
- Local water sources are impacted by mining; industries using chemicals; waste dumping. Appropriate regulations in the Mining and Petroleum Codes are required.
- Populations particularly at risk live along rivers, in rural areas or in areas of intensive industry.
- MEEF is starting mercury surveillance but more equipment is required to detect mercury contamination in various environmental media and biological samples of humans.
- There are several municipal waste management efforts underway, however there is little data on the extent and toxicity of runoff and groundwater contamination related to industrial and municipal landfills and informal waste dumps.
- Madagascar is building up data on pollutants but more research and analysis on health impacts is needed.
- There is a need to strengthen regional capabilities for environmental monitoring of chemical contamination.

Need for Refinement and Updating of Health Data

The data presented and discussed at the HPAP Inception Meeting and subsequent Working Group meetings were from the 2015 and 2016 Global Burden of Disease Studies of the Institute for Health Metric and Evaluation. These results were largely based on data initially collected by agencies in Madagascar. These data indicate the numbers of premature deaths associated various pollution-related risk factors. It was agreed by the Working Group that there is a need for more specific and localized data for each major pollution issue, ideally quantifying the size and characteristics of the contamination sources (by district), providing more detail on human exposure pathways, and clearly identifying the populations at risk and affected by the pollution.

Issues Not Selected as Priorities

Challenges related to biological contamination of water and related issues of sanitation and hygiene were not selected as priorities for the HPAP process for several reasons. First, the Ministry of WASH was contemporaneously developing a national strategy to improve health outcomes related to water. The HPAP participants concluded that it would not be productive to have two national plans addressing the same topic. Further, the participants agreed that the issue of

water contamination was receiving more attention and resources relative to other pollution issues, and that current programs were making progress on the issue. This conclusion is supported by the available burden of disease data, which shows steady declines in rates of deaths from water-related illnesses in Madagascar, but comparatively little progress on issues of air pollution and chemical contamination.

Subsequent activities

Following the Inception Meeting, work continued on collecting relevant data, reviewing and discussing possible solutions and necessary interventions, and examining effective actions. The following sections present the conclusions in regard to each of the priority issues, together with a discussion of related institutional and policy aspects.

Priority Issue 1 – Reducing Impacts from Household Air Pollution

Disease Burden from Household Air Pollution in Madagascar

Household air pollution refers to air pollution created inside or near homes and is primarily the result of burning biofuels such as wood, charcoal, dung and other solid fuels for cooking or heating. It is estimated that 95% of households in Madagascar depend on woody biomass, predominately fuelwood and charcoal (World Bank, 2011). According to IHME 2016 estimates, household air pollution is the largest pollution risk factor in Madagascar, contributing to the death of more than 21,000 people annually, or 10.7s% of all annual deaths (Table 5).

Table 5. Impacts of household (indoor) air pollution on deaths and DALYs in Madagascar (IHME, 2016).

Demographic	Deaths	As % of All Deaths	DALYs	As % of All DALYs
Sex				
Male	10,325	10%	462,228	7%
Female	10,821	11.4%	449,778	7.6%
TOTAL	**21,146**	**10.7%**	**912,006**	**7.3%**
Age				
<5 years	5,205	7.5%	447,124	7.3%
5-14 years	462	6.3%	35,974	3.8%
15-49 years	3,542	8.7%	178,741	5.4%
50-69 years	6,123	15.8%	174,219	11.7%
70+ years	5,813	14.9%	75,947	15.5%
TOTAL	**21,145**	**10.60%**	**912,005**	**8.7%**

Dependence on biomass fuels is a result of lack of money for, or access to alternatives such as liquid petroleum gas (LPG) and ethanol. The impacts of poor-quality fuels are made much worst by inefficient stoves, lack of ventilation, and ignorance of the effects.

The World Bank Country Environmental Analysis identified the scale of the household air pollution challenges, highlighting that more than 90% of the population use solid fuel (Carret, 2013). The general population does not understand well the link between household air pollution and poor health. Many people view coughs and other respiratory problems as “traditional” and accept them as genetic and inevitable. There is a clear need for better communication of the risks of traditional cooking behaviors.

The health impacts of particulates in household air are well understood by the Ministry of Public Health and other government agencies and a number of efforts have been made over the years to deal with the problems. Individual health officials have noted the high levels of chest complaints identified in households

that use biomass fuels and have indicated that these problems are directly related to pollution levels. This conclusion is fully in line with international understanding and research on the impacts of household air pollution.

The health impacts of chronic exposure to high levels of particulate pollution are well established. Approximately 40% of respiratory infections are thought to be associated with indoor air pollution (Carret, 2013). Household air pollution is also known to contribute to heart attacks, strokes, cancer, and a range of respiratory diseases, among other illnesses.

Studies conducted on household air pollution in Madagascar found that average concentrations of particulate matter 10 micrometers or less in diameter (PM_{10}) in the households ranged from 300 to 3,000 $\mu g/m^3$, with levels reaching as high as 10,000 $\mu g/m^3$ during cooking (Carret, 2013). To compare, the WHO has set PM_{10} guidelines of 20 $\mu g/m^3$ annual mean and 50 $\mu g/m^3$ 24-hour mean for both ambient and indoor settings (World Health Organization, 2010, 2018).

Roles and Responsibilities in Addressing Household Air Pollution

Attention to the scale of HAP and its effects is increasing in Madagascar among non-governmental organizations and within ministries, but large-scale response has been limited. MPH and MEEF have identified and begun to address HAP within the Libreville Declaration framework.

In concrete terms, few visible efforts have been made to increase awareness of the substantial health impact of HAP apart from discouraging smoking indoors. This latter issue is addressed mainly during a designated “Fighting Tobacco Day”. On a smaller scale, the Pneumology Association has been raising awareness about HAP through conferences but the impact of this initiative is limited. Now, the Association is doing a survey of HAP in two cities (Antananarivo and Mahajanga) covering 500 people in urban areas and another 500 people in rural areas. This will be accompanied by a sensitization campaign on the heath impact of using solid biomass fuels. Results of the survey were due by the end of 2017 and will be used for discussion with the Ministry of Public Health to try to raise this risk factor as a priority.

Much of the HAP problem is related to the inefficient use of biomass for energy. The current National Energy Policy of Madagascar (2015-2030) takes on challenges in three subsectors: biomass (production and use), electricity, and hydrocarbons. In order to deal with biomass fuel issues, energy substitution will be promoted, helping the population to climb the “energy ladder” to cleaner fuels. The increasing use of charcoal is well recognized as one of the main causes of deforestation in Madagascar, with forest loss of 40,000 ha/year. On the ground, an increase in demand and a lack of controls drive environmental issues such as the logging of primary forest. According to the National Energy Policy, use of more sustainable “green” charcoal, economical cooking stoves, and agro-

combustibles (solid waste from rice cultivation and sugar cane) are preferred, in order to reduce the consumption of traditional charcoal and firewood.

Although not explicitly expressed in the National Energy Policy, HAP reduction could be taken on as an objective through the Ethanol Program supported by World Bank within its Carbon Credit Framework. The current Ethanol Program (Programme National Éthanol Combustible or PNEC) is a presidential program with a national scope. To encourage the availability and use of bioethanol, the Program presents initiatives to establish more micro-distilleries throughout the country and encourage the cultivation of sugar cane. Subsidies encourage local retailers to sell clean cookstoves and reduce the costs for consumers. On the supply side of bioethanol, taxes on materials for micro-distilleries are either reduced or eliminated and the NGO Clean Cooking Madagascar actively supports the technology transfer to local investors. For the moment there are two challenges to overcome: to build micro-distilleries with standardized and environmentally friendly materials and to promote sugar cane cultivation among the local population, not all of whom are aware of these initiatives.

Clean Cooking Madagascar promotes and popularizes ethanol stoves through local retailers. The aim is to produce and sell more than two million stoves across the island in 3-5 years, but uptake has been slow and several thousand stoves were distributed in the first year. It is hoped that uptake will increase if costs can be reduced as a result of more micro-distilleries and more options for stoves.

Moreover, many initiatives, though limited to some communities, have been implemented to promote upgraded energy-efficient stoves and the use of renewable energy sources for cooking such as solar energy.

Practical Options for Addressing Household Air Pollution

The overall scale of the HAP problem is vast, with almost 5 million households at risk. Progress will require a long-term strategy, linked with broader cleaner energy access efforts. The coverage of the electricity grid in Madagascar is reported to be about 13% of households (Power Africa, 2018).

The basic approach to the problem has been outlined in the Situational Analysis and Needs Assessment (or ASEB by the French acronym) and Joint National Action Plan (PNAC)—popularizing improved cookstoves and clean household fuels, promotion of research on fuel substitution, and promotion of standards for healthy housing, particularly for vulnerable individuals. However, like many programs, this remains to be integrated among the priority actions of MPH, MEEF, and other relevant ministries, and is yet to be fully supported by technical and financial partners.

In terms of action to date, the main initiative has been centered around the promotion of upgraded stoves and bioethanol. An Ethanol Committee was set up

at the level of Prime Minister. This task group gathers the main stakeholders on bioethanol. Indoor air pollution and deforestation are mentioned as justifications of the program. This program should continue to be supported and lessons can be gleaned from its activities regarding what works in different areas and where and how actions can be scaled up. There have also been large-scale promotion initiatives of biofuels supported by environmental partners.

