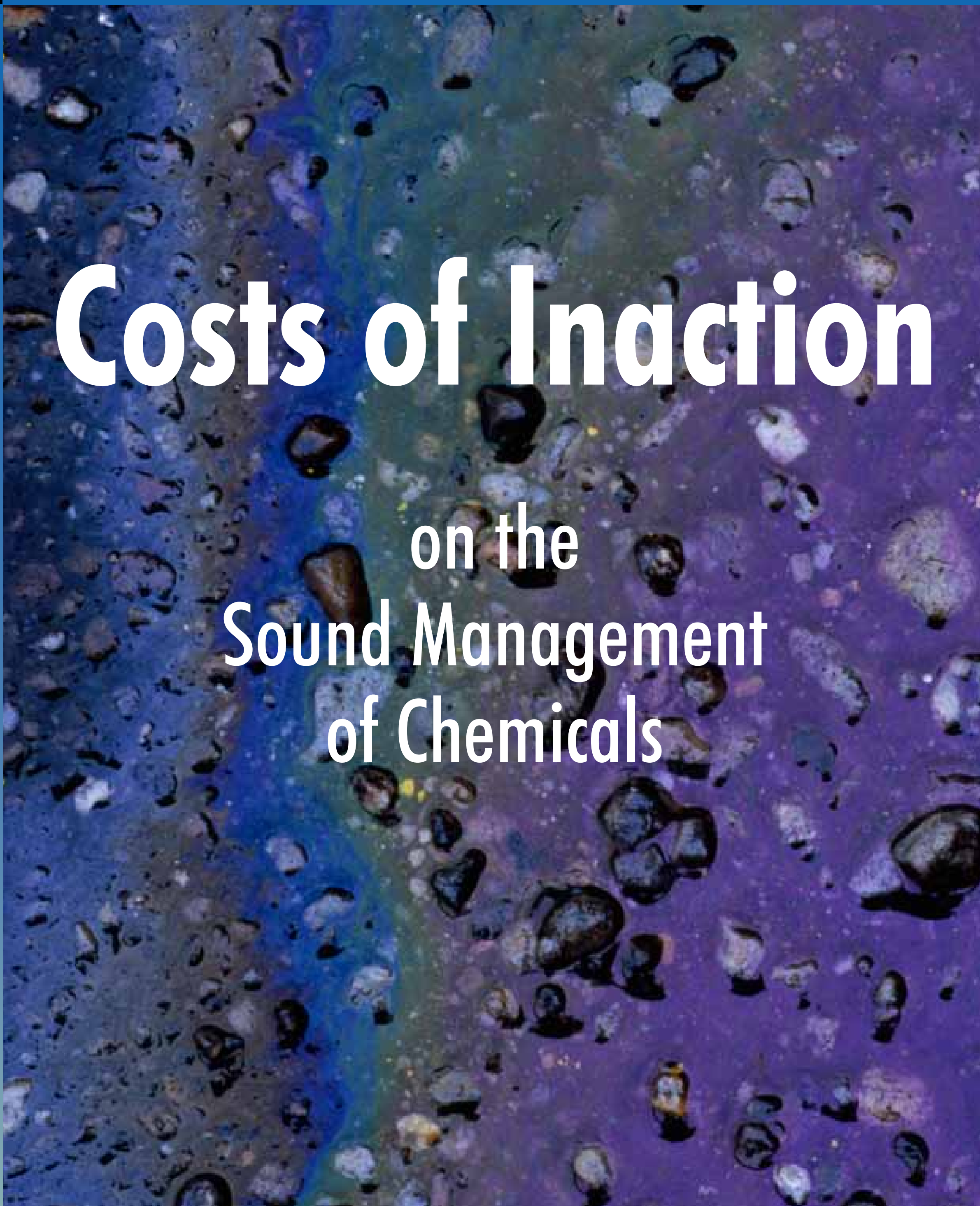

Costs of Inaction

on the Sound Management of Chemicals

United Nations Environment Programme

Job Number: DTI/1551/GE

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Glossary

AfDB	African Development Bank
CIA	Central Intelligence Agency
COI	Costs of Inaction
COPD	Chronic Obstructive Pulmonary Disease
DALYs	Disability-Adjusted Life Years
FAO	Food and Agricultural Organization of the United Nations
GAP	Good Agricultural Practices
GDP	Gross Domestic Product
(GDP) PPP	Purchasing Power Parity adjusted Gross Domestic Product
HESA	Health and Environment Strategic Alliance
HPV	High Production Volume
ICCA	International Council of Chemicals Association
ICCM	International Conference on Chemicals Management
ILO	International Labour Organization
IPM	Integrated Pest Management
IQ	Intelligence Quota
KemI	Swedish Chemicals Agency
LIRA	Legal and Institutional Infrastructures and Measures for Recovering Costs of National Administration
NOx	Nitrous Oxide
ODA	Official Development Assistance
OECD	Organization for Economic Co-operation and Development
PM	Particulate Matter
POPs	Persistent Organic Pollutants
PRI	Principles for Responsible Investment
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
SAICM	Strategic Approach to International Chemicals Management
SMC	Sound Management of Chemicals
SOx	Sulfur Oxide
TEEB	The Economics of Ecosystems and Biodiversity
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNEP FI	United Nations Environment Programme Finance Initiative
U.S. EPA	United States Environmental Protection Agency
VOC	Volatile Organic Compounds
VSL	Value of Statistical Life
WHO	World Health Organization
WSSD	World Summit on Sustainable Development
WTP	Willingness to Pay

Contents

Preface

Increasing production and use of chemicals, particularly in developing countries and countries with economies in transition, result not only in benefits but also in costs to human health, the environment and economic development. The report on the *Costs of Inaction on the Sound Management of Chemicals* shows that these costs – borne by all segments of society, including business, from the production, use, and disposal of harmful chemicals – are too high. To reduce these costs and more effectively achieve national development planning goals, improvements in chemicals management are required.

The Costs of Inaction report provides evidence that supports the Vision of the United Nations Secretary-General's High-Level Panel on Global Sustainability (2012) to make explicit and transparent the economic, social and environmental costs of action and inaction on sustainable development.

> *The Panel argues that by embracing a new approach to the political economy of sustainable development, we will bring the sustainable development paradigm from the margins to the mainstream of the global economic debate. Thus, both the cost of action and the cost of inaction will become transparent. Only then will the political process be able to summon both the arguments and the political will necessary to act for a sustainable future.*
>
> -- United Nations Secretary-General's High-Level Panel on Global Sustainability (2012)

Work on the Costs of Inaction report began in 2010, with funding from the Governments of Norway and Sweden, with the establishment and meeting of an international Steering Committee. The Costs of Inaction work builds on the UNDP-UNEP Partnership Initiative for the Integration of the Sound Management of Chemicals into Development Planning Processes, contributes to the WHO-UNEP Health and Environment Strategic Alliance, and provides support for UNEP Guidance on the Development of Legal and Institutional Infrastructures for Sound Management of Chemicals and Measures for Recovering Costs of National Administration (LIRA-Guidance).

This document provides a practical and useful assessment of the current state of knowledge of the economic costs of inaction on the sound management of chemicals. It makes available early research findings and the evidence needed to support the argument for enhanced political action.

Executive Summary

REFINERY WITH HAY BALES IN THE FOREGROUND © JOHN SHORT / DESIGN PICS/STILL PICTURES

Key Messages

- For the international community to move forward on sound chemicals management, available information should be used to create awareness of the importance of chemicals management to human health, the environment and economic development. Current information, which reveals high economic consequences of unsound chemicals management, is for the most part undervalued, as many health and welfare impacts are not always included in current analyses. By using current data, particularly from the UNDP-UNEP Partnership Initiative on Integration of Sound Management of Chemicals into Development Planning, it has been possible to conduct regional extrapolations and to present a conservative, but significantly high estimate of health costs due to injuries, pesticide poisonings and exposure to toxic and hazardous chemicals.

- A key driver for mainstreaming the sound management of chemicals into national development policies and plans is collection of data and information on the costs of inaction and the benefits of action for the three pillars of sustainable development: environmental sustainability, economic sustainability and sociopolitical sustainability. Demonstration of practical techniques and necessary precautions in the Costs of Inaction report should stimulate additional research and provide pertinent data. This new data can be extrapolated for key development sectors in more UN regions, thus revealing the costs of inaction that would affect a significant portion of GDP, especially in developing countries and countries with economies in transition.

- When the costs of inaction are shown to be mounting, informed financial decision makers at the centre of government and industry will seek out and support actions that are beneficial to human health, the environment and sustainable development.

The Costs of Inaction on the Sound Management of Chemicals

The sound management of chemicals, including hazardous wastes, aims to prevent and, where this is not feasible, to reduce or minimize the potential for exposure of people and the environment to toxic and hazardous chemicals as well as chemicals suspected of having such properties. It includes prevention, reduction, remediation, minimization and elimination of risks during the life cycle (production, storage, transport, use and disposal) of chemicals and chemicals in products and articles. It involves the application of the best managerial practices of chemicals, which requires strengthened governance and improved techniques and technologies at each stage of the life cycle (UNDESA 2009).

The lack of a knowledge-based, preventive approach to chemicals risks management throughout their life cycle results in significant risks to human health and ecosystems, and associated economic costs for individuals, firms and society as a whole. The key concept of the costs of inaction has been put forward by the Organisation for Economic Co-operation and Development (OECD) which defines inaction as the lack of development of "no new policies beyond those which currently exist" (OECD 2008). Inaction may also include failure to enforce existing national and regional policies on sound management of chemicals or to implement international conventions and protocols. Particular attention is required in defining inaction in developing country contexts, where awareness of risks from chemicals is very low, the magnitude of the problem is unknown, and policies to address sound chemicals management are limited or non-existent.

The Costs of Inaction report aims to raise political awareness in order to highlight the economic benefits of advancing the integration of chemicals management into national development policies and plans, consistent with the policy directives issued by governments and stakeholders in the Strategic Approach to International Chemicals Management (SAICM). Adopted in 2006, SAICM recognized, in its Overarching Policy Strategy, the extent to which developing countries, particularly least developed countries and small island developing countries, and countries with economies in transition can make progress towards reaching the World Summit on Sustainable Development (WSSD) target: "using and producing chemicals by 2020 in ways that do not lead to significant adverse effects on human health and the environment".

Reaching this target depends, in part, on provision of financial support by the private sector, and bilateral, multilateral and global agencies or donors. Thus, SAICM calls for strengthened focus, at the international, regional, national and local levels, on improved cross-sectoral governance for the development of coherent precautionary approaches for managing chemicals throughout their life cycle. This was reconfirmed in 2009 by the second International Conference on Chemicals Management (ICCM2), the governing body for SAICM, in resolution II/3 (SAICM 2009).

Compiled Data Reveals Substantial Costs

The Costs of Inaction report includes an extensive literary review in order to identify economic information on the health, environmental, and development planning effects of harmful chemicals. Chemicals reviewed within the scope of study include commodity, high production volume (HPV), industrial, specialty, minerals and metals, agricultural, household chemicals and pharmaceuticals (described in Annex 1).

Although fragmented and difficult to compare, the emerging data on the economic consequences of harmful chemicals related to negative health, environment, and development planning effects, clearly point to very high effects and associated costs. For example:

- Health Effects

  - ☐ In 2011, WHO reported that globally, 4.9 million deaths (8.3% of the global total of deaths in 2004) and 86 million Disability-Adjusted Life Years (DALYs) (5.7% of the global total of DALYs in 2004) were attributable to environmental exposure and management of selected chemicals in 2004, for which data were available. This includes annual deaths from indoor smoke from solid fuel use (2.0 million), outdoor air pollution (1.2 million), and second-hand smoke (0.6 million). In addition, WHO reported annual deaths due to occupational particulates (375,000), chemicals involved in acute poisonings (240,000), and pesticides involved in self-poisonings (186,000). Fifty-four percent of the global burden of disease (counted in DALYs), due to the chemicals assessed by WHO, is borne by children under the age of 15 (Prüss-Ustün et al 2011).

  - ☐ Estimates for selected chemicals (including pesticides) involved in unintentional acute and occupational poisonings, a limited number of occupational carcinogens and particulates and lead, in 2004, resulted in a total of **964,000 deaths** and **20,986,153 DALYs**, corresponding to 1.6% of the total deaths and 1.4% of the total burden of disease world wide (Ibid).

  - ☐ Among the global top ten leading causes of death in 2004, were: HIV/AIDS (2 million); tuberculosis (1.5 million); road traffic accidents (1.27 million); and malaria (0.9 million) (WHO 2008).

  - ☐ Comparable DALYs in 2004 include: the adult onset of hearing loss (27.4 million); congenital anomalies (25.3 million); alcohol use disorders (23.7 million); violence (21.7), and diabetes mellitus (19.7 million) (Ibid).