The scale of the health impacts is large and a National HAP Program will have to be developed, with clear targets and specific resource needs. The existing Health and Environment committee should be given a specific mandate to take this forward.

An initial basic requirement is to prepare a detailed understanding of the problems and needs, at the level of districts and villages. This should include analysis of the key differences in physical parameters (dwellings, fuel, stove type, other energy uses and needs), together with data on attitudes and behaviors. With this information and inputs from international experience, sites can be identified for more detailed analysis and possibly selected for initial pilot interventions.

Feasibility and Practicality of Specific Actions Considered

Issues to be discussed and agreed upon at government level:

- Clear and persuasive target outcomes for a National Program
- Development of public and political support
- Practical timescale for the first stage
- Geographic area to be targeted initially

Possible Steps

1. Establish a specific HAP Reduction Program within the existing general National Energy Policy, including responsibilities and targets.

2. Set up a clear coordination mechanism, since HAP is not a priority for any ministry. A small group might be established, perhaps under the HPAP Working Group or GTSE, and should be given specific tasks and deadlines.

3. The burden of disease figures for HAP should be revised and updated using specific Madagascar data. This will require the collection of a range of data on fuel use, dwelling type, health statistics, etc., at a suitable sub-national level, together with support for the analysis required.

4. Map out patterns of fuel use, etc. and the broad risk patterns (from the burden of disease analysis) to be mapped out at district or lower level in order to provide a basis for defining the initial interventions. Review

current planning and projections for fuelwood and charcoal sectors, as baseline estimates of household fuel use.

5. Continue to support realistic targets and efforts for the promotion of upgraded energy-efficient stoves and clean fuels such as the Ethanol Program.

6. Review, with support from GAHP members, successful experiences and lessons from overseas for moving households and whole communities up the “fuel ladder.” On this basis, examine social and economic feasibility of having communities move up the fuel ladder and prepare a broad strategy and short-term pilot project.

7. Prepare a detailed pilot project. A draft concept note for a pilot has been drafted and is attached.

Priority Issue 2 – Reducing Impacts from Outdoor Air Pollution

Sources and Characteristics of Outdoor Air Pollution

Ambient outdoor air pollution is a subject of increasing concern in Madagascar, and a significant contributor to death and disease. Sources of outdoor air pollution include:

- Increasing intensity of road traffic and old, poorly maintained vehicles (including small and big vehicles, motorcycles as well as buses)
- Large increase of the number of scooters
- Fuel containing high levels of sulfur and benzene
- Fires from agricultural burning and forest clearing
- Thermal power plants
- Urban dust from construction and lack of road cleaning
- Brick-making
- Emissions from industrial sources
- Open burning of wastes

Among these contributing factors, the two primary drivers of increasing levels of particulate matter are believed to be the high sulfur fuel imported to Madagascar that is referred to as “African quality” diesel; and the used vehicles imported to Madagascar which are less efficient and lack basic environmental controls. Unless these issues are addressed, ambient air pollution levels and associated health impacts are expected to rise steadily as vehicle ownership increases.

Compared to other countries in Southern Africa, Madagascar is among the most lax in its maximum sulfur standards for diesel (5,000 ppm) and gasoline (2,000 ppm). Furthermore, Madagascar has not yet implemented restrictions on the import of used cars; other countries in the region have implemented restrictions based on the age, mileage, or emission standard of the vehicle.

Madagascar does not maintain a national network for air quality monitoring, but limited data is available for Antananarivo. There, the data shows that market days have the highest levels of air pollution, exceeding WHO guidelines for $PM_{2.5}$ and PM_{10}.

Disease Burden from Ambient Outdoor Air Pollution in Madagascar

Table 6 captures the deaths and DALYs attributed to ambient air pollution in Madagascar.

Table 6. Deaths and DALYs from ambient (outdoor) air pollution in Madagascar (IHME, 2016).

Demographic	Deaths	As % of All Deaths	DALYs	As % of All DALYs
Sex				
Male	4,404	4.3%	186,060	2.8%
Female	4,096	4.3%	164,185	2.8%
TOTAL	**8,500**	**4.3%**	**350,246**	**2.8%**
Age				
<5 years	1821	2.6%	156,432	2.5%
5-14 years	158	2.2%	12,265	1.3%
15-49 years	1,525	3.8%	76,107	2.3%
50-69 years	2,610	6.3%	74,495	5.0%
70+ years	2,386	6.1%	30,947	5.3%
TOTAL	**8,500**	**4.3%**	**350,246**	**2.8%**

Along with household air pollution, outdoor air pollution was cited as a likely contributor to the elevated prevalence of bronchial asthma among urban children in Antananarivo (Wolff, Arison, Rahajamiakatra, Raserijaona, & Niggemann, 2012). During this study, which the authors claimed was the first epidemiological examination of schoolchildren living in an urban environment at a high altitude in Madagascar, the rates were found to be higher than in other major African cities.

Roles and Responsibilities

Officially, MEEF is in charge of monitoring urban air emissions and air quality but in practice its capacities are limited. A lack of technical staff and financial means prevent efforts to improve efficiency and so little progress has been made. Regarding the current legislative framework, there are technical specifications for fuels (Schwela, 2012), but little information is available on implementation. There is conflicting information on the existence of emissions standards sources, with one report indicating that they exist for mobile sources (Schwela, 2012), and another indicating no such standards exist for imported vehicles (Naré & Kamakaté, 2017). Thus, existing legislation and regulations do not appear to cover the full range of air pollution.

MEEF has provided two opacimeters for smoke density testing (smoke from exhausts) to the service in charge of technical inspections of cars and they found that 70% of cars did not meet requirements. In addition, there has been some work carried out by the National Institute for Nuclear Sciences and Techniques related to air quality in Antananarivo, particularly PM. Generally, MEEF does not have the resources to fully meet its responsibility concerning urban emissions.

There is no formal mechanism for discussion or coordination around air pollution across ministries. However, ad-hoc meetings can be arranged when there are visible and serious pollution problems or accidents brought to attention by the media or by communities living near emission sources. A strategy was developed

and specific activities planned to fight pollution, but unfortunately, very little was implemented. The strategy is to be updated, which would be an opportunity to include a small number of real priority actions and to define the minimum resources required.

It should be noted that some practices and problems are very localized, for example, the production of bricks, which requires hot fires to bake the bricks. This activity is damaging to local air quality as it involves burning biomass such as rice bran, which produces a great amount of smoke. Many neighborhoods of Antananarivo that contain rice fields are practicing this activity as an alternative income generating activity. In this case, it is difficult for local authorities to prevent people from producing bricks as it is a main source of income. In other countries, actions have been taken to switch to other, cleaner fuels or at least to improve the efficiency of combustion. There may be useful lessons to be learned from these experiences.

Ambient air pollution related to transport is mainly a problem for bigger population centers, particularly the city of Antananarivo. However, the trends of increasing vehicles and greater traffic congestion are slowly affecting other areas in the coastal zones. While second-hand vehicles are a known driver of pollution, it is unlikely that their importation will be restricted, as the population is generally unable to afford new cars and the State benefits from Customs duties.

Moving to lower sulfur diesel would bring significant health improvements, and therefore reductions in health costs, but would cost consumers more. An analysis of the price impacts of moving to cleaner fuels and of ways to manage these increases would allow decision-makers and the public to better understand the costs and the benefits to public health. At present, Madagascar has adopted a true price system while directly subsidizing fuel for cooperatives of bus owners in order to keep the cost of public transport down.

Several countries in West Africa have moved to requiring higher grades of fuel, and in particular low-sulfur diesel, with the aim of improving health outcomes. The process adopted in these countries and the legal and technical issues addressed should be examined and discussed for their relevance to Madagascar. The present loss of GDP from cumulative health impacts is an important argument to convince the government to move forwards, despite the financial consequences.

The levels and impacts of ambient air pollution are likely to increase with the development and wealth in the country. A strategic and preventive approach is required to minimize impacts to public health as growth continues. While the regulatory framework already exists, enforcing these laws and regulations is the main constraint that needs to be addressed. The relevant service or department responsible needs to be given the means to effectively carry out their tasks, including authorization to regulate factories and enforcement of environmental

laws. In this context, the Working Group highlights the need for an inter-ministerial agreement (industry, health and environment ministries) to assess factories before they are allowed to commence production. Any strategic approach should prioritize health impacts and find the best way to effectively implement the polluter pays rule, whereby ”the polluter should bear the cost of measures to reduce pollution according to the extent of either the damage done to society or the exceeding of an acceptable level (standard) of pollution” (United Nations, 1997).

Finally, the Working Group emphasized the need for advocacy training and the value of some kind of broad and flexible funding for fighting pollution. The development of such a fund requires an analysis for fiscal opportunities and restraints.

Feasibility and Practicality of Specific Actions Considered

Possible steps:

1. Review and update any existing air quality (AQ) information on Antananarivo and other towns. Obtain data on current and projected levels of traffic (cars, trucks, buses), if possible by town or district.

2. Identify all known point sources of air pollution (factories, power plants, brickmakers, etc) as the basis for AQ projections.

3. Implement an early warning system on air quality based on an AQ monitoring plan with clear objectives for use of each set of data. Define equipment needs. This will probably require additional technical advice. A draft concept note is attached.

4. Develop with involvement of all relevant ministries a plan to move to low sulfur fuel. Prepare timetable and costs. Define consultation and information, education and communication (IEC) activities.