- Environmental Effects

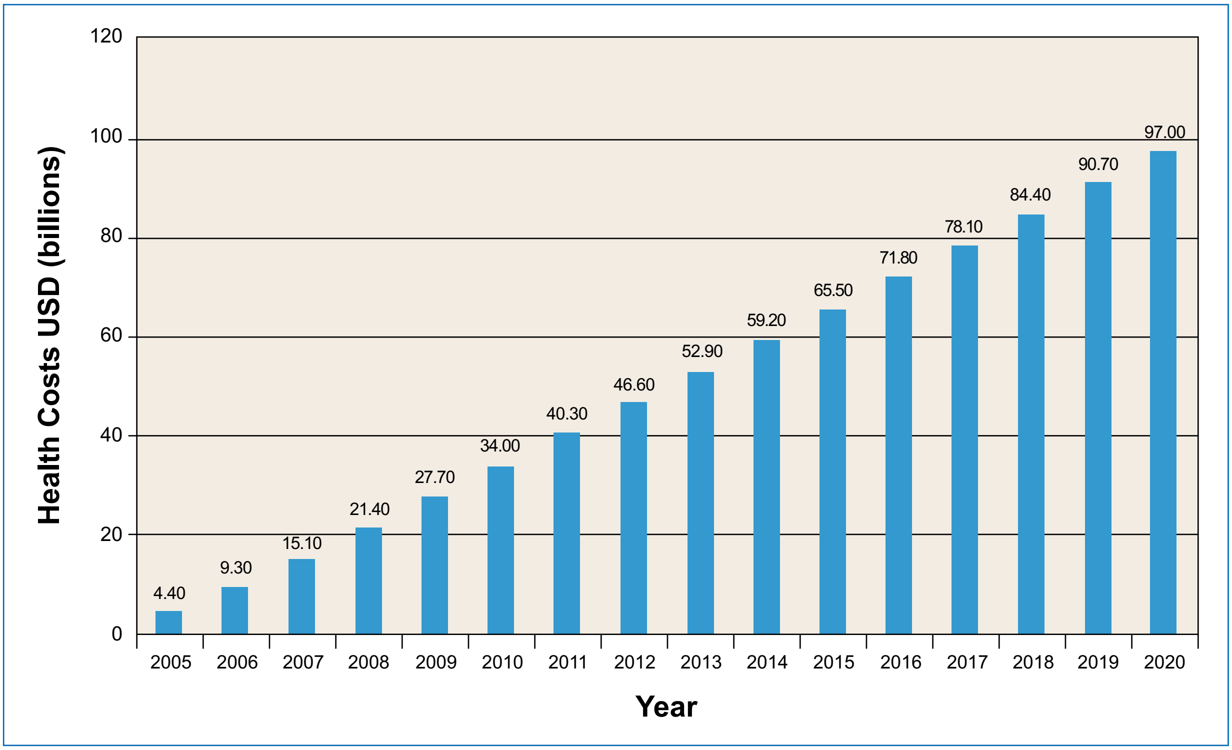
  - ☐ In 2010, the United Nations Environment Programme (UNEP) Finance Initiative (FI) and Principles for Responsible Investment (PRI) reported that in 2008 the global environmental external costs due to human activity included USD 236.3 billion due to volatile organic compounds (VOCs), which can come from a variety of sectors and sources, including transport and coal combustion, and USD 22 billion due to mercury emissions. However, the analysis excludes most natural resources used as well as many environmental impacts including water pollution, most heavy metals, land use change and waste in non-OECD countries, due to a lack of available global data (UNEP FI and PRI 2010).

    These figures give an indication of the magnitude of the economic costs of environmental effects due to chemicals. VOCs and mercury emissions alone account for 5.7 to 13 percent of the *annual* USD 2 trillion to 4.5 trillion (or USD 2000 billion - 4500 billion) in ecosystems and biodiversity losses estimated by the UN led international initiative, The Economics of Ecosystems and Biodiversity (TEEB 2008).

- Development Planning

  - ☐ From data extrapolated in the Costs of Inaction report, the costs of injury to pesticide users on smallholdings in 37 sub-Saharan African countries revealed that the estimated costs of injury,

Figure 1. Accumulated Costs of Injury to Smallholder Pesticide Users in Sub-Saharan Africa from 2005 to 2020



Source: Calculations made by the authors of this report.

defined as lost work days, outpatient medical treatment, and inpatient hospitalization, from pesticide poisonings in this region alone amounted to USD 4.4 billion in 2005. It should be noted that this figure is an underestimate of the costs of inaction because it does not include the costs of lost livelihoods and lives, environmental health effects, and other chemicals effects.

☐ In a SAICM context, a conservative future risk scenario analysis suggests that accumulated health costs in sub-Saharan Africa will increase to approximately **USD 97 billion by 2020** (Figure 1). This is assuming the current inadequate capacities for the sound management of pesticides at the national and local levels remain constant. These costs are only with respect to direct injury and not environmental costs for which data was not available.

☐ Total Official Development Assistance (ODA) to Health in Africa in 2009 was USD 10.3 billion (Annex 4). However, when targeted aid for HIV AIDs is excluded, total assistance for basic health services in Africa is closer to USD 4.8 billion. To compare, in 2009 the conservatively projected costs of inaction related to current pesticide use alone is greater than the total ODA to general healthcare in Africa (Figure 2).

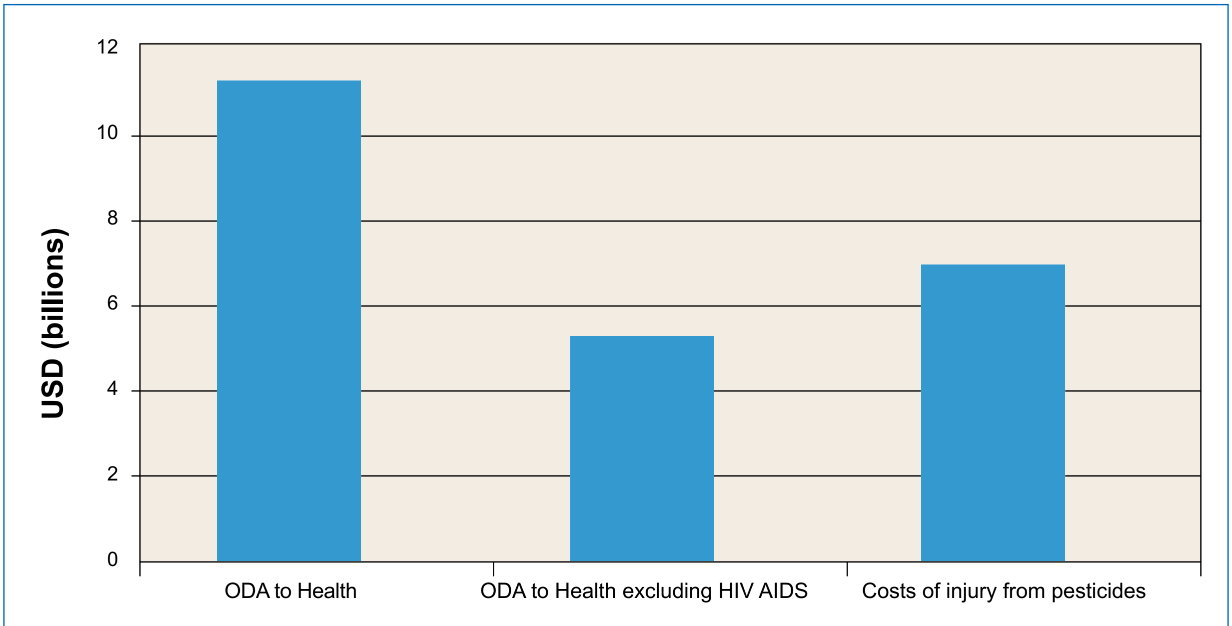
☐ The return on investment in improved chemicals management infrastructure could be very large indeed, from a relatively small investment. In Uganda alone, the total costs of the proposed national actions for sound chemicals management, including strengthening the legal framework in the governance of chemicals, are estimated to be USD 17.2 million from 2010 to 2025 (Republic of Uganda 2010). The pesticides extrapolation study shows health costs of USD 230 million in Uganda in 2005.

- The agricultural sector is the most important income generator for many developing countries. It is also one of the few areas where the data allow initial comprehensive presentation of economic evidence, including a more fulsome cost-benefit analysis, for the sound management of chemicals. Of particular interest is the economic evidence uncovered in this study showing how agriculture yields, household incomes and gross domestic product (GDP) can increase with sound chemicals management. In Uganda, and similarly in a number of other countries, crop yield gains of 20% are estimated with strengthened governance of chemicals management for the agriculture sector (Ibid).

The Way Forward with Existing Information

There is a significant body of literature that generally addresses the costs of inaction on the sound management of chemicals. The authors identified and reviewed 281 documents for this study, out of which 75 primary sources (see References) contained relevant monetized or quantified primary research data on the health, environmental, and development planning effects of harmful chemicals. This data came from 28 countries, including six OECD countries and four UN Regions, representing approximately 65% of the global population.

Figure 2. ODA to Health and Costs of Injury from Pesticides in 2009



Source: OECD (2011) and calculations made by the authors of this report

Various methodologies, including sophisticated and simple calculations, were used to estimate the costs of environmental, health, and development planning effects of chemicals mismanagement. However, the results of these studies are difficult to compare and/or aggregate, especially across developed and developing country contexts. In this study, most of the monetized effects reported were based on actual incurred costs, such as medical expenses, lost work days, lost market output, and environmental clean-up costs. Such cost data are relatively easier to collect and compare than data from more complex methodological frameworks, that attempt to address costs that are more difficult to monetize. Although this simpler method can only show an underestimation of the costs to society, there is value in using this type of defensible data as illustrated in the extrapolation of pesticides injury costs in sub-Saharan Africa.

Identification of the gaps in economic evidence for sound management of chemicals, and approaches to filling these gaps, have led to the development of proposed Next Steps for the Costs of Inaction. These include: valuing ecosystem services for sound management of chemicals; incorporating the public health costs and benefits of chemicals in national development planning for agriculture, mining, leather and textiles, and waste management sectors; accounting for environment and health effects in cost-benefit analysis of pesticides use in African countries; linking to the WHO-UNEP proposed African Surveillance System on Environment and Health; and studying the costs of inaction and the costs and benefits of alternatives for mercury elimination in artisanal and small-scale gold mining.

Summary of Findings

- The available data on the health, environmental, and development planning effects of harmful chemicals show high costs of inaction. However, it was not easy to uncover and assemble these costs. The data are fragmentary with respect to chemicals effects studied and, with little standardization in methods used, are difficult to compare and aggregate in a timely manner for effective use in policy-making processes. There is very little assessment of what findings might mean for other sectors and regions.

- Although the available data show high costs, there are limitations to the scope of the data uncovered. The data were found mainly in areas that are chemical intensive, such as agriculture and for health effects. However, chemicals are prominent and growing factors in all sectors of society, but we have little data to show costs of inaction on these chemicals throughout their life cycles. Even in traditional chemical intensive sectors, such as mining and leather and textiles, which are critical to economic development in developing countries, the readily accessible data remain limited.

- For the majority of data uncovered we see only a historical snapshot of the costs of inaction, with no picture of the future risk scenario. The tools are not currently in place to readily forecast how the costs of inaction will evolve over time. As chemicals become more complex and dispersed throughout the global economy, the health and environmental costs will escalate without preventive action.

The Costs of Inaction report provides a practical and useful assessment of the current state of knowledge on the economic costs of inaction on the sound management of chemicals. It provides key data and shows how this data can be used to provide initial evidence needed for enhanced political action.

1. Introduction

The *Costs of Inaction on the Sound Management of Chemicals* report aims to raise political awareness of the benefits stated in economic terms of providing resources to sound management of chemicals and to strengthen the rationale for inclusion of sound chemicals management priorities into national development policies and plans. It also aspires to build capacity for ongoing assessment at international, national, and local levels through demonstration and practical application of proven techniques.

The hypothesis of the Costs of Inaction (COI) report is that current developing country funding (public, private, national and international), for improved chemicals management is inadequate, relative to the scale of the costs and impact of inaction on human health, the environment and economic sustainability; this is due to unsafe production, transport, use and disposal of chemicals. The main reason for the funding shortfall is due to the fact that decision/policy makers are not fully aware of the mounting costs of inaction. Thus far, the significant and rising external costs of unsound chemicals management have not been explained in the language of the dominant economic paradigm of government decision making at all levels. Debating the utility of the dominant economic paradigm at only a theoretical level is not particularly useful or practical to improve sound management of chemicals in a meaningful timeframe. The need for action is now. Arguments over economic research and communications hinder integration of chemicals management priorities

RIVER POLLUTION, UK © ANDREW DAVIES/STILL PICTURES into crucial government planning and budgets. The lack of budgeting and national assistance strategies, negotiated with bilateral and multilateral donors, is seriously undermining the process of, and progress for, the sound management of chemicals.

Improved communication and understanding of the costs of inaction derived through monetization or other forms of quantification of information will help the international community to:

- Compare investment costs to improve the sound management of chemicals with the current and escalating future costs of inaction (the future risk scenario in the Global Chemicals Outlook/GCO) (UNEP 2012);

- Prioritize investments in improved chemicals management to address the most serious costs (prioritization and maximizing returns on investments); and

- Help encourage improved policy approaches for chemicals management, including in national development planning, national budgeting, cross-sectoral cooperation, cost recovery policies needed to fund legal and institutional infrastructure, and international negotiations (political drivers for more impactful policy and financing at all levels of governance).

The Costs of Inaction report is an effort to advance these needed improvements, consistent with policy directions issued by governments and stakeholders in the Strategic Approach to International Chemicals Management (SAICM). Recognizing the World Summit on Sustainable Development (WSSD) target, "to ensure that, by the year 2020, chemicals are produced and used in ways that minimize significant adverse effects on the environment and human health," SAICM highlighted that reaching this target depends, in part, on financial resources provided by governments, the private sector, bilateral and multilateral agencies. The high costs of inaction and the need for funding were reconfirmed in 2009 by the second International Conference on Chemicals Management (ICCM2), the governing body for SAICM.

1.1 Key Messages

- For the international community to move forward on sound chemicals management, available information should be used to create awareness of the importance of chemicals management to human health, the environment and economic development. Current information, which reveals high economic consequences of unsound chemicals management, is for the most part undervalued, as many health and welfare impacts are not always included in current analyses. By using current data, particularly from the UNDP-UNEP Partnership Initiative on Integration of Sound Management of Chemicals into Development Planning, it has been possible to conduct regional extrapolations and to present a conservative, but significantly high estimate of health costs due to injuries, pesticide poisonings and exposure to toxic and hazardous chemicals.