Priority Issue 3 – Reducing Impacts from Contaminated Sites and Chemical Exposures

Sources and Characteristics of Contaminated Sites and Chemical Exposure

In low- and middle-income countries (LMICs) around the world, including Madagascar, there is a troublesome cycle that can prevent ministries of environment from adequately addressing chemical contamination. These ministries are often under-funded relative to their mandate. This resource scarcity prevents the ministries from collecting the type of data that would allow them to calculate the national health and economic impacts from chemical pollution. Without compelling data on the impacts, ministries cannot make strong justifications for increased resources to their ministries of finance and international development partners. Without a compelling justification for increased resources, they cannot collect data or adequately address chemical pollution challenges.

The Government of Madagascar has limited information regarding the prevalence, location and severity of soil and water contaminated by toxic chemicals and the health risks associated with such sites. Madagascar does not have a national database of contaminated “hotspots” such as the U.S. Superfund program. Without a basic understanding of the number, characteristics, and locations of contaminated sites within the country, it is impossible to estimate the full health and economic toll from exposures to toxic chemical contamination and to design appropriate interventions and policy solutions. Establishing a basic understanding of the country’s contamination profile is a critical first step to ensure that resources are properly allocated toward the highest priority issues and to addressing the country’s pollution challenges in a systematic and cost-effective manner.

Globally, there is a growing body of information on the health effects of chemicals used for industrial or agricultural purposes or released as byproducts into the environment. Depending on the chemical, long-term effects of exposure may include developmental impacts in children, endocrine disruption, or increased incidence of certain types of cancer, for example. Despite these risks, few countries have accurate measures of public exposures to chemicals, and there is no comprehensive estimate of health impacts. While the previous two priority issues addressed air pollution, here the focus is on chemical contamination of water and soil.

In Madagascar, attention to specific chemical contaminants and industries is growing, but currently the extent of pollution is not well documented. For instance, one significant industrial contamination problem that is being addressed is an identified leather tannery near Antananarivo. The industrial operations have

been upgraded but the extent of past contamination in the vicinity has not yet been determined in detail.

Several other potential sources of chemical contamination were identified by the Working Group. Concerns were raised over the mixing of industrial and municipal waste and the consequences of this contamination. Highly localized sources were also noted. Many communities receive water from a water pump which is often locally made to reduce costs. Many of these pumps use recycled lead in their construction because it is heavy and cheap. As a result, elevated lead levels have been measured in the water being used by a number of communities. Investment cases can explore the costs and benefits of different technical options in dealing with this problem.

Biological contamination of water associated with unsafe sanitation practices is not included as part of this priority issue. The limited access to clean water and sanitation facilities is reflected in the high health impacts seen in the IHME data. However, the government, with the Ministry of WASH as the lead agency, has put much effort into the WASH sector. They are working with international technical and financial partners, including UNICEF and the Water Supply and Sanitation Collaborative Council (WSSCC), to expand and accelerate the provision of services, which will improve health outcomes.

Disease Burden from Chemical Exposures in Madagascar

Little data is available on the prevalence and severity of exposures to chemical contamination in Madagascar. Because of this, existing estimates on the health impacts from chemical exposures are understood to be a significant underestimate, including the data on lead exposures below. Based on inputs from local experts, experience in comparable countries, and anecdotal evidence, it is fair to assume that the death and DALY impacts from chemical exposures are several times higher than the available data suggest (Table 7).

The HPAP program prioritizes pollution issues based on two factors: 1) the known health impacts from individual pollution challenges, and 2) on known or suspected gaps in our knowledge and response. In the case of chemical exposures, the known health impacts are relatively small compared with the impacts from air pollution, unsafe water, and unsafe sanitation. However, chemical exposures are believed to be a significant gap in current state of knowledge, and are therefore included among the selected pollution priorities.

The major sources of health risk from contaminated sites and chemical exposures, as seen in other developing countries worldwide, are the heavy metals (especially lead and mercury); some of the persistent organic pollutants (POPs); and a range of other chemicals known to cause cancer or other health impacts. The only one of these for which burden of disease figures are available is lead, and these numbers are widely accepted to be a low estimate of the

overall impact. Furthermore, the DALY numbers below do not include the intellectual disability caused by childhood exposures to lead.

Table 7. Available data on the burden of disease from lead exposure in Madagascar (IHME, 2016).

Demographic	Deaths	As % of All Deaths	DALYs	As % of All DALYs
Sex				
Male	622	0.6%	24,233	0.4%
Female	312	0.3%	13,161	0.2%
TOTAL	**934**	**0.5%**	**37,395**	**0.3%**
Age				
<5 years	0	0%	912	0.0%
5-14 years	0	0%	4,425	0.5%
15-49 years	99	0.2%	13,632	0.4%
50-69 years	412	1.0%	12,807	1.0%
70+ years	423	1.1%	5,619	1.0%
TOTAL	**934**	**0.5%**	**37,395**	**0.3%**

Roles and Responsibilities

Regulation of chemicals and of contaminated land is in the mandate of MEEF. Up to now, no projections have been made on future growth in the production or use of hazardous chemicals. This is partly due to the absence of sufficient laws permitting the control of hazardous chemicals, which would allow MEEF to collect updated statistics. However, an administrative note issued by the Customs service obliges all imported chemicals to be declared to, and authorized by MEEF.

The necessary basic regulatory framework is in place to control discharges from industry, mining and other sources. However, the capacity to control actual performance is lacking at each ministry, making some operators less respectful of existing regulations. For example, there is misuse of pesticides in the agricultural sector; certain industries still discharge untreated wastewater; mining exploitation such as gold mining involves the uncontrolled use of mercury; and thermal power stations discharge used oil into the sewage system. Better information on the extent of chemical contamination from industry would allow for a deeper understanding of the health consequences.

Four international conventions related to chemical management are of relevance (Basel, Rotterdam, Stockholm and Minamata) along with SAICM for the strategic part of the management of chemicals and hazardous substances. It is important to note that all five focal points in charge of these conventions report directly to the Branch of Environment at MEEF. As each convention traditionally implements its action plan independently of the other conventions, it is clear that

only through the help of the Branch can integrated pollution actions and outputs be created.

Practical Options for Addressing Contaminated Sites and Chemical Exposures

Given the absence of governmental data related to chemical contamination of soil and water and associated health impacts, the Working Group recognized the importance of implementing a national contaminated sites identification and screening program. The information collected through this program would be stored in an online database owned and operated by the government. Training should be included in the contaminated site identification and screening program to support institutional uptake and build capacity.

A national contaminated site identification and screening program would use human health risks as the primary metric for prioritizing contaminated sites for further detailed assessments and potential interventions. Such a program would take advantage of existing rapid site screening protocols developed specifically for the purpose of establishing national databases of contaminated sites in low- and middle-income countries where technical capacities and resources may be limited. Similarly, the program could use existing online database software and health risk algorithms developed for similar programs in other countries to store data and analyze health risks based on the screening data collected.

This data from such a program could be used by the Government of Madagascar and other stakeholders to begin estimating the morbidity and mortality associated with exposures to chemical pollutants across Madagascar and to prioritize cost-effective risk-reduction projects, programs, and policies.

Feasibility and Practicality of Specific Actions Considered

Possible actions:

1. Establish coordination point for a Contaminated Sites Identification and Screening Program with the aim of determining the extent and geographic distribution of chemical contamination in soil and water. Implement training and first round of site screenings.

2. Establish basic water quality requirements, as a basis for river and water body quality mapping and classification. Ensure that groundwater is included as part of the overall system.

3. Carry out initial investigation of extent of contamination at Anjeva Tannery. Outline extent of remediation work required.

The Toxic Sites Identification Program, implemented by GAHP, has site screening, protocols, tools, and online database platforms which could be put in place quickly to support a national program aimed at establishing chemicals profile and baseline for future actions.

Institutions, Monitoring and Measuring Impacts

The current analyses and priorities are based on the best data available through WHO and IHME. However, the data used, which are often incomplete for some risk factors, comes from a range of sources and hence the health risk estimations are at varying levels of refinement and confidence. It would be possible, using the analytical methods developed by WHO and IHME, to prepare more detailed local estimates of the burden of disease from pollution. This would require obtaining, expanding and collating the relevant data and might also require support in analyzing the data. Locally developed findings, based on international approaches, may be more influential for decision-makers than WHO or IHME estimates.

Further analytical work would allow the definition of specific health outcome measures that are consistent with broader national health status monitoring and reporting. For all selected interventions, information should be collected to track what activities are implemented and what outputs are achieved.

The government will have to define the responsibility to collect and review available data on health impacts; to refine the estimations; and to communicate the findings within the government and to the public at large.

Data collection

With the exception of the MPH, no ministry was reported to gather specific data on health impacts related to their respective activities. Data available at these ministries are not directly relevant to the process of evaluating links between health and pollution. INSTAT hold many kinds of relevant data from sources such as the General Population and Housing Census (Recensement Général de la Population et de l'Habitat) but these are not updated on a routine basis.

At the MPH, data are collected from different levels of the ministry's network (basic health centers, hospital centers) and presented annually in a statistical format. One unit is in charge of managing and updating these data. Access to these data is understandably controlled and requires agreement from the General Secretary of the Ministry. Representatives from the MPH explained that the system is structured for routine reporting on health status and that it would be very difficult to change that way of working. Within the framework of Libreville Declaration, the Ministry was asked to include WASH information in the data collected but this is not yet in effect.

Apart from regular monitoring, specific reports are prepared on an ad-hoc basis. National inventories on POPs and mercury have been created to fulfil obligations under international agreements. In addition, there is a study in progress on the impact of solid biomass used for cooking, carried out by the Pneumology

Association and the National Institute of Nuclear Science and Technique, with the support of the University of Bordeaux.

Coordination

The importance of having data on risk factors is fully agreed upon but the specific practical requirements remain to be discussed. The requirements will have to be carefully examined and justified in order to have the most relevant ones included in the health data collection system. There is a department within the MPH that is in charge of health monitoring and epidemiological surveillance (Direction de veille sanitaire et de surveillance épidémiologique) but it does not focus on pollution-related health issues. One option would be to have this department tasked with health and pollution status monitoring in addition to their usual work. The Working Group expressed concern that such an option might not be realistic if it is going to be largely dependent on external funding.

One alternative discussed was a flexible structure that could be a “Health and Pollution Commission,” integrating designated representatives from the ministries concerned and even from the private sector. Such a commission would facilitate data sharing among the relevant ministries, allow for coordinated actions, and provide a mechanism for planning intersectoral programs. By drawing on existing expertise within each ministry, it was anticipated that the financial implication of this commission would not be overly burdensome, although additional training in areas such as data handling may be required.

Possible support from GAHP secretariat and members:

GAHP can provide access to some of the analytical methods used by WHO and IHME in making estimates of health impacts. It remains to be determined how this expertise can best be provided to Madagascar, in a way that will be sustainable and increase local capacity.

Public Policy and Political Leadership

In light of its international experience, the GAHP team suggests the following policy actions to increase attention and focus in governmental and non-governmental agencies to reduce the health and environmental impacts from pollution in Madagascar.

1. **National political leaders should declare that pollution is a critical public health challenge in Madagascar and a national priority to be mainstreamed into decision-making in relevant ministries and levels of government.**

   Countries rarely succeed in addressing national pollution challenges without clear leadership from the head of state. This was the case in the U.S., in China, in India, and in every country were significant progress in pollution has been made. If pollution is not stated as a priority, it will not be treated as one.

2. **Prioritize key pollution issues in national development strategies discussed with multilateral and bilateral development agencies.**

   Madagascar would benefit by elevating pollution as a priority issue in development plans for international development partners. Development partners respond directly to the requests and priorities of recipient countries and could provide increased resources if specifically identified.

3. **Establish pollution priorities within national ministries and in internal/national planning documents.**

   To date, pollution is not significantly integrated into the decision-making processes of ministries beyond MEEF. Until pollution is elevated as an issue among all relevant ministries, it will remain under-addressed.

4. **Establish a formal, inter-ministerial platform or committee for developing and implementing policies, programs, and projects related to pollution and its effects on public health.**

   In order to avoid duplication and possible administrative delays, the existing HPAP Working Group, GTSE, or a combination of both could be given this responsibility.

5. **Mobilize national and international resources for additional capacities within the environmental health unit of the MPH.**

There is a need for an office to be responsible for monitoring progress on controlling pollution and for reporting. The Environmental Health Unit is appropriate but under-resourced, hence the need to strengthen its capacities.

Summary of Recommended Actions

The following are the main recommendation for actions emerging from the HPAP process. These are the recommendations of the HPAP team, including the GAHP specialists and consultants, and the national Working Group. They are presented for review, revision and possible endorsement by the Validation Meeting. Some of the recommendations have been discussed with government officials and staff of development partners but no commitments to implementation have been made.

Institutions

There should be a formal government mechanism for promoting, monitoring and reporting on progress in dealing with health and pollution problems. It should have a mandate and resources to work across ministries and with non-governmental groups. The Working Group considered a number of possibilities including an existing department or committee, a new cross-sectoral "Commission", or an ad-hoc Working Group. Whichever mechanism is adopted, it must be provided with adequate leadership and resources to function successfully.

A specific unit should be charged with monitoring health outcomes, possibly the existing Environment Health Unit in the Ministry of Health. International support can be sought for building capacity in that unit to manage data collection and analysis, consistent with WHO and IHME approaches.

Policy

There is need for high-level political commitment to addressing pollution as a critical public health challenge. Pollution priorities should be mainstreamed into decision-making across relevant ministries and levels of government. Agreed key pollution interventions should be included in national development strategies and in discussions with development partners.

Adequate resources should be provided to sustain a national effort to improve public health and the economy by reducing pollution.

Issue 1: Household Air Pollution

- Establish a specific HAP Reduction Policy within the existing National Energy Policy, including responsibilities and targets. Set up clear coordination mechanism, since HAP is not a priority for any ministry.

- Continue to support realistic targets and efforts under the Ethanol Program.

- Review, with support from GAHP members, successful experiences and lessons from overseas for moving households and whole communities up the "fuel ladder". On this basis prepare a broad strategy and short-term pilot (draft concept note is attached to this report).

Issue 2: Outdoor Air Pollution

- Review and update any existing AQ information on Antananarivo and other towns and identify sources of air pollution as the basis for AQ projections. Prepare an AQ monitoring plan with clear objectives for use of data.

- Examine contribution of high sulfur fuel to current AQ problems and develop a plan to move to low sulfur fuel. Prepare timetable and costs.

Issue 3: Contaminated Sites and Chemical Exposures

- Establish coordination point for a Toxics Sites Inventory, in order to determine the extent and geographic distribution of chemical contamination in both soil and water. Implement training and first round of site screenings.

- Establish basic water quality requirements, as a basis for river and water body quality mapping and classification. Ensure that groundwater is included as part of the overall system.

- Carry out initial investigation of extent of contamination at Anjeva Tannery. Outline extent of remediation work required.

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Annex A – Concept Note on Pilot-Scale Household Air Pollution Reduction

Background

Madagascar has limited modern energy sources and severe household air pollution (HAP) challenges. Reducing the health impacts of HAP will require a focused long-term approach, employing a range of practical options.

Making major improvements in the health consequences of HAP will require helping households to move up the “fuel ladder.” This means moving from poor quality solid fuel to cleaner burning fuels. In Madagascar, typically these clean fuels would be ethanol and liquid petroleum gas (LPG). Ideally, all households could “leapfrog” from current practices to using cleaner fuels but this is not practical in the short-term in Madagascar, given the nearly universal use of solid fuels and lack of financial capacity of households to buy cleaner fuels.

Major HAP programs are typically put in place as part of a broader national program of improving energy access and upgrading household energy supply. In Ethiopia, the “National Program for Improved Household Biomass Cookstoves Development and Promotion” has been developed under the national Green Economy Plan, to support a strong framework for increased investment in clean stoves. The “National LPG Master Plan” in Cameroon takes a different approach, aiming to increase LPG uptake to about 60% of the population by 2030. In each case, these programs were developed by, or in close collaboration with, the relevant energy ministry.

This intervention will also look for effective community-based solutions that have the potential for scaling up. Community-level programs have benefits over individual household interventions in terms of providing efficiencies of scale, eliminating cross-pollution from neighbors, and providing social support for HAP reduction efforts.

Program Objectives

The specific objective is to identify and to begin to implement interventions that can make a measurably reduce HAP levels and improve associated health outcomes at the local level.

The broader objective is to use the initial work to identify reliable and sustainable community schemes that would reduce the health toll of current biomass use, and to set out a strategy for expanding such schemes to communities across Madagascar.

Project Area and Target Beneficiaries

The initial interventions will be small-scale, to develop the approaches and to test implementation feasibility. The specific project area or areas will be identified in the early planning stages. The Minister of Environment has committed to obtaining support at the local level for the pilot interventions. The direct beneficiaries will be the households (particularly women and children) who are supported to upgrade their cooking fuels.

Project Description and Actions

The potential interventions would include some standalone actions such as stove upgrade programs and others which are carried out in conjunction with the other sectors (for example, expanding bioethanol and charcoal use). The pilot would address acceptability, technology options, and cost issues.

An essential element will be to build coordination across government departments and between different levels of government and to involve communities and the business sector.

A key component of the work is to compile an information base to support interventions and to allow for analysis and tracking of outcomes and impacts on health. Communication and education are also important elements of the HAP reduction efforts.

Specific actions include:

1. Establish responsibilities and interinstitutional cooperation mechanisms. HAP is a complex intersectoral challenge, which is a reason why progress has often been slow. There is a need for a broad and flexible approach, with interventions designed to meet local conditions and priorities. This will require the involvement of different agencies, depending on the specifics of the situation. The Government has to establish clear responsibilities for addressing HAP, within broad energy policy, and needs to set up the necessary coordination mechanisms, together with operational budgets.

   Action by the Government to have the necessary mechanisms operational as quickly as possible will be a strong sign of commitment to achieving progress.

2. Collect baseline data and begin to manage information. An essential component is to compile reliable information on existing conditions in order to support interventions and to allow for analysis and tracking of outcomes and impacts on health. Key data to be collected would be based on existing administrative or statistical divisions and would include, at a minimum, current household energy sources and usage.

Data is initially assembled from existing household surveys, ministry and statistical records and any available reports and investigations. Some of the data should be readily available while other may require discussions with relevant groups and individuals. New surveys are not recommended at the initial stages.