- A key driver for mainstreaming the sound management of chemicals into national development policies and plans is collection of data and information on the costs of inaction and the benefits of action for the three pillars of sustainable development: environmental sustainability, economic sustainability and sociopolitical sustainability. Demonstration of practical techniques and necessary precautions in the Costs of Inaction report should stimulate additional research and provide pertinent data. This new data can be extrapolated for key development sectors in more UN regions, thus revealing the costs of inaction that would affect a significant portion of GDP, especially in developing countries and countries with economies in transition.

- When the costs of inaction are shown to be mounting, informed financial decision makers at the centre of government and industry will seek out and support actions that are beneficial to human health, the environment and sustainable development.

1.2 Four Main Questions Addressed by This Analysis

The Costs of Inaction report addresses four questions:

1. *How possible is it to find existing information within the scope of research (Section 2)?*

2. *How extensive is the analysis and associated documentation (Section 3)?*

3. *How useable is the existing information seen from the authors' experience with policy making processes (Sections 4 and 5)? and*

4. *Where are the most significant gaps or weaknesses in existing economic information (Section 6)?*

2. Finding the Existing Data

BATTERY RECYCLING IN THE NETHERLANDS © TON KOENE/LINEAIR/STILL PICTURES

The search for data adhered to the scope of chemicals (Annex 1), effects (health, environmental, and development planning) and data (monetized and quantified) agreed by the International Project Steering Committee, listed below. The scope of the Costs of Inaction closely follows criteria from SAICM, which includes: (a) environmental, economic, social, health and labour aspects of chemical safety; and (b) agricultural and industrial chemicals, with a view to promoting sustainable development and covering chemicals at all stages of their life-cycle, including those contained in products. The Strategic Approach does not cover products to the extent that the health and environmental aspects of the safety of the chemicals and products are supposed to be regulated by a domestic food or pharmaceutical authority or arrangement.[1]

A. Chemicals (anthropogenic sources only):

- Commodity Chemicals (High Production Volume (HPV), Industrial, Specialty);
- Minerals and Metals;
- Agro-chemicals;
- Household Chemicals; and
- Pharmaceuticals.

B. Effects:

- Environment, including air, water, land, ecosystems and biodiversity;

[1] *UNEP 2006. Strategic Approach to International Chemicals Management SAICM Texts and Resolutions of the International Conference on Chemicals Management. Available at:* http://www.saicm.org/documents/saicm%20texts/SAICM_publication_ENG.pdf

- Human health, both acute and chronic effects; and
- Development planning at the meso (sectoral) and macro (national) levels, including degradation of production inputs, negative cross-sectoral effects, and escalating costs of providing for basic human needs, such as clean water.

C. Data:

- Monetized; and
- Quantified in scientific units of measurement.

Qualitative analysis, while also important, was not expanded in this study, as the purpose of the research is to assess exclusively the extent of monetized and quantified data on the costs of inaction on chemicals management. As the study aimed to assess the ease of access and usability of this data by policy-makers, highly technical and proprietary information (i.e. scientific databases) were not included in the assessment.

The research effort included:

- Searching extensively for published secondary research;
- Identifying primary research of numerous organizations posted on the Internet;
- Tracking of references in secondary literature; and,
- Sending a 'Call for Information' to different target organizations and individuals identified as potentially having access to knowledge of primary and secondary studies relevant to the costs of inaction on chemicals management.

Finding existing information within this research scope was a major undertaking, described in detail in the Literature Search Methodology.[2] The time and resources needed to undertake this research would not be readily achievable for the vast majority of organizations, policy makers and chemical management practitioners, especially in developing countries with limited budgets. Given the nature and time constraints of most policy making processes in general, it was not possible to undertake this kind of effort at the highest political levels.

The research identified 377 documents of interest and 281 were initially reviewed for this study. Documents were selected if an executive summary, abstract or table of contents indicated economic analyses associated with the effects of chemicals. Subsequent searches for information were targeted based on the economic data identified, including the sources cited for primary data. This effort identified 75 sources of primary data on health, environmental and development effects of chemicals, noted in the Annotated Bibliography.[3] No quality or comparative analyses of reported data and underlying methodologies were carried out at this stage.

While it would have been possible to identify additional relevant studies, budgetary constraints prevented this. Table 1 summarizes the research effort and sources used.

[2] Available at: http://www.unep.org/hazardoussubstances/Portals/9/Mainstreaming/COI%204th%20SC/BAR%20Background.pdf
[3] ibid

Table 1: Summary of Primary Data Sources Uncovered[4]	
Primary Data	**75 sources of primary data were identified and are listed in the References**
Monetized effects	54 sources present monetized (and quantified) data
Quantified effects	16 sources present quantified data only
Chemicals/Chemicals categories	9 sources: Chemicals 5 sources: Registration, Evaluation, Authorisation and Restriction of Chemical substances (REACH)[5] 6: Environmental/Industrial Pollution (emissions into water and air) 8: Outdoor Air Pollution 1 source: Asbestos 1 source: Cadmium 6 sources: Lead 4 sources: Mercury 2 sources: NOx (nitrous oxide) 2 sources: NO_2 (nitrogen dioxide) 5 sources: PM (particulate matter) (including one source related to Ozone) 24 sources: Pesticides; 1 source : Plant Protection Products ; 3 sources : Agricultural Chemicals ; 1 source : Agro-industrial Chemicals 1 source: SOx (sulfur oxide) 3 sources: SO_2 (sulfur dioxide) 1 source: VOCs[6]
Health effects	57 sources present human health effects, including 15 that present health effects of acute pesticide poisonings, 8 that present data on children's health effects, and 14 quantified in DALYs
Environmental effects	24 sources, including 10 related to ecosystem services and biodiversity, and 11 which are water-related (including fisheries and drinking water)
Development planning effects	43 sources presented development planning effects, including 23 in terms of public health costs (including benefits of sound management of pesticides (Table 6) and benefits/avoided public health costs (Annotated Bibliography, Table 1), 9 related to GDP, and 12 related to agriculture
Geographic coverage	The data are from 28 countries, including 6 OECD countries UN Regions (http://unstats.un.org) covered include: Africa (Eastern, Northern, Southern, and Western); Americas (Central, South, and Northern), Asia (Eastern, Southern, South-Eastern, and Western); and Europe (Eastern, Northern, Southern, and Western)

4 Annex 2 includes additional sources uncovered, including benefit-cost analyses.
5 REACH is the European Community Regulation on chemicals and their safe use (EC 1907/2006). Available at: http://ec.europa.eu/environment/chemicals/reach/reach_intro.htm
6 Air pollutants such as VOCs, NOx, PM, and SOx can come from a variety of sectors and sources, including the transport sector and from coal combustion.

Most UN regions are covered in the primary data identified in the preliminary literature review. Although the data are sparse at national and regional levels and across the entire study scope, 28 countries with a total population of 4.5 billion (65% of the global population) are represented, many at the sub-national level. The primary data sources listed in the References do not include data from only one UN region: Oceania,[7] and 3 UN sub-regions: Middle Africa, the Caribbean and Central Asia.

Literature that mentions significant costs associated with chemicals mismanagement is extensive, albeit fragmentary. However, most of it does not provide monetized and/or quantified data to the extent needed for improved policy decision making. Furthermore, existing data often address effects on broad categories of environmental media (e.g. air, water, soil) or human health (e.g. premature mortality), limiting utility for disaggregating effects and identifying those that are attributable to specific chemicals.

Given the scarcity of chemicals specific costs of inaction data, general categories of pollution such as environmental, industrial, and air pollution, where chemicals within the study scope are known to occur (i.e. industrial water pollution), were included to provide a more realistic sense of the scale of the costs of chemical pollution. Where it was clearly not possible to associate any part of the estimated costs to chemicals in the study scope (i.e. arsenic poisoning in Bangladesh; fisheries losses in Uganda), the data were not included; such examples found in secondary literature were used to illustrate the costs of inaction.

[7] See Australia's Pesticide Impact Rating Index (PIRI) for the environmental effects and benefits of sound management of pesticides. Available at: http://www.clw.csiro.au/research/biogeochemistry/organics/projects/piri.html

WATER POLLUTION OF THE NANCHUAN RIVER © SINOPICTURES/CNS/STILL PICTURES

3. Findings from the Literature Review

The review of the existing literature on the costs of inaction on sound management of chemicals revealed that there are limited monetized and quantified data ready for use in policy decision making. However, to the extent that data exist on the health, environmental, and economic development planning effects of harmful chemicals, the literature suggests there will be huge costs. This data can be carefully considered, with more investigation into the methodologies and assumptions used in calculations, for extrapolations to national, regional, and global levels. Precaution is required to ensure that data from one context (chemical or sector) is not incorrectly extrapolated to another.

In the sections that follow, Section 3.1 presents the chemicals found in the literature with respect to the study scope. Section 3.2 presents some of the most relevant data found at the global, regional, and national levels on the health, environmental, and development planning effects of harmful chemicals. This section provides some commentary, analyses, and conclusions which are put forward in Section 4: Commentary on the Usefulness of Existing Analysis; Section 5: Use of Existing Data; Section 6: Filling the Gaps in Knowledge; Section 7: Proposed Next Steps; and, Section 8: Concluding Observations.

3.1 Chemicals Predominantly Discussed

The existing literature on the health, environmental and development planning effects of harmful chemicals covers only a fraction of chemicals that fall within the study scope. Much of the existing literature assesses general pollution sources and does not allow for easy identification of component chemicals. These include environmental media based studies such as air and water pollution involving a range of contributing pollutants. The other general type of study identified includes chemical (i.e. mercury) or chemical class (i.e. pesticides) specific studies where chemicals in the study scope are more easily identified.

As the following sections show, the majority of readily available studies that are reasonably disaggregated with respect to chemicals effects tend to address pesticides, outdoor air pollutants (including combinations of NOx, NO_2, PM, SOx, SO_2, and VOCs), some of which might be addressed by the sound management of chemicals, and heavy metals (mercury and lead). This may be because of international attention to air pollution and children's health issues that called for more research. As more chemicals issues gain attention, particularly as they impact ecosystem services, more chemicals and their effects need to be scientifically and economically assessed.

This study uncovered only some data that draws attention to the costs to health, environment, and development planning from 'commodity' and 'household chemicals', including chemicals in products and pharmaceuticals. To effectively target actions for the sound management of chemicals, improved reporting of chemicals effects data are required.

3.2 Health, Environment and Development Planning Effects

The data in this report indicate that, if mismanaged, chemicals can have significant negative effects on human health and the environment, and that associated costs to society can be considerable. Studies presenting effects of chemicals in monetized and/or quantified terms generally approach this issue by focusing either on a health endpoint or on environmental media. Economic development effects are not easily apparent in the data uncovered in this study.

Health, environment, and development planning effects have been monetized at the micro, meso and/or macro levels. Given the goal of the Costs of Inaction, effects for which costs were estimated at the meso (sectoral) and macro (national) levels – the most relevant levels for development planning and financial decision making – are highlighted in the following sections on health, environmental[8] and development planning effects.

3.2.1 Health Effects

Most of the data uncovered in this study assess the health effects of harmful chemicals. The need for this type of data are well understood, for example, to assess occupational health and safety measures particularly in developing countries where labour is a significant input to production. More data were found on acute health effects than on environmental health effects, other than from air pollution. The environmental effects data uncovered in the review are presented in Section 3.2.2.

[8] Environmental Medium is "one of the major categories of material found in the physical environment that surrounds or contacts organisms, e.g., surface water, ground water, soil, or air, and through which chemicals or pollutants can move and reach the organisms". Available at: http://www.greenfacts.org/glossary/def/environmental-media-environmental-medium.htm

Both monetized and quantified effects were identified at global, regional, and national levels. The following sub-sections highlight findings that may be useful for further expert analyses, including categorization and possible extrapolations to obtain more policy-relevant evidence for cost-effective financial decision making across key development sectors.

3.2.1.1 Quantified Health Effects

As mentioned above, harmful chemicals cause millions of deaths and illness each year. The most comprehensive effort to quantify health effects of chemicals is from WHO: *Knowns and Unknowns on Burden of Disease Due to Chemicals: A Systematic Review* (Prüss-Ustün et al 2011).[9] Health effects are quantified in terms of deaths and DALYs (Annex 3).

In 2011, WHO reported that globally, 4.9 million deaths (8.3% of total) and 86 million DALYs (5.7% of total) were attributable to environmental exposure and management of selected chemicals in 2004, for which data were available. This figure includes indoor smoke from solid fuel use, outdoor air pollution and second-hand smoke, with 2.0, 1.2 and 0.6 million annual deaths, respectively. In addition, occupational particulates, chemicals involved in acute poisonings, and pesticides involved in self-poisonings, resulted in 375,000, 240,000 and 186,000 annual deaths, respectively. Fifty-four percent of the global burden of disease (counted in DALYs) due to the chemicals assessed by the WHO is borne by children under the age of 15 years (Prüss-Ustün et al 2011).

The WHO authors note that the burden attributable to chemicals is undoubtedly underestimated. They also note that chemicals with known health effects, such as dioxins, cadmium, mercury and chronic exposures to pesticides could not be included due to incomplete data and information (Prüss-Ustün et al 2011).

Table 2 below summarizes the findings of Prüss-Ustün et al (2011) on the number of deaths and DALYs in 2004 due to chemicals and chemicals categories that fall within the scope of the Costs of Inaction on Sound Management of Chemicals; However, Table 2 does not include deaths and DALYs from second-hand smoke nor from indoor air pollutants from solid fuel combustion. The deaths and DALYs from "outdoor air pollutants" and diesel exhaust (the latter can not easily be separated out of the category for "occupational lung carcinogens"[10]) are included in the table below, although it remains unclear to what extent sound management of chemicals could lessen this global burden of disease beyond existing policies. Some chemical aspects of pollutants released through combustion might well be subject to sound chemicals management polices, such as mercury released through coal combustion. Table 2 does not include arsenic in drinking water as the data in this category comes from a study in Bangladesh where people are largely poisoned by naturally occurring arsenic seeping into well water. However, arsenic poisoning is a serious problem that also results from industrial processes. Also, while the unintended use of pesticides involved in self-inflicted injuries cannot be ignored, Table 2 does not include the deaths and DALYs from these categories.[11]

If "pesticides involved in self-inflicted injuries" are added into the totals cited on pages 14 and 69, the estimates are 1,150,000 deaths and 25,406,183 DALYs in 2004 due to chemicals in the Costs of Inaction study scope. See Box 1 below for a comparison with other major causes.

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[9] This study presents no data or discussion on chemicals exposures due to industrial accidents.
[10] Based on Prüss-Ustün et al (2011).
[11] 186,000 deaths and 4.4 million DALYs are attributed to pesticides involved in self-inflicted injuries (Ibid)

The report has relied heavily on the 2011 WHO study (Prüss-Ustün et al 2011), as it appears to be the only attempt so far to quantify the health effects of chemicals generally and on a global scale. More useful quantified health effects that focus on specific substances and/or geographic areas include the following:

- Lead in water, air, and soil, may contribute 0.9 percent of the burden of disease in developing regions (WHO 2002);

Table 2: Deaths and DALYs due to Chemicals and Chemicals Categories[12]		
Chemicals in unintentional acute poisonings (unintentional ingestion, inhalation or contact with chemicals)[13,14]	**346,000**	**7,447,000**
Asbestos[15]	107,000	1,523,000
Occupational lung carcinogens (lung cancer caused by exposures to arsenic, asbestos[16], beryllium, cadmium, chromium, diesel exhaust, nickel and silica)	63,000	261,000
Occupational leukaemogens (benzene, ethylene oxide and ionizing radiation)	7,400	113,000
Occupational particulates (COPD)	375,000	3,804,000
Occupational particulates (silica, asbestos, coal mine dust)	29,000	1,061,000
Outdoor air pollutants[17,18,19,20] (urban air pollution, largely from combustion sources)	1,152,000	8,747,000
Lead (lead-induced cardiovascular diseases in adults)	143,000	1,789,000
Lead (mild mental retardation due to lead-associated IQ deficits (childhood exposure)	Not given/ applicable	7,189,000

Source: (Prüss-Ustün et al 2011)

[12] The total deaths and DALYs for each category as presented in the text of Prüss-Ustün et al (2011) and in most of this table cannot simply be added up as there would be double-counting, for example, for lung cancer from occupational asbestos exposure. See footnote 16.

[13] "Chemicals responsible for unintentional poisonings may include methanol, diethylene glycol, kerosene, pesticides, and many others (Prüss-Ustün et al 2011)."

[14] Agents linked to "poisonings" in the WHO "Global Burden of Disease analysis", also include medications and narcotics. Available at: http://www.who.int/healthinfo/global_burden_disease/en/index.html and www.who.int/entity/healthinfo/statistics/gbdestimatescauselist.pdf; See also, the WHO International Classification of Diseases, the standard diagnostic tool for epidemiology, health management and clinical purposes. Available at: http://www.who.int/classifications/icd/en/. Therefore, the deaths and DALYs in this category that might be addressed by the sound management of chemicals, are lower than what is presented here; they are accounted for in the number of deaths and DALYs due to chemicals in the Costs of Inaction study scope.

[15] By 2002 in the US, compensation claims for asbestos-related injuries cost businesses and insurance companies more than USD 70 billion (RAND 2005). Future claims could cost businesses as much as USD 210 billion or more, according to the Rand Corporation. Available at: http://www.truthaboutlloyds.com/news/news_rand_092502.htm).

[16] Among the global burden of disease attributable to asbestos, 41,000 deaths and 370,000 DALYs were due to asbestos-caused lung cancer, and 7,000 deaths and 380,000 DALYs to asbestosis. Deaths and DALYs from lung cancer and asbestosis are included in the estimates for occupational lung carcinogens and occupational particulates but are not counted more than once (Prüss-Ustün et al 2011).

[17] Outdoor air pollution includes secondary pollutants such as ozone (O3), and carcinogens such as benzo[a]pyrene, benzene, and 1,3-butadiene (Ibid).

[18] Only urban air pollution in cities with more than 100,000 inhabitants is taken into account. Health impact from rural air pollution is unknown (Ibid.).

[19] Respiratory infections in children contributed 121,000 deaths and 1,555,000 DALYs to this burden (Ibid).

[20] Exposure was measured using particulate matter (PM10 and PM 2.5) as an index for common mixtures of urban air pollution (Ibid).

Box 1: Comparison of Deaths Attributable to Chemicals with Other Major Causes

To compare, WHO reports that among the top ten leading causes of death in 2004 were:

- Diarrhoeal diseases: 2.16 million
- HIV/AIDS: 2.04 million
- Tuberculosis: 1.5 million
- Road traffic accidents: 1.27 million
- Malaria: 0.9 million

Source: (WHO,2008). "Global Burden of Disease: 2004 update". Available at: http://www.who.int/healthinfo/global_burden_disease/GBD_report_2004update_part2.pdf; (Prüss-Üstün and Corvalán 2006.) WHO. Preventing disease through healthy environments. Towards an estimate of the environmental burden of disease.
Available at: http://www.who.int/quantifying_ehimpacts/publications/preventingdisease.pdf

- Each year in Europe, 88% of recognized occupational skin disease cases and 36% of occupational respiratory disease cases are related to chemical exposure (Musu 2004); and
- In China each year, approximately 4,000 people suffer premature death from pollution-related respiratory illness in Chongqing; 4,000 in Beijing; and 1,000 in Shanghai and Shenyang. If trends persist, large cumulative losses in human life are projected through 2020: Beijing could lose nearly 80,000 people, Chongqing 70,000 and other major cities could suffer losses in the tens of thousands (Dasgupta et al 1997).

With investigation into the methodologies and assumptions used in calculating these effects, and with careful consideration and necessary adjustments, this data may be useful for extrapolations to global or regional estimates. The quantified data presented in this section may also be carefully considered in monetizing effects, examples of which are presented below.

3.2.1.2 Monetized Health Effects

While Prüss-Ustün et al (2011) did not attach a monetary value to deaths and DALYs, there is still a considerable amount of literature that does monetize health effects as presented in Table 3 below. The diversity characterizing the monetized health effects or consequences of chemicals in terms of methodologies,[21] substances, health endpoints and geographic coverage, makes findings difficult to compare and aggregate into a meaningful global estimate. For ease of understanding, the monetized data in the Costs of Inaction report is converted to United States dollars (USD) in the year of data (if given): if not, then it is converted to correspond to the year of study.

[21] Descriptions, strengths and weaknesses of the various types of methodologies used to monetize health effects are given in Annex 3.

Table 3: Monetized Health Effects: AIR POLLUTANTS				
Country, City/ Region	**Chemical/Chemical Category**	**Health consequences**	**Monetized Data**	**Source**
China	Air pollution	Premature mortality and morbidity from air pollution	157.3 billion Yuan (USD 19 billion) in 2003	(World Bank and State Environmental Protection Administration, P.R. China 2007)
Japan,Yokkaichi City	SO_2 pollution	Health damage, loss of life and health	Yen 21,000 million (USD 160 million) in 1989 (worst-case scenario); Yen 1,300 million (USD 10 million) in 1989 (in actual)	(Japan Environment Agency 1991)
United States	Toxic chemicals of human origin in air, food, water, and communities	Asthma in American children	USD 2.0 billion per year	(Landrigan et al 2002)
South Africa, Vaal Triangle Region	Particulates, SO_2 & NO_2, from domestic fuel burning, vehicle emissions, industrial and mining operations and electricity generation activities	Respiratory and cardiovascular ailments, and premature deaths	ZAR (South African Rand) 289 million (USD 46 million) per year	(Scorgie 2004)
United States	Toxic chemicals of human origin in air, food, water, and communities	Lead poisoning/ neurologic damage/cognitive and behaviour consequences in American children	USD 43.4 billion	(Landrigan et al 2002)
Pakistan	Lead exposure from all sources (leaded gasoline, industry and possible other sources such as water, soil, paint and food)	IQ losses (represent 78 percent of total cost), and mild mental retardation (represent 15 percent of total cost)	38-52 billion Rs (USD 655-896 million) per year, with a mean estimate of 45 billion Rs (USD 775 million), in 2004	(World Bank 2006b)

[continued]

Table 3 (continued): Monetized Health Effects : METALS				
Country, City/ Region	**Chemical/Chemical Category**	**Health effect**	**Monetized Data**	**Source**
Global	Mercury	Loss of IQ (Intelligence Quotient) following ingestion of methyl mercury/ consumption of contaminated fish	USD 8 billion annually (in 2005 dollars) from by-product emissions USD 2.9 million (in 2005 dollars) from inhalation of mercury	(Pacyna et al 2008)
Japan, Minimata	Mercury	Health damage; Minamata disease/ neurological affliction	one-year expenses of 7,671 million Yen (USD 59 million) FY1989	(Japan Environment Agency 1991)
United States	Mercury	Loss of intelligence in terms of diminished economic productivity over the lifetime of children born with elevated cord blood mercury levels	USD 8.7 billion annually (range USD 2.2 – 43.8 billion in 2000 USD)	(Trasande et al 2005)
United States	Toxic chemicals of human origin in air, food, water, and communities	Neurobehavioural disorders in American children	USD 9.2 billion per year	(Landrigan et al 2002
United States	Toxic chemicals of human origin in air, food, water, and communities	Lead poisoning/ neurologic damage/cognitive and behaviour consequences in American children	USD 43.4 billion	(Landrigan et al 2002)
Pakistan	Lead exposure from all sources (leaded gasoline, industry and possible other sources such as water, soil, paint and food)	IQ losses (represent 78 percent of total cost), and mild mental retardation (represent 15 percent of total cost)	38-52 billion Rs (USD 655-896 million) per year, with a mean estimate of 45 billion Rs (USD 775 million), in 2004	(World Bank 2006b)

[continued]

Table 3 (continued): Monetized Health Effects : AGRO-CHEMICALS

Country, City/ Region	Chemical/Chemical Category	Health effect	Monetized Data	Source
Europe	Pesticides	Pesticide poisonings	Reach € 9.7 million (USD 15 million) per year for hospitalizations, and € 2.5 million (USD 3.9 million) for lost work (calculated using Pimental 1992)	(Blainey et al 2008)
Ecuador, Carchi Province	Pesticides	Acute pesticide poisonings	Private health costs: approximately USD 17 per case[22]	(Yanggen et al 2003)
Germany	Pesticides	Acute pesticide poisonings	USD 14 million	(Waibel et al1999)
Mali	Pesticides	Acute and chronic effects of pesticide poisonings	Total yearly costs of 167.2 to 1,058 million CFA francs (USD 242,861 to USD 1.5 million)	(Ajayi et al 2002)
Thailand	Pesticides	Acute poisonings	15 million Baht (USD 382,555) per year	(Jungbluth 2000)
Uganda	Agricultural chemicals	Chemical related illnesses: respiratory and skin infections	Farm labour output loss: USD 78.54 million by 2024/2025	(Republic of Uganda, National Environment Management Authority 2010)
United States	Pesticides	Acute poisonings, cancer and other chronic effects, fatalities	USD 787 million annually	(Pimentel et al 1992)
United States	Pesticides	Acute pesticide poisonings	Annually: USD 8 million for hospitalizations; USD 17 million for outpatient treatment; USD 1.76 million for lost work	(Pimentel et al 1992)
Zambia, Kafue Basin	Chemicals used on cotton fields	Acute pesticide poisonings	Kwacha 11,286.85 million (USD 2.1 million): lost labor income due to illness (51.1%), medical costs (40.7%); transport and other costs (8.1%)	(Bwalya 2010)

[22] The cost per case is 11 times greater than the average daily wage of an agricultural worker (OAS Secretariat 2005). Although very few cases of hospitalization are cited, in a context where 40 times more cases are possibly treated at home. See Cole, D., Sherwood, S., Crissman, C., Barrera, V., and Espinosa, P., (2002). "Pesticides and Health in Highland Ecuadorian Potato Production: Assessing Impacts and Developing Responses". *International Journal of Occupational Environmental Health*, Vol. 8, No. 3, July, pp. 182-190(9). This study deserves attention for its methodology and possibilities for extrapolating to the national level.

In general, these studies mainly estimate the costs of health effects from air pollutants, metals (mercury and lead), and pesticides. While scattered, incomplete, and sometimes inconsistent, the findings point to huge costs associated with health effects of chemicals. Furthermore, as research is refined and data collection is improved, the costs grow. For example,

- In the United States, the Landrigan et al (2002) findings, reported above, have been "updated and expanded" by Trasande and Liu (2011)[23] as "few important changes in federal policy have been implemented to prevent exposures to toxic chemicals". Trasande and Liu (2011) report that "the costs of lead poisoning, prenatal methylmercury exposure, childhood cancer, asthma, intellectual disability, autism, and attention deficit hyperactivity disorder were USD 76.6 billion in 2008". Landrigan et al (2002) previously reported that the annual costs of lead poisoning, asthma, cancer, and neurobehavioural disorders in American children amounted to USD 54.9 billion.