3. Identify a range of possible interventions. Based on technical advice from national and international partners, a range of options will be developed that may include the following specific intervention types (or a mix thereof):
    - Improved cookstoves
    - Upgraded access to better biomass fuels (organised fuelwood, sustainable charcoal, etc)
    - Switching to liquid fuels (ethanol is clean; kerosene is not)
    - Access to bottled gas – LPG
    - Access to gas or electric networks.

In practical terms, households and communities are constrained in their options by factors including finance, awareness, priorities and the availability of alternatives. Understanding these constraints for different groups is a key step in choosing priority areas for interventions and also options to be considered. Based on community discussions and feedback, interventions can be selected, drawing from a range of different mechanisms.

Depending on progress with implementation arrangements and with technical discussions, pilot projects can begin in selected communities.

Key Outputs

The short-term outputs would be numbers of households being provided with improved systems or fuels and the lessons and recommendations on which to base a scaled-up program.

Longer-term outputs would include plans for the continuation of interventions, ideally in the context of a national energy strategy, since the scale of the household energy challenge is significant.

Ideally, basic health parameters such as reported/treated illness would be collected and monitored but this would require upgraded health monitoring systems, which will take time to be agreed upon and implemented, and which require committed funding.

Implementation and Monitoring

A specific HAP Working Group will be established within the current Health and Pollution Action Plan Working Group with the purpose of identifying and beginning to implement a Pilot-Scale program. This HAP Working Group must be established and resourced before the program begins.

The Health and Pollution Working Group already includes representatives from the Ministry of Energy. This link can be used to initiate more structured discussions with the Ministry about integrating HAP measures within national energy access programs.

A full-time project manager will be appointed to support the HAP Working Group and to ensure smooth and timely planning and implementation. Technical support, national and international, will be provided to bring detailed knowledge of practical options and actions.

Timeline

In the first six months: data assembled, options identified and communities identified. In the following six months: interventions planned and costed; communities actively involved.

In the second year: installation of household appliances, roll out of community engagement and support, and implementation of associated upgrades. Evaluation carried out and scaling up strategy outlined.

Budget

International technical assistance to be provided for analysis and design. Estimated costs US$50k for preparation, design of pilot and outreach to communities and officials. Allow budget of US$1 million for first community intervention, including infrastructure upgrades and health tracking.

Annex B – Concept Note on Upgrading Transportation Fuel Quality

Background

Madagascar imports transportation fuel with a high sulfur content. Other African countries have moved away from this polluting fuel. It has been argued that the costs to transportation users of cleaner fuels would be too high, but no recognition has been made of the health costs stemming from low-quality fuels. The benefits to the country of cleaner fuels would be high, which is why other countries are moving towards lower sulfur fuel.

Program Objectives

To determine the costs and benefits of cleaner fuel and to set out practical options for moving to use of lower sulfur transportation fuels.

Project Area and Target Beneficiaries

A switch to high-quality fuels would impact the entire country and provide health benefits to all residents Madagascar, but would be particularly impactful in dense urban areas where poor transportation fuel contributes to poor air quality most.

Primary Outcome

The primary outcome of this program would be a roadmap illustrating the costs and benefits to upgrading the quality of fuel imported to Madagascar, the institutions and mechanisms that would be involved in such a change, and the functional steps the government and private sector would take.

Outputs

1. Parties are identified whose involvement is required and establish a group with the mandate and resources to identify and examine options and to make recommendations to the government.
2. Report on current quantities, qualities (against existing standards and European standards) and types of fuel imported into and used in Madagascar. The report will compare this information with relevant other countries, in Africa and elsewhere.
3. Report on the costs of different fuels and impacts of moving to cleaner fuels.
4. Report estimating health impacts of cleaner fuels, in context of increasing traffic and urban air pollution.
5. Report on air quality in 7 key cities (Antananarivo, Toamasina, Antsirabe, Mahajanga, Toliara, Fianarantsoa, Antsiranana).

Implementation and Evaluation

The program will be implemented by a Working Group or Committee established specifically for the purposes of this analysis and comprising representatives of relevant government institutions.

Timeline

The program will be conducted over the course of one year.

Budget

An initial budget would be required to review the current status of fuel imports and relevant standards and to begin to identify the relevant parties to be involved in improving fuel quality in practice.

Annex C – Concept Note on National Contaminated Site Identification and Screening Program

Project title:	National Contaminated Site Identification and Screening Program
Location(s):	Madagascar
Planned start date:	TBD
Duration:	Two years
Government coordinating agency and Executing agency/cooperating agency:	National Environmental Research Center, Ministry of Environment, Ecology and Forests
Budget (USD):	125,000

1. Project summary

The National Contaminated Site identification and Screening Program will establish, for the first time, a database of sites that are contaminated by toxic chemicals in Madagascar. The program will aim to identify and screen sites across the country where soil and water pollution pose public health risks.

The program will begin with a review of relevant datasets and publications regarding the presence of chemical contamination throughout the country. Based on this review, the program managers will develop a preliminary list of known or suspected contaminated sites that are targeted for a screening assessment. Once a preliminary list of sites is complete, the managers will prioritize the lists based on the human toxicity of the contaminant or the suspected concentration of the contaminant relative to national or international standards, screening thresholds, or guidance levels.

Once a preliminarily list of target sites is developed, a team of trained investigators will conduct rapid site screening assessments following a standardized screening protocol aimed at confirming the presence of chemical contaminants and an exposure pathway to human receptors (local population), and evaluating the relative severity of associated public health risks. The screening assessment will include a tour of the source and likely contaminated area, photos, interviews with local stakeholders, the creation of maps, sampling of soil and water, and the collection of relevant geographical, geological, hydrological, social, and demographic data used to evaluate the source and

migration of contaminants, the likely pathways into the human body, and the overall risk to the local population.

The data from the screening assessments will be uploaded into an online database that is designed to collect all relevant types of data and to generate a preliminary risk score for each site. This data and risk score will be used by the Government of Madagascar and other stakeholders to begin estimating the morbidity and mortality associated with exposures to chemical pollutants across Madagascar and to prioritize cost-effective risk-reduction projects, programs, and policies.

2. Relevant background

In low- and middle-income countries (LMICs) around the world, there is a troublesome cycle that can prevent ministries of environment from adequately addressing pollution. These ministries are often under-funded relative to their mandate. This resource scarcity prevents the ministries from collecting the type of data that would allow them to calculate the national health and economic impacts from chemical pollution. Without compelling data on the impacts, ministries cannot make strong justifications for increased resources to their ministries of finance and international development partners. Without a compelling justification for increased resources, they continue to be under-funded and cannot adequately address pollution challenges or collect impact data.

The Government of Madagascar has limited information regarding the prevalence, location and severity of sites contaminated by toxic chemicals and the health risks associated with such sites. Madagascar does not have a national database of contaminated “hotspots” such as the U.S. Superfund program. Without a basic understanding of the number, characteristics, and locations of contaminated sites within the country, it is impossible to estimate the health and economic toll from exposures to toxic chemical contamination and to design appropriate interventions and policy solutions. Establishing a basic understanding of the country’s contamination profile is a critical first step to ensure that the resources are properly allocated toward the highest priority issues and to addressing the country’s pollution challenges in a systematic and cost-effective manner.

3. Project description

A. Project beneficiaries

The Program has two primary beneficiary groups: direct beneficiaries and ultimate beneficiaries. The direct beneficiaries of the program include the representatives of CNRE, the Ministry of Environment, Ecology and Forests, and other ministries that will work on the program or will benefit from access to the

data collected. This is estimated to be approximately 200 individuals within the Government or in research institutes.

The ultimate beneficiaries of the program include all residents who live near, or are impacted by chemical contamination in Madagascar. In similar site assessment programs implemented in other countries (the global Toxic Sites Identification Program), the mean population at risk of exposure to toxic chemicals at each contaminated site is approximately 3,000 individuals. After 100 site screenings in Madagascar, the beneficiaries would be approximately 300,000 residents whose personal health risks are measured and understood by the relevant government authorities, and who may benefit from future pollution abatement policies, risk-reduction programs, and remediation projects.

B. Overall project objective

The objective of the National Contaminated Site identification and Screening Program is to reduce the morbidity and mortality associated with exposures to toxic chemicals in soil and water in Madagascar by increasing the capacity of the CNRE and MEEF to identify and assess contaminated sites and prioritize high-risk sites or sources of contamination for risk-mitigation programs or remediation projects.

C. Intervention strategy

The program will use human health risks as the primary metric for prioritizing contaminated sites for further detailed assessments and potential interventions. The program will take advantage of existing rapid site screening protocols developed specifically for the purpose of establishing national databases of contaminated sites in low- and middle-income countries where technical capacities and resources may be limited. Similarly, the program will use existing online database software and health risk algorithms developed for similar programs in other countries to store data and analyze health risks based on the screening data collected. The use of existing protocols and database software will reduce costs, increase efficiency, and help ensure that the best available tools and methodologies are employed.