- The Pimentel et al (1992)[24] findings reported above were updated by Pimentel (2005).[25] The "major economic and environmental losses due to the application of pesticides in the USA" amounted to: USD 1.1 billion per year in public health costs; USD1.5 billion per year in pesticide resistance; USD 1.4 billion per year in crop losses; USD 2.2 billion per year in bird losses; and USD 2.0 billion per year in groundwater contamination.

  The total estimated USD 10 billion per year in environmental and societal damages estimated in this study are an increase over the USD 8 billion per year reported in 1992. The increase in costs, particularly to public health effects, mainly results from new studies and the data and estimates that they provide.

More studies and analysis of chemical-related health impacts can be found in a 2011 report from OECD (Hunt 2011)[26], which includes a summary of welfare costs including medical treatment costs, productivity loss costs, disutility (value of a case) for lung cancer, skin cancer, leukemia, and neuro-development disorders. The report cautions that care should be taken in the use of the values given for policy evaluation and for cost-benefit analysis. For example, values vary along with methodologies and many health effects remain un-quantified.

Of particular note are occupational health effects due to chemicals in the work place. In the European Union, these effects have been significantly monetized for analysis of the benefits of REACH, which entered into force in 2007.

- A 2005 study from Sheffield University (Pickvance et al 2005) estimated that without REACH, health service costs, productivity costs, and the value of the lost health-related quality of life to the individual of occupational asthma, chronic obstructive pulmonary disease (COPD) and dermatitis, would have been approximately, (using a 2007 rate of exchange):€ 90.3 billion (USD 122.2 billion); € 19.6 billion (USD 26.5 billion); and € 58.5 billion (USD 79.2 billion), respectively, over a 30 year

[23] Trasande, L. and Liu, Y. (2011). "Reducing The Staggering Costs of Environmental Disease In Children, Estimated at 76.6 Billion in 2008". *Health Affairs*, Vol. 30, No. 5, May.
[24] Pimentel (1992) was used in Blainey et al (2008) to estimate the health impacts of pesticide poisonings in Europe.
[25] Pimentel, D. (2005). "Environmental and Economic Costs of the Application of Pesticides Primarily in the United States", 7: 229-252. Available at: http://www.beyondpesticides.org/documents/pimentel.pesticides.2005update.pdf
[26] Hunt, A. (2011), "Policy Interventions to Address Health Impacts Associated with Air Pollution, Unsafe Water Supply and Sanitation, and Hazardous Chemicals", OECD Environment Working Papers, No. 35, OECD Publishing. Available at: http://dx.doi.org/10.1787/5kg9qx8dsx43-enOECD

Table 4: Midpoint estimates of the cost impact of REACH (Euro millions) (30 year time horizon)				
Total Costs	**Asthma**	**COPD**	**Dermatitis**	**Total**
Without REACH	90,394	19,689	58,546	168,629
With REACH	45,428	9,572	22,678	77,678
Cost Savings	44,966	10,116	35,868	90,951

Source: (Pickvance et al 2005)

time horizon after the implementation of REACH. These costs are noted in Table 4, along with the estimated savings (much lower costs) that would have occurred with REACH. Cost savings would total over Euros 90 € billion (USD (2007) 121.8 billion) over the 30 year time period, providing that implementation of REACH were, for the majority of its members, in place.

To compare, Pickvance et al (2005) report that the European Commission estimated that the total costs of REACH for the chemical industry and the downstream users to be in the range € 2.8-€ 5.2 billion over 15 years.

- Another study from Risk & Policy Analysts Limited (RPA 2003) determined that the present value (discounted over 30 years at 3 %) of the estimated benefits/health impact reductions arising from REACH, range from around € 18 billion - € 54 billion (USD (2007) 24.3-73.1 billion). These figures result mainly from (an estimated) 20%[27] of cancer deaths, assumed to be associated with exposure to unknown chemical carcinogens in the workplace that are monetized with Values of Statistical Life (VSL), ranging from a low VSL of € 1.39 million (USD 1.5 million) to a 'best estimate' VSL of Euros € 2.14 million (USD 2.4 million).

With the required expertise, monetized health effects such as from Pickvance et al (2005) and RPA (2003) could be very carefully assessed for extrapolation to existing global data on deaths and DALYs from WHO. WHO Choosing Interventions that are Cost Effective (WHO-CHOICE)[28] provides more information for consideration of the use of DALYs than the health metric in cost-effective analyses. In as much as the quantified costs presented by Prüss-Ustün et al (2011) is alarming and supports investment in sound chemicals management, it is monetized data that is required for financial decision making. It must be stressed, however, that monetized health (and environmental) effects are often underestimated, as many quality of life benefits are not taken into account thus, stakeholders must be very cautious in applying these estimates to financial analyses.

[27] RPA (2003) reports that findings from a study by the International Agency for Cancer Research and discussions with other occupational health experts suggest that around 20% of (an estimated 32,500) annual deaths may stem from exposure to unknown chemical carcinogens.
[28] Available at: http://www.who.int/choice/en/

3.2.2 Environmental Effects

Harmful chemicals damage the environment, thus impairing its ability to provide environmental goods (such as food and water) and ecosystem services (such as air and water purification). There is a growing body of economic research on environmental values that have been used to highlight the cost of losses to ecosystem services and biodiversity. However, this data are often not readily disaggregated into its chemical components as research is more focused on the environmental resource, rather than on the chemicals effects.

Moreover, the search for literature on the costs of chemicals effects on the environment (air, water, and soil) uncovered even less data, compared to the chemicals effects data that focused on human health endpoints. Of the identified environmental effects data, most relate to water, ecosystem services and biodiversity, while a few mention direct effects to air and soil. In most cases, studies that monetized and/or quantified the effects of pollution on the environment did not provide disaggregated data on effects attributed to specific chemicals.

The environmental effects of harmful chemicals are qualified and illustrated with some quantified data in the key literature. In addition, the 2010 report on "Practices in the Sound Management of Chemicals", prepared by the Division for Sustainable Development, United Nations Department of Economic and Social Affairs (UNDESA), the Secretariat of the Stockholm Convention on Persistent Organic Pollutants (POPs), UNEP[29] generally qualifies effects to atmosphere, water and soil resources, biodiversity, agriculture, and fisheries. In addition, the 2008 OECD "Costs of Inaction on Key Environmental Challenges"[30] gives consideration to general categories of chemical effects on the environment, including air and water pollution. However, the 2008 OECD "Environmental Outlook to 2030" (OECD 2008) notes that there remains "a need for better understanding of certain uses or sources of exposures (e.g. chemicals used in products)". It is only with such type of scientific data that economic assessment of the costs of chemicals pollution to the environment can begin.

Apart from the literature that qualified and quantified the effects of general pollution on the environment, some chemicals' relevant monetized environmental effects data were uncovered during the development of this report. As most environmental resources do not have traditional market prices, the uncovered environmental effects data were mainly monetized using proxy market data such as financial losses to agriculture and fisheries or drinking water treatment and supply costs.[31] Similarly, the effects of chemicals on air, land and water are illustrated in the costs of cleaning up toxic wastes and emissions (Japan Environmental Agency 1991; Pesticide Action Network, UK, on-line; Wilson et al 2008). With such monetized data, we can begin to understand the magnitude of the effects of harmful chemicals on the environment and the implications for development planning. These effects are presented in Table 6 below in the section on Development Planning Effects. These costs, however, can only be considered as underestimates, as they do not capture the total value of losses to ecosystems and societies.

In addition to the data reported in this study, there is a significant amount of literature on economic values for ecosystem goods and services that can be used to monetize quantified losses of, for example, forests and soil, due to any number of causes. Such is the case in *The Economics of Ecosystems and Biodiversity (TEEB)*, a major UN led international initiative that began in 2007. In 2008, TEEB reported

[29] Available at: http://www.un.org/esa/dsd/resources/res_publsdt_toxichem_2010.shtml
[30] Available at : http://www.oecd.org/env/costsofinactiononkeyenvironmentalchallenges2008.htm
[31] For example, see: (Japan Environmental Agency 1991); World Bank and State Environmental Protection Administration, P.R. China. (2007), and Annex 2: Benefits/Avoided Costs).

Box 2: Estimated Global Costs of VOCs and Mercury Emissions

Despite difficulties in disaggregating existing environmental effects data into its chemical components, TEEB data were used to estimate that pollution from SOx, NOx, PM, VOCs and mercury cost an estimated USD 546 billion or 0.91% of global GDP in 2008. VOCs alone accounted for USD 236.3 billion and mercury emissions accounted for USD 22 billion. However, "due to lack of available global data, the analysis excludes most natural resources used, as well as many environmental impacts including water pollution, most heavy metals, land use change and waste in non-OECD countries". The report also notes that the costs would also be higher if degradation of environmental services such as watershed protection or climate regulation could be included (UNEP FI and PRI 2010).

Given the limited number of chemicals and environmental impacts included in this study, these figures only give a preliminary view of global costs of environmental effects due to chemicals. They give us an indication of the proportion of the environmental costs due to VOCs and mercury emissions, which we estimate to be at least 5.7 to 13 percent of the *annual* USD 2-4.5 trillion (USD 2000-4500 billion) in ecosystems and biodiversity losses estimated by TEEB.

As more chemicals effects and costs to the environment are uncovered, particularly to ecosystems services such as water purification, these estimates will increase.

Source: (UNEP FI and PRI 2010).The calculation of the global environmental costs was based in part on data on the valuation of forest resources from the Valuation Database of the UNEP Initiative on the Economics of Ecosystems and Biodiversity.

that the loss of ecosystems and biodiversity was estimated to cost between USD 2-4.5 trillion (or USD 2000-4500 billion) per year (see Box 2).[32] TEEB builds on the 2008 report, *Costs of Policy Inaction: The case of not meeting the 2010 biodiversity target (COPI Biodiversity)*, which indicated that because of biodiversity loss between 2000 and 2050, due to change in land-use and a loss of quality of the land due to climate change, pollution, and fragmentation, the world is expected to lose ecosystem services, mainly in climate regulation, soil quality maintenance and air quality maintenance, worth around 7% of world GDP in 2050.[33] More data on the costs of chemicals to ecosystem services, such as water purification, need to be uncovered. Although chemicals specific data are not readily available from the TEEB database, more chemicals data could be investigated with clearly defined indicators.[34]

Some studies provide costs of environmental effects of harmful chemicals using more defined approaches. For example:

- In Mali, pesticide resistance and destruction of natural enemies, resulting from ineffective pest management, were estimated to cost over USD 8.5 million annually, in cotton alone (Ajayi et al 2002). The increase in expenditures for insecticides from the period 1990-1995 to 1998 was used as a proxy to monetize the cost of pesticide resistance and resurgence of secondary pests; no effects to agricultural yields are reported in this estimate.

[32] TEEB. (2008). "The Cost of Policy Inaction: The case of not meeting the 2010 biodiversity target". Available at: http://ec.europa.eu/environment/nature/biodiversity/economics/teeb_en.htm
[33] Ibid
[34] E-mail communication with TEEB authors (Benjamin Simmons (UNEP/DTIE/Economics and Trade Branch), Pushpam Kumar (UNEP/DTIE/Ecosystem Services Economics Unit) and Salman Hussein (Scottish Agricultural College), Carsten Neßhöver, Helmholtz Center for Environmental Research UFZ).

Other important but still tenuous biodiversity effects of chemicals, particularly pesticides, on pollinators are gaining notoriety. For example, the BBC News reported that:

- The disappearance of bees and other pollinators would cost the UK economy up to £ 440 million per year and amount to 13% of the country's income from farming. However, there is "... no single factor that could explain the pollinators' decline. [...] There's a whole range of agricultural and land use, disease, environmental change [and] pesticides." More "wide-ranging research" and "robust science" is required (Moskvitch 2010).

Another area receiving focused attention is the effect of pharmaceuticals in water, from both human and industrial disposal and waste.[35] The International Society of Doctors for the Environment proposed Environmentally Persistent Pharmaceutical Pollutants (EPPPs) as a possible emerging policy issue for consideration by the International Conference on Chemicals Management at its third session in 2012 (ICCM3). This proposal is supported by emerging evidence of the harmful effects of chronic accumulation of EPPPs in water. These effects include genetic, developmental, immune and hormonal health effects to humans and other species, as well as effects to reproductive systems in aquatic life which may lead to ecosystems imbalance and decline.[36] Only some economic consequences, in terms of costs of action, of the effects of pharmaceuticals in water were found from media sources and are noted below.

- China has become the world's largest producer of active pharmaceutical ingredients (API), accounting for 20% of the world's total. The Chinese government recognized this industry as a leading polluter and in July 2010, released stricter standards for the discharge of pharmaceutical pollutants into water. Following a pollution scandal, one major pharmaceutical company signed an agreement to build a new production plant at a cost of approximately Yuan 2 billion (USD 294 million) for the first phase only.[37]

- In Orange County, California, reverse osmosis and ultraviolet radiation of treated wastewater are used to remove pharmaceutical chemicals, but not all, from the drinking water supply. The costs of this process are considered to be high, "costing USD 15 per month for the 12,000 gallons used by a typical family of four, not including overhead charges, such as construction, salaries and maintenance".[38]

This section on environmental effects reveals that we have significant economic data to support investment in the sound management of chemicals. To target actions, however, it may require more details on the sources of chemicals and the costs of their effects on the environment (see *Box* 3). For example, toxic waste from mining pollutes water resources, thus making access to clean water more difficult and expensive. It also degrades fish habitat and limiting seafood production. Furthermore, significant cultural, recreational, and aesthetic values of environmental resources are being lost due to chemical pollution. Such environmental effects of harmful chemicals and their associated costs need to be identified in order to target cost-effective and cross-sectoral actions for the sound management of chemicals.