The site screening protocol will likely include the collection of the following types of environmental, geographic, geologic, hydrologic, demographic, and health data:

- Site name, location, GPS coordinates
- Abstract or summary of the site, contaminant, source industry
- Date of assessment
- Estimated population exposed to sampling areas and other suspected contaminated areas
- Key pollutant

- Geotagged soil and/or water samples from between 10-20 locations around the site
- Detailed narrative site description including how the population interacts with the contaminated area, how the contaminant migrates from the source to the receptor community, and how the contaminant likely enters the body (inhalation, ingestion, dermal exposure).
- Description of the sources industry type
- Site size of contaminated area in hectares
- Depth of contamination
- Soil type
- Population density
- Land uses in the contaminated area
- Assessment of crops or livestock grown at the site
- Description of the relative ease of public access to the site
- Hydrological information and different water uses at the site
- Slope and elevation of the site
- Interview with local stakeholders
- Photographs
- Maps

D. Implementation partnership(s)

The program will be implemented by the Centre National de Recherches en Environnement (CNRE), which is under the supervision of MEEF. CNRE will implement the program in partnership with the international technical experts experienced in contaminated site identification and rapid risk assessment protocols, which will provide technical support and training. In consultation with these experts CNRE will develop a site screening protocol that is designed to assess a wide variety of contaminants in diverse contexts. CNRE will make use of a pre-existing online database tool that can accept a wide variety of site screening data types and can analyze that data to create a relative risk score for each site. This database is already accessible to the government of Madagascar through a previous partnership with the non-profit organization Pure Earth, and can be transferred to national governments for purpose of establishing a government owned and independently operated database.

E. Project results/outputs

Program outputs include:

1. A research report analyzing existing information about contaminated sites and associated impacts and establishing a list of preliminary sites targeted for initial screening assessments
2. A site screening protocol that uses the best available methods from other national and international programs and is modified to address the needs

of the Government of Madagascar and the types of contamination challenges present in the country

3. An online database capable of storing all relevant site assessment data and generating relative risks scores based on an algorithm that analyzes the type and toxicity of the contaminant/s, the concentration of the contaminant/s in soil and water samples, the exposure pathway to humans, the population at risk of exposure, and other geographic and demographic data relevant to estimating environmental health risks
4. A training workshop where government representatives and other partners/stakeholders receive technical training on the site screening protocol
5. Screening assessment conducted at 100 known or suspected contaminated sites across Madagascar
6. A report on the findings of the National Contaminated Site identification and Screening Program that contains a summary of the data collected, a list of high-priority sites that require detailed assessments, and recommendations to address specific sites and common sources of contamination.

F. Key project activities

Output	***Activities***	***Locations***	***Timing***	***Partners***
1. Research report on existing information about contaminated sites	1.1 Establish research team	Antananarivo, Madagascar	Q1, Y1	CNRE,
	1.2 Gather all relevant reports and datasets	Antananarivo, Madagascar	Q1, Y1	CNRE, Int'l Consultants
	1.3 Draft report analyzing existing data and establishing a list of targets sites	Antananarivo, Madagascar	Q1, Y1	CNRE, Int'l Consultants
2. Site screening protocol	2.1 Review existing rapid assessment protocols	Antananarivo, Madagascar	Q2, Y1	CNRE, Int'l Consultants
	2.2 Draft screening protocol for Madagascar	Antananarivo, Madagascar	Q2, Y1	CNRE
3. Create online database for site screening data	3.1 Transfer Toxic Sites Identification Program online	Antananarivo, Madagascar	Q2, Y1	Pure Earth

	database to CNRE, translate to French			
	3.2 Conduct training for CNRE staff in the use of the database	Antananarivo, Madagascar	Q2, Y1	CNRE, Int'l Consultants
4. Training in site screening protocol	4.1 Identify a team of site screening investigators including technical staff of CNRE or other partners who may conduct site screening assessments on behalf of the government	Antananarivo, Madagascar	Q2, Y1	CNRE, Int'l Consultants
	4.2 Develop and implement a training workshop for site screening investigators	Antananarivo, Madagascar	Q2, Y1	CNRE, Int'l Consultants
5. Site Screening Assessments	5.1 Assign specific sites to site investigators and develop an investigation plan and timeline	Antananarivo, Madagascar	Q2, Y1	CNRE
	5.2 Conduct site screening assessments and upload site data into online database	Madagascar, all regions	Q3, Y1 through Q3, Y2 (12 months)	CNRE
6. Report findings and develop priorities and recommendations	6.1 Analyze site data and develop a list of priority sites for further detailed assessment	Antananarivo, Madagascar	Q4, Y2	CNRE
	6.2 Draft final report on	Antananarivo, Madagascar	Q4, Y2	CNRE

	program findings, priorities for future actions, and recommendations to address specific sites and common problems			

G. Gender mainstreaming

Women, especially pregnant women and those of childbearing age, are disproportionally impacted by toxic pollution. Heavy metals and other chemicals can be transmitted to the fetus in utero and via breast milk. Exposures can exacerbate other health concerns, trigger long-term illness, cause permanent neurological damage and lower IQs. They can have a multigenerational impact, affect the future reproductive and genetic health of a fetus, and have been linked to pre-term birth and infant mortality.

Small children often accompany their mothers at work. Women working in livelihoods that involve toxicants or chemicals are at high risk for poisoning themselves, their babies and children. Women are commonly pushed to the fringe in many industries, thereby forming a de facto high-risk population. Women can bring home toxic dust on their clothes and in their hair, creating a secondary source of exposure at home. Inadequate hygiene before meal preparation can contaminate food. Educational differences or biases in access to training may mean that women are less equipped than men to understand, deal with and make decisions about pollution problems and exposures. Women are also at greater risk for multiple exposures, such as exposures to lead or mercury at work, and particulates released from cook stoves at home. As primary caregivers, women's workloads may be additionally burdened if pollution exposures cause illness or disability in the family.

This project will directly address gender issues by ensuring participation in and benefits from the project are equitable, and that all project activities involve and enable women. Gender-appropriate accessible tools, language, and procedures will be used.

Specific gender objectives are to:

1. Ensure equitable participation of women and men in technical assistance and education/communication activities, so that women are represented, can voice their needs/opinions, and can access appropriately presented information and training. Special accommodations will be made for any nursing mothers.

2. Incorporate gender considerations into baseline data collection and project design. Answer key questions, such as: Are women and girls disproportionately affected, how and why? What are the economic/ socio-cultural reasons? Does this in/directly increase/decrease women's risks? Do these differences require different interventions or strategies? Are there sensitivities or existing conflicts/issues to consider regarding gender that the project unless properly planned could potentially worsen? What is the project's potential impact on women? Are there any local women, female experts/scientists/leaders/government employees, or women's organisations already working on these issues and/or championing solutions?

3. Hire and train an inclusive project staff representative of the population served, including languages spoken, gender, and cultural background.

H. Project financing and indicative budget

Madagascar Contaminated Sites Identification and Screening Program	
Budget Items	**USD**
Technical Advisors	$8,000.00
National Investigator Daily Rate	$20,000.00
Project Coordinator	$24,000.00
International Flights	$4,800.00
National Flights	$5,400.00
Land Travel	$5,200.00
Accommodation	$4,000.00
Fixed Per Diem	$8,000.00
Meals	$2,000.00
Visas	$100.00
Technical Training Workshop (x2)	$3,000.00
GPS Unit / Camera	$2,000.00
XRF Analyzer	$25,000.00
Personal Protective Equipment	$1,800
Lab Tests / Sampling	$10,000.00
Communications (Phone/Internet)	$500.00

Printed Materials	$800.00
Bank Fees	$400.00
Total Expenses	**$125,000.00**

The program will benefit from significant in-kind contributions from the non-profit organization Pure Earth in the form of a ready-to-use online database for the collection and analysis of site screening data that has been developed and refined over a ten-year period. This database infrastructure will be transferred to the Government of Madagascar at no cost.

I. Sustainability of project results

This program is designed to generate the type of data that will allow the Ministry of Environment, Ecology and Forests, the Ministry of Public Health, and other stakeholders to communicate the health and economic impacts from exposures to pollution, thus allowing these agencies to make more compelling justifications for increased resources from national and international sources. For example, if the Ministries of Health and Environment could adequately estimate and communicate the productivity loss from illness and premature deaths associated with pollution exposures, they could make persuasive cost-benefit arguments about that value of pollution mitigation programs. In this way, the program is fundamentally structured for long-term sustainability, as its primary goal is to create a foundation for increasing future resources to address pollution.

J. Risks to project implementation

Project assumptions	***Risk of failure***	***Mitigation action(s)***
Assumption 1. Existing report and data will be sufficient to develop a preliminary list of targeted sites for screening assessments.	Low. CNRE has previously collaborated on an environmental health program that identified published studies on chemical contamination in Madagascar and have identified specific chemical and industrial sources that are believed to cause contamination within the country. This data should be sufficient for the development of a	CNRE will reach out to other government agencies, including regional and municipal agencies and research institutes to collect as much information as possible to aid in the development of a list of targeted sites.

	preliminary list of targeted sites.	
Assumption 2. The mandate and priorities of the Ministry of Environment, Ecology and Forests, an those of CNRE, do not change in a way that discourages or prevents the collection of data from contaminated sites.	Low. CNRE was expressly created for the collection and management of scientific data pertaining to the environment.	CNRE will consult with leadership personnel within the Ministry of Environment to ensure that program activities are in line with the Ministry's priorities and will be be disrupted by elections or other shifting mandates.

K. Monitoring, reporting and evaluation

(To be determined by relevant executing agency and funding agencies)

L. Communication and visibility

(To be determined based on the requirements of the funding agencies)

ANNEX D – Methodology for Estimating Economic Costs from Pollution in Madagascar

The following is an excerpt from the Lancet Commission on Pollution and Health and from pages 43-56 of the Commission's Annex.