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[35] (WHO). 2011. Pharmaceuticals in Drinking Water_ Technical Report . Available at: http://www.who.int/water_sanitation_health/publications/2011/pharmaceuticals/en/index.html [36](SAICM). 2011. "Final Versions of Submissions for Nominated New Emerging Policy Issues". Available at: http://www.saicm.org/documents/OEWG/Meeting%20documents/OEWG%20INF%209_Final_submissions%20on%20EPI%20_EDC_EPPP.doc

[36] (SAICM). 2011. "Final Versions of Submissions for Nominated New Emerging Policy Issues". Available at: http://www.saicm.org/documents/OEWG/Meeting%20documents/OEWG%20INF%209_Final_submissions%20on%20EPI%20_EDC_EPPP.doc

[37] Royal Society of Chemistry. (2011). "Pharma pollution is out of Control in China". Available at: http://www.rsc.org/chemistryworld/News/2011/June/24061103.asp

[38] The equivalent of 12,000 gallons in liters is 45,424.9. See: "Removing pharmaceuticals from water doesn't come cheap or easy". Available at: http://www.freedrinkingwater.com/water-news/remove-pharmaceuticals-from-water-not-cheap.htm

Box 3: Clean-up Costs in the Context of Developing Countries

Severe environmental effects arise from disposal of chemicals and used products containing chemicals in landfills, toxic waste sites, and stockpiles. Chemicals escape into soil, water and air damaging the environment, human health and ultimately economic productivity. These costs of chemicals pollution are highlighted by the costs of clean-up operations. For example:

- The African Stockpiles Program calculates that to clear up the 50,000 tonnes of obsolete pesticides in Africa will cost around USD 150-175 million (http://www.pops.int/documents/implementation/gef/montevideo.pdf).
- Each year in the United States, more than USD 1 billion is spent on efforts to clean up hazardous waste Superfund sites. Cleanup costs for future sites are estimated at about USD 250 billion (Wilson et al 2008).

While the US may spend at least USD 1 billion per year in hazardous waste clean-up, less developed countries cannot afford such costs. The effects of chemicals pollution are felt more acutely by the world's poor, increasingly so as production and use of chemicals increases in developing countries and countries with economies in transition.

> *"The development that has taken place in the rich world, where we are increasingly surrounded by various chemicals and articles that contain hazardous chemicals, can be expected to spread rapidly to the newly industrialised countries and later to countries that today are less technically developed. People's exposure to a number of hazardous chemicals, such as pesticides, is already greater today in developing countries than in the rich countries (Pesticide Action Network Asia and the Pacific 2010). This is due to weak policy on chemicals and inadequate knowledge among the population. In addition to this there is waste or articles containing hazardous chemicals that have been exported from rich countries. Developing countries already face difficult challenges today in steering away from chemicals hazardous to health and the environment. In addition, they will increasingly have to grapple with the massive complexity and quantity of information that follow from the trend towards more and increasingly complex chemicals, including synergistic effects". (KemI 2011).*

It is expected that the sound management of chemicals will decrease or even eliminate these costs to business and society as chemical pollution and the need for environmental remediation will be avoided or minimized. More economic data on the health, environmental, and economic development impacts of toxic chemicals waste are required for all regions, particularly given the forecasted global growth in chemicals production (OECD 2008).

3.2.3 Development Planning Effects

Unsound chemicals management may result in high or hidden health and environmental costs that decrease efforts to achieve national development goals such as providing safe access to clean water, achieving food security and reducing poverty. A lack of good chemicals management may deepen poverty as harmful chemicals damage the health of the poor and the natural resources upon which they depend for their economic livelihoods.

Table 5: Development Planning Effects	
Percent of GDP	
Egypt	In Egypt, annual damage costs from outdoor air pollution amount to approximately 1.8% of GDP (Arif 2005).
Lebanon	In Beirut, Lebanon, the cost of lead pollution from transport is estimated at 0.17-0.24 percent of GDP (while the cost of switching to lead-free gasoline is estimated at 0.17 percent for all of Lebanon) (Sarraf et al 2004).
Mali	In assessing the costs of pesticide use in Mali, Ajayi et al (2002) found the chronic loss of productivity to cost 50% of the annual agricultural GDP per habitant.
Pakistan	In Pakistan, the annual cost of lead exposure to a quarter of the population living in cities was estimated at 0.7% of GDP in 2004. IQ losses represent 78 % of total cost, and mild mental retardation 15% (World Bank 2006b).
Agricultural Sector	
China	In China, it was estimated that acid rain, caused mainly by increased SO_2 emissions due to increased fossil fuel use, causes over 30 billion Yuan (USD 3.9 billion) in damages to crops each year, primarily to vegetable crops (about 80% of the losses) (World Bank and PRC 2007).
Japan	One-year damage expenses for crop loss due to soil pollution through cadmium in the Jinzu River Basin in Japan amounted to 882 million Yen in 1989 (USD 6.78 million) (Japan Environment Agency 1991). The one-year soil restoration costs amounted to 893 million Yen in1989 (USD 6.86 million) (Japan Environment Agency 1991).
Commercial Fisheries	
China	In China, the effect of acute water pollution incidents on commercial fisheries is estimated at approximately 4 billion Yuan (USD 485 million) in 2003 (World Bank and PRC 2007).
Japan, Minamata	Water pollution caused by organic mercury lead was 690 million Yen in 1989 (USD 5.3 million) in one-year expenses for fishing damage compensation (Japan Environment Agency 1991).
Trade (Product Recalls)	
United Kingdom	In its report on *Chemical Safety in Consumer Products Industries*, Henderson (2009) reported that in the United Kingdom, there has been a 10% increase per annum in product[39] recalls since 2003 (Henderson 2009).
Public Infrastructure (Clean Water Supply)	
Mali	Replacing drinking water contaminated by pesticides: USD 64,200 (Ajayi et al 2002)
United States	Household willingness to pay (WTP) for protection of groundwater from chemical contamination: USD 197-730 (Crutchfield et al 1995)
United States	Drinking water treatment facilities to meet Safe Drinking Water Act regulations for pesticides and other chemicals: USD 400 million (US EPA 1997b)

[39] Product categories may include children's goods, healthcare and personal care, appliances, food, home and garden, food, beverages, and electronics and computers (Henderson 2009).

This study aims to uncover meso- (sectoral), and to the extent possible, macro- (national) costs of harmful chemicals effects to human health and the environment. This type of data may provide the best information for investing in sound chemicals management in national development planning; thus, this section on development planning effects focuses on monetized effects at the sectoral and national levels. Furthermore, some quantified macro-level effects were expressed in terms of GDP, mainly reflecting human health effects from chemicals in the environment, which are meaningful to national development planners.

Many of the environmental costs of harmful chemicals uncovered in this study were monetized in terms of sectoral losses. These meso-effects data include costs to the agricultural and fisheries sectors, as well as to public infrastructure for clean water supply as presented in Table 5 above.

Meso-economic development planning effects data include monetized costs to public health as seen in the country level data presented above in Table 3. Other noteworthy meso-economic health effects were found as benefits of action data seen as avoided public health costs (Annex 2), as well as in the health and other productivity benefits of sound management of pesticides presented in Box 4 and Table 6 below.

Trade effects resulting from product recalls are critical to note as chemicals use and production increases in developing countries and countries with economies in transition. Such effects are often felt acutely by business investors. For example, in the second half of 2007, the share price of toy-maker Mattel underperformed the sector by approximately 35% after large scale recalls following the discovery of lead in its products (Henderson 2009).

Box 4: Benefits of Action in the Agriculture Sector

Of significant importance is the economic evidence showing that agriculture yields, household incomes, and GDP can increase with sound management of agricultural chemicals. Although this report is focused on the costs of inaction, compelling information is illustrated in Table 6 on the benefits of integrated pest management (IPM), good agricultural practices (GAP) and taxes on pesticides. The agriculture sector is one of the few areas where the data will allow the beginnings of a comprehensive presentation of the economic evidence for the sound management of chemicals. UNEP (2011) reports that the global agricultural area is estimated to increase by approximately 10% from 2005 to 2030. If business continues as usual, with projections of increased pesticide use, the unsound use of agricultural chemicals could result in even more harmful effects. Alternatively, UNEP (2011) reports that green investments in agriculture lead to improved soil quality, increased agricultural yield and reduced land and water requirements. Greening agriculture also increases GDP growth and employment (up to 47 million additional jobs in the next 40 years), improves nutrition and reduces energy consumption and carbon dioxide (CO2) emissions.

Source: (UNEP 2011). "Investing in Natural Capital.: Agriculture", in Towards A Green Economy: Pathways to Sustainable Development and Poverty Eradication. Available at: http://www.unep.org/greeneconomy/Portals/88/documents/ger/GER_2_Agriculture.pdf

Table 6: Benefits of GAP, IPM, and Taxes on Pesticides	
Bangladesh	In assessing Integrated Pest Management (IPM) in Bangladesh, it was found that on average, farmers can increase rice output, and thus increases profits, by approximately 17% (Dasgupta et al 2004).
Belize	In Belize, implementing Good Agricultural Practices (GAP) over a five year period would allow for the net benefit of Belize Dollars (BZ $) 324.5 (USD 166) per acre per year and BZ $119,071,604.37 (USD 61 million) net present value over a five year period. The benefit/cost ratio of 3.15 shows that GAP is economically beneficial and fosters environmental and social development objectives (Parades 2010).
Indonesia	In Indonesia from 1991 to 1999, an IPM programme was able to help farmers reduce the use of pesticides by approximately 56% and increase yields by approximately 10% (Oka 1995, cited in Resosudarmo 2001).
Indonesia	The total estimated GDP gain from implementing the national IPM programme from 2001-20 is equivalent to 3.65% of Indonesia's GDP in 2000, while the increase in household incomes is 1.5-4.8% (Ibid).
Indonesia	The revenue from only a 5% increase in the tax on pesticides would be enough to train more than 80% of rice farmers in the IPM technique over the next 20 years. The effects/ benefits of this are: (1) the avoidance of 23,000 of acute and 79 million cases of chronic pesticide poisoning among rice farmers; (2) a total GDP gain equivalent to 22% of Indonesia's GDP in 2000; and (3) household income gains of 8-28% (Ibid).
Philippines	In the Philippines, the aggregate value of environmental benefits for the five villages in the Central Luzon where the IPM research program was centered was estimated at USD 150,000 for the 4600 local residents (Cuyno et al 2001).
Uganda	In Uganda, the total discounted [using a 4% discount rate] monetized benefits of proposed actions for strengthening the governance of chemicals management for the agriculture sector are estimated to be USD 1.98 billion over the entire analysis period [2011 to 2025]. Crop yield gains are estimated to be 20% of the projected value added from cultivated areas, expected to be effected by the proposed actions (Republic of Uganda 2010).
Vietnam	In Vietnam, if a health tax of 10% is imposed on current pesticide prices, farmers' health costs would be reduced by 4,597 VND in 1996 (USD 0) per hectare. Additionally, farmers would gain 46,826 VND in 1996 (USD 3) per hectare because of savings from pesticide, labour, and fertilizer expenditures. As such, total benefit and net benefit to farmers would be 51,423 VND in 1996 (USD 3) per hectare and 12,292 VND in 1996 (USD 1) per hectare, respectively. Thus, at the farm level, net benefit continues to increase as pesticide health tax increases. It is also noted that government would receive an amount of 36,022 VND (USD 2) per hectare with this tax level (Nguyen and Tran 2003).

Some data uncovered show implications for cross-sectoral development planning in public health, energy and transportation sectors. For example,

- In Iran, damage (health)[40] costs in the energy sector are 2.3% of GDP, with the main problem being the growth of pollution from private vehicles powered by petrol (Arif 2005).
- In Beirut, Lebanon the cost (mainly impaired neurological development in children) of lead pollution from transport is estimated at 0.17-0.24% of GDP, while the cost of switching to lead-free petrol is estimated at 0.17% of GDP for all of Lebanon (Sarraf et al 2004).

The extent to which sound management of chemicals can address chemicals released through combustion remains unknown. However, using information similar to that from Sarraf et al (2004), shown in Box 5 below, illustrates that the removal of lead from petrol has clear health benefits.

Box 5: Global Benefits from the Phase-out of Leaded Fuel

UNEP reports that lead poisoning has been one of the world's most serious environmental health problems, with impacts including increased blood pressure, higher risk of cardiovascular disease, delayed mental and physical development, reduced attention span (including attention deficit hyperactivity disorder or ADHD) and increased crime rates. The WHO estimates that between 15 and 18 million children in developing countries currently suffer from permanent brain damage due to lead poisoning; according to the results of WHO research, leaded petrol was responsible for some 90% of human lead exposure (UNEP 2011).

UNEP's Partnership for Clean Fuels and Vehicles (PCFV), involving civil society, governments and the private sector including major oil and vehicles companies, has supported over 100 countries to phase-out lead in transport fuel and has over the past decade resulted in a near-global elimination of leaded fuel. At the turn of the 20th century, the majority of developing countries were still using leaded petrol, but after the PCFV campaign, now more than 10 years later, only a handful are still using leaded fuel and the world market is more than 99% unleaded.

With support from the UNEP PCFV, researchers at California State University estimated that the global benefits from the phase-out of leaded fuel amount to USD 2.45 trillion, or 4% of global GDP, per year. USD 702 billion per year in benefits accrues to developing nations and USD 1.74 trillion per year accrues to developed nations. Individual health benefits for children and adults include avoided loss in IQ, and societal and individual effects including avoided losses in tax revenue, ADHD and lead-linked crimes . The benefit to cost ratio for the phase-out of leaded fuel is at least 10 to 1. These estimates were calculated using the technique of GDP extrapolation applied to available country level data from published literature, including country studies from the US and Lebanon. The tested technique and resulting estimates are "increasingly important in justifying research and policies in green chemistry and environmental health" (Tsai and Hatfield 2011).

Source: UNEP (2011) and (Tsai and Hatfield 2011)

[40] (1) The total health damage from air pollution in 2001 is assessed at about USD 7 billion; equivalent to 8.4% of nominal GDP. In the absence of price reform and control policies, it is estimated that damage in Iran will grow to USD 9 billion by 2019, in 2001 prices. This is equivalent to 10.9% of nominal GDP, i.e. a larger percentage of a larger GDP. Of this total, USD 8.4 billion comes from the transport sector (Shafie-Pour and Ardestani,2007). Environmental damage costs in Iran by the energy sector. Available at: http://www.sciencedirect.com/science/article/pii/S0301421507000894), and (2) Impact on the Environment of Measures without Price Reform: 8.4% of nominal GDP; adjusting for PPP: 2.3% of GDP (Arif 2005. The Energy Environment Review, in the Islamic Republic of Iran. Available at: http://info.worldbank.org/etools/docs/library/117846/677_1382_sherif_arif.ppt#275,22

Some studies present cross-sectoral costs of health and environmental effects in specific situations. For example, in the US, the economic effects of harmful algal blooms caused by excess nutrients, particularly phosphorous from agricultural fertilizers and household detergents, are at least USD 82 million per year (Hoagland and Scatasta, 2006). This cost includes:

- Commercial Fisheries Impacts: USD 38 million per year
- Public Health Costs of Illnesses: USD 37 million per year
- Recreation and Tourism Impacts: USD 4 million per year
- Coastal Monitoring & Management: USD 3 million per year.

This section on development planning effects reveals significant, but for the most part discrete, sectoral effects data at the national level. The last example from Hoagland and Scatasta (2006) is one of the few studies uncovered that shows development planning effects to multiple sectors. More effort is needed to highlight cross-sectoral effects, trade effects and future risk scenarios of unsound chemicals management. According to KemI (2011), "the aggregate health and environmental effects of chemicals, known as synergistic effects, need to be studied more closely". This type of policy-relevant research could help improve understanding of the development planning effects and actions needed for the sound management of chemicals.

Nevertheless, the literature review uncovered some highly significant quantified and monetized health, environmental and development planning effects data that was estimated using defensible methods. In the sections that follow, Sections 4 comments on the usefulness of the data uncovered, and Section 5 shows how some of the data uncovered were used to highlight the costs of inaction on the sound management of chemicals.

4. Commentary on the Usefulness of Existing Analyses

FLAMES AT A REFINERY © JOHN SHORT / DESIGN PICS/STILL PICTURES

This report reveals how few studies are readily useable to inform national and international discussion on investments in sound management of chemicals. The quantified and monetized effects data are scattered and disjointed, and does not provide a comprehensive picture of the current costs of chemicals mismanagement. Furthermore, almost no consideration is given to future risks.

While the emerging data on the economic consequences related to negative health and environment effects of chemicals clearly point to huge costs, these data are still insufficient to provide the evidence required for informed policy-making on an international scale. However, in just one test completed for this study, it was possible to extrapolate from the existing data to provide a meaningful estimate of the costs of injury due to pesticides poisonings in sub-Saharan Africa. Similar extrapolations could be conducted for other key development sectors, such as mining, waste, leather and textiles, which would show utility for all developing countries.

► *Fragmentary analysis*

The effects of chemicals on health and the environment are often not studied as such. The focus of most studies on broad health and/ or "environmental pollution" issues result in findings that are often not disaggregated into chemicals-specific effects. Much of the data pertain to health effects of harmful chemicals. Much less comprehensive data were uncovered on environmental effects.

In particular, data on costs to ecosystem services due to chemicals are sorely lacking. Some efforts have been made to demonstrate the effects in quantified and/or monetized terms – especially in the TEEB framework – but the scope of environmental issues related to chemicals is far from complete. Still, with some reasoning based on existing data (UNEP FI and PRI 2010; TEEB 2008), we know that the costs due to only two types of chemicals represent a significant proportion of the best current estimate of global ecosystems and biodiversity losses. As more chemicals effects and costs to ecosystems and biodiversity are uncovered, we may find a substantially increased proportion of the trillions of dollars in losses estimated by TEEB.

The review of existing analysis clearly shows that environmental and health effects of chemicals are interconnected and must be treated as such. For example, many health effects uncovered were due to emissions of harmful chemicals into the environment. Yet, very few studies address chemicals effects on health and the environment in an integrated way. Studies that focus on specific substances/groups of substances or development issues would allow for more meaningful integration of environmental and health effects of chemicals.

► *Covers a narrow spectrum of the issues*

The review shows that existing quantified and monetized data cover only a very limited number of the issues raised by chemicals mismanagement. Chemicals costs due to development are most often studied through sectoral lenses that do not capture the full spectrum of issues arising from chemicals across key development sectors. Issues related to industrial, household and pharmaceutical chemicals are only covered to a very limited extent.

Chemicals can have many hazardous effects on health and the environment throughout their lifecycle, and these effects result in various types of costs for economic development. For example, some data presented in terms of benefits of an action were also uncovered and often estimated in terms of avoided health costs (Annotated Bibliography, Table 1; see also World Bank (2006a)).

Some effects data in terms of mitigation costs are also available, as with industrial water pollution abatement costs (see for example World Bank (2006a) and Table 2 of the Annotated Bibliography). However, the direct environmental and health costs of such pollution, and thus the economic evidence for investment in mitigation technologies, need to be strengthened.

Of particular note, is that development planning effects data were uncovered with respect to gains in agriculture from sound management of chemicals used in agriculture. Moreover, a number of country studies showed that in those countries with sound management of chemicals there were increased agricultural yields, household incomes and GDP. More economic evidence for sound management of chemicals is found in reports on chemicals accidents, which were received in response to the above mentioned 'Call for Information'.

For example, on 11 December, 2005, a series of explosions and subsequent fire destroyed large parts of the Buncefield oil storage and transfer depot in Hemel Hempstead, UK causing widespread damage to neighboring properties. The overall cost of the Buncefield incident totaled £894 million (USD 1.7 billion). The costs included £625 million (USD 1.2 billion) in compensation claims by operators, £245 million (USD 487 million) in aviation cost; £15 million (USD 29.8 million) in Competent authority and government response, £7 million in emergency response. In addition, environmental effects costs were estimated at a potential £2.1 million (USD 4.1 million) (Buncefield Major Incident Investigation Board 2008). There are many more examples of chemicals-related disasters that have occurred around the world over the past 50 years. Actions for prevention of chemicals accidents deserve critical attention as frequency of such accidents and their resultant costs increase.

► *Very little extrapolation of what findings might mean for other sectors and other geographical regions*

Chemicals effects on health and the environment cut across sectors and current areas of management. Such crossovers can help focus attention on cost-sharing in terms meaningful to development planning, given limited financial resources. For example, research by the World Resources Institute (WRI)[41] on the effects of pollution, including agricultural chemicals, on reefs and resulting economic impacts for fishing, coastal protection and tourism, clearly points to significant cross-sectoral effects. According to the literature reviewed, these are almost never clearly recognized and studied adequately.

Similarly, consequences of the effects across countries and regions are also not fully considered. Some data are available on trade effects, but these generally focus on trade effects only for the specific country/ sector analyzed.

► *Comparability issues*

The various methodological approaches used to monetize and quantify data in the existing literature (Annex 3) make comparison of findings very difficult for aggregation across nations and regions. For example, each of the country studies, assessed for baseline data for the pesticides extrapolation case study, used different scopes and methods in calculating the number or percentage of farm workers affected.

Difficulties in comparing existing data emerge from differences in the scope of the various studies. In particular, the diverging scope of health-oriented (health endpoints) and environment-oriented studies (environmental media, specific substances), and the fragmentation of issues addressed lead to the inclusion of varying groups of substances in the analysis. In some cases, the exact group of substances included in the analysis is not even identifiable.

In addition, the estimated costs are presented at various levels (micro, meso, macro and global) in many different units, and the information provided is not always sufficient to allow comparison. As a result, the findings of the different studies are not easily reconciled.

► *Very little standardization in methods*

Various methodologies are used for quantifying and/or monetizing the health and environmental effects of harmful chemicals. These methodologies have differing strengths and weaknesses; resulting studies include various assumptions that need to be carefully assessed before comparing findings.

[41] World Resources Institute (WRI) (2011). *Reefs at Risk Revisited*. Available at: www.wri.org/project/reefs-at-risk

However, studies uncovered often do not include the necessary level of methodological detail to accurately assess the assumptions underpinning the data, and thorough investigation into study design would be needed in order to assess the degree of data comparability. This makes usability for the busy decision maker a far more tenuous exercise.

► *Snapshot treatments with very little consideration of future risk scenarios*

Data are generally presented in a static way and very few studies include projections of the future risks based on current trends. More dynamic analysis is vital to inform preventive measures in integrated economic planning.

5. Use of Existing Data

PESTICIDE USE FOR ROSE CULTIVATION IN TANZANIA © JOERG BOETHLING/STILL PICTURES

This section of the COI report provides a practical demonstration on how to estimate health costs of inaction on the sound management of chemicals when data are minimally adequate, fragmentary and difficult to compare. The perception of inadequate data does not need to result in fatalism and inaction when practical and defensible techniques can be used to bring richer information to the priority of sound management of chemicals. When costs of inaction are demonstrated to be mounting, delay is a far less attractive option for financial decision makers at the centre of government and industry.

5.1 Extrapolation of Pesticides Data in Sub-Saharan Africa

A significant portion of the health effects data uncovered in the COI report represent health costs of pesticides[42], and a relatively significant portion of the data came from certain countries in sub-Saharan Africa, including those countries that undertook mainstreaming projects under the UNDP-UNEP Partnership Initiative on Integration of Sound Management of Chemicals into Development Planning.

[42] Pesticides means any substance or mixture of substances intended for preventing, destroying or controlling any pest, including vectors of human or animal disease, unwanted species of plants or animals causing harm during or otherwise interfering with the production, processing, storage, transport or marketing of food, agricultural commodities, wood and wood products or animal feedstuffs, or substances which may be administered to animals for the control of insects, arachnids or other pests in or on their bodies. The term includes substances intended for use as a plant growth regulator, defoliant, desiccant or agent for thinning fruit or preventing the premature fall of fruit, and substances applied to crops either before or after harvest to protect the commodity from deterioration during storage and transport (FAO Code of Conduct 2002). Available at: http://www.fao.org/fileadmin/templates/agphome/documents/Pests_Pesticides/Code/Code.doc

This section of the Costs of Inaction report describes how recent data on the health costs of injury of pesticide poisonings in certain sub-Saharan African countries were extrapolated[43] to the sub-Saharan Africa region to estimate total annual health costs for a 2005 baseline year. This analysis was then projected to 2020 through a future risk scenario analysis.

The extrapolation uses low imputed health costs in cases where higher costs could be defensible, and does not take into account environmental costs (e.g. effects on water quality, ground and surface, land, pest resistance, biodiversity decline, etc.) or economic sustainability costs (e.g. effects on inland fisheries, tourism, travel times for clean water, etc.). These costs, were they able to be calculated from reasonable baseline data, which is not the case given the data scarcity noted in the Costs of Inaction report, would increase the overall costs of pesticides to the sub-Saharan African region in the baseline year of 2005. Such costs of inaction could ultimately feed into a more fulsome cost-benefit analysis, where the potential return on investment in sound management of chemicals would be prominent. Furthermore, the future risk scenario, which (a) adopts the conservative 2005 baseline estimate, (b) uses a pesticide use index available from 2000-2008 and projected to 2020; and (c) does not, due to time and resource constraints, take into account inflation or lost interest, and can logically be argued to be producing an even more conservative estimate for the total burden to sub-Saharan Africa, 2005-2020.

Finally, this extrapolation was never intended to look at benefits of pesticide use, although the benefits is needed to ultimately be fully reflected in analyses for good public policy . Rather, the extrapolation provides a demonstration for countries regarding how health costs can be calculated to feed into a more complete cost - benefit[44] analysis of pesticides use. This extrapolation also does not consider costs and benefits of all other categories of chemicals, organic and inorganic, to the sub-Saharan African region, including industrial chemicals, pharmaceuticals and household chemicals.

5.2 Method

5.2.1 Scope

This extrapolation focuses on financial health costs to farm workers and the public health care system from pesticides use on small land holdings in 37 sub-Saharan African countries, since the baseline report identified a number of relevant data sources for such an extrapolation. The choice of small land holdings is furthermore based on data from the African Development Bank (AfDB) Group that smallholder farming accounts for over 75% of employment and about 75% of production in the agriculture based economies assessed in the AfDB study (Salami et al 2010). Growing attention to smallholder farming in Africa as a valuable, poverty-reducing market sector makes this extrapolation a valuable contribution to inform government assistance to sectoral strengthening and modernization in a development planning context.

No attempt is made in this analysis to account for environmental costs (e.g. effects on water quality, ground and surface, land, pest resistance, biodiversity decline, etc.) or economic development costs (e.g. effects on inland fisheries, tourism, and travel times for clean water, etc.). It also does not consider costs and benefits of all other categories of chemicals, organic and inorganic, to the sub-Saharan African region, including industrial chemicals, pharmaceuticals and household chemicals.