Ways to Measure Pollution's Costs

A method to estimate the tangible costs of pollution- related disease was developed in the early 1980s by an expert committee convened by the Institute of Medicine. The core of this method is calculation of the so-called "fractional contribution" of pollution to causation of a particular disease. This environmentally attributable fraction is defined as ''the percentage of a particular disease category that would be eliminated if pollution was reduced to the lowest feasible levels.'' This fractional contribution is then multiplied by the number of cases of pollution-related disease in a population and by the average cost per case to calculate the total costs of pollution-related disease.

The cost of a case of illness is often measured by the medical expenses incurred when a person is ill (the direct costs of illness) and by the loss in productivity when a person dies prematurely or is disabled (the indirect cost of illness). This method has been used to estimate the costs of pollution-related disease in children and of occupational disease in workers, has enabled quantification of the effects of pollution-related disease on GDP, and has provided a means to calculate costs that are typically externalized and not captured by standard accounting methods, and thus were previously hidden. Information derived from this so-called full-cost accounting method has proven to be a powerful lever for shaping public policy and is an effective antidote to one-sided arguments for not taking or delaying action against pollution that are based solely on the costs of pollution control.

The cost of illness approach to calculating costs of pollution-related disease works reasonably well in countries with strong public health data systems and robust information about the costs of disease. However, it is less applicable in countries without those resources. Therefore, the GBD study and WHO estimates of the burden of disease due to pollution are based primarily on data for premature deaths and do not adequately reflect the full burden of pollution-related disease because, in many countries, researchers are not able to capture information about pollution-related morbidity. In countries where data are available relating pollution to morbidity and to the costs of disease, these costs are often substantial. Such studies suggest that the morbidity costs resulting from pollution-related disease might conservatively increase mortality costs by 10–70%, and some individual country studies suggest that the increment might be even greater: 25% for Colombia, 22–78% for China, and 78% for Nicaragua.

A second shortcoming in using the cost of illness approach to estimate the health costs of pollution is that it can never capture the intangible losses caused by pollution-related disease, even when comprehensive data are available. For example, this method can neither measure the family disruption that follows the premature death of a mother or a father nor can it quantify the grief that follows the death of a child. Those losses are separate and qualitatively different from losses in income generated or in goods produced. Similarly, a method that is based solely on the effect of pollution on GDP cannot fully describe the negative effects of pollution on societal health, on diminished visibility in national parks, on ecosystem services, or the benefits of pollution control in enhancing national welfare.

To overcome these shortcomings in the cost of illness approach, economists have devised a second strategy to assess disease costs: the so-called "willingness-to-pay" method. This metric is a measure of how much people are willing to pay to reduce the risk of premature death. This approach captures individuals' preferences for avoiding increases in risk of death by analyzing their behavior in risky situations (the revealed preference approach) or in hypothetical choice situations involving changes in their risk of death (the stated preference approach).

To aggregate data from willingness to pay (WTP) studies, economists have developed the Value of a Statistical Life (VSL) concept. The VSL is defined as the total of what many people would pay for small reductions in the probability of dying over the coming year that, together, add up to saving one life. For example, if each of 10,000 people were willing to pay US$100 over the coming year to reduce their risk of dying by 1 in 10 000, one statistical life would be saved and the VSL would equal $100 × 10,000, or $1,000,000.

Multiplying the number of lives lost to pollution by the VSL provides an estimate of the health costs associated with pollution, often referred to a "welfare costs." Multiplying the number of lives that pollution control would save by the VSL provides an estimate of the benefits of pollution control.

Although the VSL method has the disadvantage of relying on estimates of what people say they will pay to reduce mortality risks, it overcomes many of the limitations that hinder e orts to estimate pollution-related disease costs; for instance, by expanding estimates from those made solely in terms of productivity losses and effects on GDP. The VSL method has been used by governments in high-income countries and in Colombia, Malaysia, Mexico, and Peru, amongst others, to estimate the benefits of reducing pollution.

Methodology

The Lancet Commission on Pollution and Health uses both approaches in the current analysis. Economic losses from pollution-related disease are therefore

measured in terms of lost productivity and health-care costs, and the costs of pollution-related disease are also presented using estimates derived from WTP studies. Costs associated with air, water, and lead pollution are included in this analysis, but costs associated with soil pollution are not yet available and are not included. To calculate the VSL in countries where no original studies are available, we have extrapolated estimates from other countries, taking differences in income levels into account. This method is described in the Commission Appendix (pages 25–28).

The economic benefits that result from the control of pollution and prevention of pollution-related disease are the same as the costs that result from pollution-related disease. Losses in economic productivity are a key component of the costs of pollution-related disease. When pollution-related disease results in the death of children or adults of working age, the economic output that those people would have produced is lost forever. The productivity losses associated with premature mortality are measured by calculating the output that an individual would have produced over his or her working life, summing these losses to the present.

Pollution-related disease also reduces the productivity of ill people while they are working. Hanna and Oliva estimated that the closing of a heavily polluting refinery in Mexico City, Mexico, increased the hours worked by people living near the refinery by 3.5%. Zivin and Neidell found that a 10 ppb reduction in ground-level ozone increased the productivity of farm workers in California, USA, by 5.5%. Chang and colleagues report that each 10 µg/m3 increase in outdoor PM2·5 concentrations reduced the productivity of factory workers by 6% in northern California, USA. Similarly, water pollution has also been shown to reduce adult productivity. An estimated 35 million people in Bangladesh are exposed to concentrations of arsenic in groundwater that exceed 50 µg/L and 57 million people are exposed to concentrations above the WHO standard of 10 µg/L. Carson and colleagues, who performed this study, estimate that reducing arsenic concentrations to the WHO standard would increase annual hours worked by the average household in their sample by 6.5%.

A method to measure lost output is to calculate its effects on a worker's contribution to GDP. Table 3 shows reductions in GDP that result from pollution-related deaths as a percentage of a country's GDP. Losses are reported by World Bank income group and pollutant category (lead exposure, ambient air pollution, household air pollution, unsafe water, and unsafe sanitation. Because the magnitude of productivity losses is sensitive to the interest rate used to discount losses to the present (discount rate), this Commission gives results using two different discount rates (1.5% and 3%). For country-level data see Lancet Commission on Pollution and Health Appendix (pages 43–47).

	Ambient air pollution and household air pollution	Unsafe water and unsafe sanitation*	Lead exposure	Total
High income	0·044% (0·048%)	0·0028% (0·0033%)	0·0027% (0·0029%)	0·050% (0·054%)
Upper-middle income	0·13% (0·15%)	0·019% (0·027%)	0·0054% (0·0059%)	0·15% (0·18%)
Lower-middle income	0·32% (0·40%)	0·28% (0·40%)	0·012% (0·013%)	0·61% (0·82%)
Low income	0·62% (0·86%)	0·70% (1·03%)	0·012% (0·013%)	1·33% (1·90%)
World	0·092% (0·11%)	0·033% (0·047%)	0·0042% (0·0046%)	0·13% (0·16%)

Results without parentheses discount future output at the rate of growth in per capita GDP plus 3%. Results in parentheses discount future output at the rate of growth in per capita GDP plus 1·5%. For the calculations see appendix (pp 25–26). *Includes, but is not limited to, no hand washing with soap.

***Table 3*: Productivity losses as a percentage of gross domestic product (GDP) by pollutant and World Bank income group**

Because pollution-related disease is most common in heavily polluted, low-income countries, productivity losses due to pollution-related disease are dis-proportionately high in these countries. Thus, in low- income countries, productivity losses due to pollution-related disease represent between 1·3% and 1.9% of GDP. By contrast, in lower middle-income countries, these losses amount to between 0.6% and 0.8% of GDP. In low-income countries, the largest productivity losses due to pollution-related disease result from lack of access to safe water and sanitation, followed by exposures to air pollution. Household air pollution alone causes losses of between 0.49% and 0.68% of GDP in low-income countries.

In upper middle-income and high-income countries, most economic losses attributable to pollution-related disease are due to ambient air pollution. These losses comprise a smaller fraction of GDP than in low-income and lower middle-income countries because there is generally less pollution in these countries and prevalence of pollution-related disease is lower. An additional factor that reduces the estimated costs of pollution-related disease in high-income countries is that more than 82% of deaths due to air pollution in these countries occur in people age 65 years and older. This reduces the calculated costs because the international definition of working age is 15–64 years of age and, hence, the economic contribution of premature death in people older than 65 years is not counted. In upper middle-income and high-income countries, estimated economic losses due to pollution- related disease in 2015 were more than US$53 billion.

Additional economic costs of coal combustion not included in this analysis are costs related to disease and premature death in coal miners due to injuries and coal workers' pneumoconiosis; costs of lung cancer in coke oven workers;

ecological and community costs of mountain top removal and strip-mining; losses in property values near mines and along railroad rights-of-way; loss of timber resources; and crop losses due to water contamination.

Chart 1. Productivity Losses as a Percentage of GDP by Pollutant

Productivity Losses as a Percentage of GDP by Pollutant

		3% Discount Rate				1.5% Discount Rate			
Country	World Bank Income Group	AAP and HAP Combined	UW and US Combined	Lead Exposure	Total	AAP and HAP Combined	UW and US Combined	Lead Exposure	Total
Antigua and Barbuda	H	0.0461%	0.0181%	0.0033%	0.0674%	0.0531%	0.0256%	0.0035%	0.0822%
Australia	H	0.0135%	0.0011%	0.0031%	0.0176%	0.0149%	0.0014%	0.0033%	0.0196%
Austria	H	0.0419%	0.0011%	0.0013%	0.0442%	0.0457%	0.0014%	0.0014%	0.0485%
Bahrain	H	0.0503%	0.0062%	0.0003%	0.0568%	0.0582%	0.0085%	0.0003%	0.0670%
Barbados	H	0.0795%	0.0205%	0.0048%	0.1048%	0.0901%	0.0272%	0.0052%	0.1224%
Belgium	H	0.0517%	0.0027%	0.0048%	0.0591%	0.0563%	0.0032%	0.0051%	0.0646%
Brunei	H	0.0155%	0.0028%	0.0003%	0.0186%	0.0176%	0.0038%	0.0004%	0.0218%
Canada	H	0.0230%	0.0016%	0.0010%	0.0256%	0.0251%	0.0019%	0.0011%	0.0281%
Chile	H	0.0356%	0.0031%	0.0007%	0.0394%	0.0399%	0.0040%	0.0008%	0.0447%
Croatia	H	0.1096%	0.0031%	0.0059%	0.1186%	0.1193%	0.0037%	0.0063%	0.1294%
Cyprus	H	0.0455%	0.0016%	0.0034%	0.0505%	0.0503%	0.0021%	0.0036%	0.0560%
Czech Republic	H	0.0707%	0.0046%	0.0016%	0.0769%	0.0769%	0.0054%	0.0017%	0.0840%
Denmark	H	0.0372%	0.0021%	0.0016%	0.0410%	0.0405%	0.0026%	0.0017%	0.0448%
Estonia	H	0.0635%	0.0055%	0.0070%	0.0759%	0.0692%	0.0064%	0.0074%	0.0830%
Finland	H	0.0275%	0.0009%	0.0008%	0.0292%	0.0298%	0.0010%	0.0009%	0.0317%
France	H	0.0368%	0.0024%	0.0024%	0.0416%	0.0403%	0.0028%	0.0025%	0.0457%
Germany	H	0.0484%	0.0021%	0.0018%	0.0523%	0.0528%	0.0024%	0.0019%	0.0571%
Greece	H	0.0615%	0.0012%	0.0045%	0.0672%	0.0682%	0.0014%	0.0049%	0.0745%
Hungary	H	0.1450%	0.0038%	0.0075%	0.1563%	0.1580%	0.0047%	0.0081%	0.1707%
Iceland	H	0.0247%	0.0024%	0.0019%	0.0290%	0.0272%	0.0029%	0.0020%	0.0322%
Ireland	H	0.0278%	0.0018%	0.0021%	0.0317%	0.0307%	0.0022%	0.0023%	0.0351%
Israel	H	0.0284%	0.0020%	0.0008%	0.0311%	0.0316%	0.0025%	0.0008%	0.0349%
Italy	H	0.0392%	0.0010%	0.0028%	0.0430%	0.0431%	0.0012%	0.0030%	0.0473%
Japan	H	0.0296%	0.0020%	0.0007%	0.0322%	0.0328%	0.0023%	0.0007%	0.0358%
Kuwait	H	0.0417%	0.0033%	0.0001%	0.0451%	0.0486%	0.0046%	0.0001%	0.0533%
Latvia	H	0.1600%	0.0090%	0.0124%	0.1813%	0.1751%	0.0105%	0.0133%	0.1988%
Lithuania	H	0.1394%	0.0080%	0.0102%	0.1576%	0.1533%	0.0094%	0.0110%	0.1737%
Luxembourg	H	0.0273%	0.0014%	0.0008%	0.0295%	0.0300%	0.0018%	0.0009%	0.0327%
Madagascar	L	0.5650%	0.6364%	0.0095%	1.2109%	0.7583%	0.9232%	0.0106%	1.6921%
Malawi	L	0.4868%	0.6403%	0.0015%	1.1286%	0.7064%	0.9373%	0.0017%	1.6454%
Mali	L	0.4539%	0.7211%	0.0023%	1.1774%	0.6489%	1.0924%	0.0026%	1.7439%
Mozambique	L	0.3669%	0.4572%	0.0106%	0.8347%	0.4906%	0.6367%	0.0116%	1.1389%
Nepal	L	0.3306%	0.2602%	0.0008%	0.5917%	0.4261%	0.3630%	0.0009%	0.7900%
Niger	L	1.0729%	2.0023%	0.0013%	3.0765%	1.5812%	3.0819%	0.0015%	4.6646%
Rwanda	L	0.7856%	0.5914%	0.0019%	1.3790%	1.1146%	0.8687%	0.0021%	1.9854%
Senegal	L	0.3867%	0.5620%	0.0039%	0.9526%	0.5246%	0.8327%	0.0043%	1.3616%

Chart 2. Welfare Damages in Billion Dollars and as a Percentage of NGI by Pollutant

Welfare Damages in Billion Dollars and as a Percentage of GNI by Pollutant

		Billion Dollars				Percent			
Country	World Bank Income Group	AAP and HAP Combined	UW and US Combined	Lead Exposure	Total	AAP and HAP Combined	UW and US Combined	Lead Exposure	Total
Antigua and Barbuda	H	0.032570076	0.007459991	0.00672394	0.046754007	2.6492%	0.6068%	0.5469%	3.8029%
Australia	H	19.02641408	1.906293676	12.95867926	33.89138701	1.3319%	0.1334%	0.9071%	2.3725%
Austria	H	18.03206729	0.554619854	2.875613562	21.4623007	4.4441%	0.1367%	0.7087%	5.2895%
Bahamas, The	H	0.23664404	0.043066449	0.048154274	0.327864762	2.8619%	0.5208%	0.5824%	3.9651%
Bahrain	H	0.44931481	0.034348269	0.005292501	0.488955579	1.6032%	0.1226%	0.0189%	1.7446%
Barbados	H	0.183726778	0.045599818	0.027753724	0.25708032	4.3678%	1.0841%	0.6598%	6.1117%
Belgium	H	24.31454679	2.425941989	6.537549871	33.27803865	4.8567%	0.4846%	1.3059%	6.6472%
Canada	H	34.43880708	3.553788628	4.453260895	42.4458566	2.0223%	0.2087%	0.2615%	2.4925%
Chile	H	9.607526878	1.116030035	0.521460859	11.24501777	3.8072%	0.4423%	0.2066%	4.4561%
Croatia	H	5.838160409	0.14534064	0.947803077	6.931304126	10.8905%	0.2711%	1.7680%	12.9297%
Cyprus	H	0.750585513	0.034292351	0.159135969	0.944013833	2.4840%	0.1135%	0.5267%	3.1242%
Czech Republic	H	14.92329938	0.814421215	0.86471384	16.60243443	7.8358%	0.4276%	0.4540%	8.7175%
Denmark	H	12.20922075	1.196544731	1.497067104	14.90283259	3.6713%	0.3598%	0.4502%	4.4813%
Estonia	H	1.625962826	0.035672366	0.405516064	2.067151256	6.7062%	0.1471%	1.6725%	8.5258%
Finland	H	7.026883263	0.346672945	0.634757755	8.008313963	2.7649%	0.1364%	0.2498%	3.1511%
France	H	82.06845947	10.36727406	19.70740882	112.1431424	3.0271%	0.3824%	0.7269%	4.1365%
Germany	H	189.3323442	13.78811349	19.53608217	222.6565398	5.0788%	0.3699%	0.5240%	5.9727%
Greece	H	15.18826536	0.540471493	2.939862528	18.66859938	6.9159%	0.2461%	1.3387%	8.5007%
Hungary	H	13.96199128	0.269345842	1.627933526	15.85927065	10.9178%	0.2106%	1.2730%	12.4014%
Iceland	H	0.284528816	0.034346173	0.076085324	0.394960313	1.7295%	0.2088%	0.4625%	2.4007%
Ireland	H	5.14031905	0.559135872	1.081653975	6.781108897	2.3729%	0.2581%	0.4993%	3.1303%
Israel	H	7.842409983	0.660618155	0.969709081	9.472737219	2.6405%	0.2224%	0.3265%	3.1895%
Italy	H	115.9499346	4.278096204	36.01107342	156.2391043	5.8158%	0.2146%	1.8062%	7.8366%
Japan	H	221.2772908	39.60369704	18.02719562	278.9081834	4.7501%	0.8502%	0.3870%	5.9873%
Korea, Rep.	H	50.7893513	3.158840239	5.750791562	59.6989831	3.6567%	0.2274%	0.4140%	4.2982%
Kuwait	H	2.360710671	0.161245617	0.007363699	2.529319988	1.4819%	0.1012%	0.0046%	1.5877%
Latvia	H	3.74128145	0.061515909	0.589694537	4.392491895	12.6914%	0.2087%	2.0004%	14.9005%
Lithuania	H	4.817200843	0.098341307	0.763632766	5.679174916	11.0352%	0.2253%	1.7493%	13.0098%
Luxembourg	H	1.20164714	0.085442307	0.130009062	1.417098509	2.7394%	0.1948%	0.2964%	3.2306%
Madagascar	L	0.513933178	0.340401595	0.019447531	0.873782304	5.0490%	3.3442%	0.1911%	8.5843%
Malawi	L	0.230925622	0.222935596	0.003519666	0.457380885	3.8326%	3.7000%	0.0584%	7.5910%
Mali	L	0.527357828	0.544401455	0.009117746	1.080877029	3.7929%	3.9155%	0.0656%	7.7740%