[43] In this study, extrapolation adheres to its definition: "to extend the application of (a method or conclusion) to an unknown situation by assuming that existing trends will continue or similar methods will be applicable "(Oxford Dictionaries, Available at: http://oxforddictionaries.com/definition/extrapolate)".

[44] At this time, no discounting of future benefits/avoided costs is taken in order to compare against the costs of action required today. For more on discounting, see (UNEP 2009). *Supplemental Cost-Benefit Economic Analysis Guide*, Available at: http://www.chem.unep.ch/unepsaicm/mainstreaming/Documents/UNDP-UNEP%20PI_Economic%20Analysis%20Supplement_Revised%20draft.pdf

This study does not try to monetize lost lives and livelihoods, typically attempted with VSL and DALYs methodologies. These methodologies are noted to be controversial (Annex 3), particularly when attempts are made to transfer values of human lives from developed to developing country contexts. Careful adjustments for purchasing power parity (PPP) adjusted GDP can be considered, but are not attempted in this study where data exists on deaths and productive years lost (Ajayi et al 2002; Republic of Uganda, National Environment Management Authority 2010).

5.2.2 Analytical Framework

The extrapolation addresses three cost categories:

1. Costs of days of work lost as a factor of wages or average daily income;
2. Medical treatment (outpatient) costs; and
3. Hospitalization stay costs.

For each country considered in the extrapolation, these cost variables are adjusted for GDP(PPP) and integrated into the following calculation (illustrated in Figure 3 below):

$$(A*B_1*(C1+D) + (A*B_2*(C_2+E) + (A*B_3*C_3) = \text{Costs of Injury to Pesticide Users on Smallholdings}$$

where,

A = Number of farm workers on small land holdings using pesticides;

$B_{1,2,3}$ = Percent of farm workers experiencing 1) serious, 2) moderate, or 3) minor incidents;

$C_{1,2,3}$ = cost of lost work days due to 1) serious, 2) moderate, or 3) minor incidents;

D = cost of hospitalization stay due to serious incidents; and,

E = cost of outpatient medical treatment due to moderate incidents.

The model can easily be expanded to include other effects, such as the losses due to pesticide poisoning of animals, specific environmental effects, etc, whenever such data inputs are available.

Figure 3: Variable Relationships

<table>
<tr><td>Number of farm workers on small land holdings using pesticides</td><td>multiplied by</td><td>Percent of farm workers experiencing serious incidents</td><td>multiplied by</td><td>Cost of hospitalization stay + cost of lost work days</td><td rowspan="5">equals</td><td rowspan="5">The cost of injury to pesticide users on small holdings</td></tr>
<tr><td colspan="5">plus</td></tr>
<tr><td>Number of farm workers on small land holdings using pesticides</td><td>multiplied by</td><td>Percent of farm workers experiencing moderate incidents</td><td>multiplied by</td><td>Cost of outpatient medical treatment + cost of lost work days</td></tr>
<tr><td colspan="5">plus</td></tr>
<tr><td>Number of farm workers on small land holdings using pesticides</td><td>multiplied by</td><td>Percent of farm workers experiencing minor incidents</td><td>multiplied by</td><td>Cost of lost work days</td></tr>
</table>

5.2.3 Data Sourcing

For their comprehensiveness of data provided on the effects of chemicals use in the agriculture sector, studies from Mali (Ajayi et al 2002), Uganda (Republic of Uganda, National Environment Management Authority 2010) and Zambia (Bwalya 2010) were assessed for baseline data. The Mali study was produced by the University of Hannover Pesticide Policy Project, in cooperation with the FAO. The studies from Uganda and Zambia were conducted under the UNDP-UNEP Partnership Initiative with funding from the SAICM Quick Start Programme and the Government of Sweden, respectively. Unless otherwise noted, all references to data from Mali, Uganda, and Zambia noted in this Section 5 of the Costs of Inaction Report are referenced to these sources.

The data inputs provided in these studies, ranging from years 2000 to 2007, were rigorously assessed for quality and reliability by being compared with studies that, while less comprehensive or needing to be adjusted for time, than the core studies used for this extrapolation, were nevertheless addressing one or more of the same variables used in our analysis. For each and every extrapolation variable, the study team rigorously vetted the data and rejected any data input that appeared inconsistent compared to any other study that was found addressing the same or highly similar variables anywhere in the world.

In each case, conservative data inputs were selected for all variables, keeping the error factors on the low side rather than the high side of the resulting cost estimate. Through this quite rigorous assessment of data quality and reliability, variable by variable, data input by data input, the 2005 data from the Zambia study (Bwalya, 2010), under the UNDP-UNEP Partnership Initiative, was found to be a particularly strong data source for extrapolation to sub-Saharan African countries. This was supplemented by the other key studies in Mali and Uganda.

Thirty-seven countries, with an estimated 159 million farm workers on smallholdings using pesticides, were included in this extrapolation. These countries are all characterized by small-scale farming and by economies largely supported by agriculture. Based on country economic information from the CIA, *The World Factbook,*[45] industrial-based or service oriented economies were excluded from the extrapolation. The gross domestic products (GDPs) of these countries ranged from USD 699 to USD 4,824 per capita in 2005. Countries with higher GDPs, such as South Africa, where commercial farming is more the norm, were not included in the study. Other high GDP countries not included in the study are characterized by more industry, mining, and service based economies.

5.2.4 Data Inputs

In order to calculate the above stated three major costs of injury from pesticides poisonings, data inputs for the following variables were needed:

1. Number of farm workers in the country;
2. Percentage of farm workers on small land holdings;
3. Percentage of farm workers on small land holdings using pesticides;
4. Relative percentages of health effects experienced in the three main categories of costs – work days lost, outpatient care, or hospital care, each of which impute different, discrete costs;

[45] Central Intelligence Agency. *The World Factbook*. Available at: https://www.cia.gov/library/publications/the-world-factbook/

5. Daily agricultural wage;

6. Average cost of outpatient health care;

7. Average cost of inpatient hospitalization care.

These data inputs were assessed, compared and adjusted if necessary, as summarized in table 7 below.

5.3 Summary Description of Data Inputs and Main Quality Tests

5.3.1 Number of Farm Workers in the Country

With data from *The World Factbook* and the World Bank,[46] the number of agricultural workers per country are calculated. Data are not available for all sub-Saharan countries; therefore, we fill gaps (for five countries) by using the average number of agricultural workers per country (76%) from the sub-Saharan countries included in the extrapolation. From *The World Factbook*, the total number of agricultural workers for the 37 countries included in the extrapolation amounts to approximately 236.2 million people. The use of ILO labour statistics were also investigated. The use of ILOs labour statistics where also investigated. ILO database had data from 11 countries only out of the 37 countries in the extrapolation. ILO labour statistics were in some cases significantly lower than those contained in the CIA Factbook. The difference reveals the tendency of most labor market statistics to better reflect the organized labor market and to under represent family labor and the disorganized migratory work force. The CIA World Factbook, by contrast, approaches the subject from the population deployment perspective. Where are the people, what are they doing, and what does that say about labor market conditions and societal stability? As a result, the CIA World Factbook appeared to be the best representation of the broad and diverse scope of farm labor on smallholdings.

5.3.2 Percentage of Farm Workers on Small Land Holdings

The percentage of farm workers per country is discounted by 25% to account for the percentage of agricultural workers not working on smallholdings. This calculation is based on data from the African Development Bank (AfDB) Group indicating that smallholder farming accounts for over 75% of employment and about 75% of production in the agriculture based economies assessed in the AfDB study (Salami et al 2010).[47] This is characteristic of the countries included in the extrapolation study, considered alongside the evidence, for example as reported by the AfDB, of the growing attention to smallholder farming in Africa as a valuable, poverty-reducing market sector.

5.3.3 Percentage of Farm Workers on Small Land Holdings Using Pesticides

To account for small land holding and livestock farmers that do not use pesticides the percentage of farm workers on small land holdings is discounted by a further 10%. This assumption is based on survey data from Tanzania and Senegal where it was found that 90-95% of farmers use pesticides (Thiam and Sagna 2009).[48] The total number of farm workers on small land holdings using pesticides was estimated to be approximately 159.4 million people.

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[46] World Bank Data. Available at: http://data.worldbank.org/

[47] Based on case studies conducted in Kenya, Ethiopia, Uganda and Tanzania.

[48] Thiam, A. and Sagna, M.B. (2009). "Monitoring Pesticides at Grassroots Community Level". Africa Regional Report. Pesticide Action Network Africa. Dakar, December 2009. Available at: http://pan-afrique.org/index2.php?option=com_docman&task=doc_view&gid=28&Itemid=85

Table 7: Data Adjustments					
VARIABLE	DATA INPUT				
	Main Data Sources	Conservative Data Test	Extrapolation Adjustments		
			Percentage Adopted for All Countries	GDP Adjusted for Each Country[49]	Inflation Adjusted for 2005 Baseline Year
1. Number of farm workers in the country	Most recent country labor market statistics	NA	NA	NA	NA
2. Percentage of farm workers on small land holdings	75% of item 1 based on African Development Bank Group estimates	No study found to dispute this percentage	Yes	NA	NA
3. Percentage of farm workers on small land holdings using pesticides	10% reduction in item 2 to reflect livestock farming	No study found to dispute this percentage	Yes	NA	NA
4. Relative percentages of health effects experienced in the three main categories of costs - work days lost, outpatient care, or hospital care, each of which impute discrete costs	Syngenta Crop Protection Study	Tested by comparison with Pesticide Action Network (2010) for minor (and moderate) incidents and with Jeyaratnam/ WHO (1990) for serious incidents	Yes	NA	NA
5. Daily agricultural wage	Zambia Study	Tested by comparison with Mali and Uganda studies adjusted for GDP and inflation. No other studies revealing concern about high extrapolation estimates	Total yearly costs of 167.2 to 1,058 million CFA francs (USD 242,861 to USD 1.5 million)	(Ajayi et al 2002)	Yes
6. Average cost of outpatient health care	Zambia Study	Tested by comparison with Mali study and WHO-Choice	NA	Yes	NA
7. Average cost of inpatient hospitalization care	Zambia Study with Factor adjustment from WHO-Choice	Factor Adjustment tested by comparison with Mali study	Yes	Yes	NA

[49] Monetized baseline data was adjusted for each country included in the extrapolation with 2005 data on per capita GDP (PPP) from Table 1 of the Human Development Report 2007/2008, available at: http://hdr.undp.org/en/reports/global/hdr2007-2008/. This adjustment, particularly for medical costs, is supported by (Adam, T., Evans, D. B. and Murray, C. J. L. (2003). Econometric estimation of country-specific hospital costs. BioMed Central Ltd. Available at: http://www.who.int/choice/en/); undertaken for WHO-Choice which determined that "GDP per capita could be used to capture different levels of technology use across countries", a close surrogate for health care costs.orld-factbook/

5.3.4 Work Days Lost to Health Effects

Data were analyzed from a survey of smallholder agricultural users of pesticides commissioned by Syngenta Crop Protection, resulting in the percentages of Tanzanian farm workers affected by pesticide poisonings (Tomenson and Matthews 2009).[50] This study reports that in Tanzania 1.2% of users experienced serious incidents that required hospital treatment, 11.6% experienced moderate incidents requiring trained medical treatment, and 62% experienced a minor incident for which the user did not seek any trained medical attention.

However, Tomenson and Matthews' (2009) data are conservative, compared to the results of a similar survey conducted in Tanzania and reported by Pesticides Action Network International (PAN)(2010). According to PAN, 69% of farmers said that their health was affected by pesticides and that 28% said that they went to the hospital for treatment. The number of users experiencing serious incidents reported in Tomenson and Matthews (2009) is also more conservative than that from the prevailing literature which indicates that, in total, 3% of agricultural workers in developing countries suffer an episode of pesticide poisoning each year (Jeyaratnam (1990),[51] as witnessed in The Republic of Uganda, National Environment Management Authority (2010). However, this estimate was based on "data from hospital admissions which would include only the more serious cases" (Jeyaratnam 1990).[52] Moreover, this estimate does not capture the high percentage of people who suffer from moderate and minor incidents of pesticide poisonings.

Furthermore, it has been well acknowledged that the type of hospital data as presented by WHO (1990)[53] seriously underestimates cases of pesticide poisonings as "the majority of … incidents never reach official statistics" (PAN UK 2007).[54] To illustrate, in South Africa a 10-fold increase of poisoning rates was found through intensive surveillance compared with routine methods; occupational cases were underreported compared to suicides and the risks to women were underestimated (London and Baillie (2001);[55] in PAN 2010). While official hospital and Ministry of Health data, as used in the studies from Ajayi et al (2002) and Bwalya (2010), are much needed, such data do not capture the greater percentages of farm workers who suffer from minor and moderate pesticide poisoning incidents.

Bwalya (2010) estimates that farmers in Zambia lose an average of three days out of 26 in the production season due to chemical poisoning. Given a distinct production season from November to April (US AID and FEWS NET, 2007),[56] we calculate that 21 days are lost per year.

To compare, Ajayi et al (2002) estimate that in Mali the days of work lost per year among cotton workers negatively affected by pesticides range from a minimum of three to a maximum of 14, with an average

[50] Tomensen, J.A. and Matthews, G.A. (2009). "Causes and types of health effects during the use of crop protection chemicals: data from a survey of over 6,300 smallholder applicators in 24 different countries", *International Archives of Occupational and Environmental Health*, Vol. 82: 935-949. Available at: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2719752/pdf/420_2009_Article_399.pdf

[51] Jeyaratnam, J. (1990). "Acute Pesticide Poisoning: A Major Global Health Problem". Available at: http://www.ncbi.nlm.nih.gov/pubmed/2238694

[52] This estimate was based in large part on hospital data from Sri Lanka and included two thirds of cases attributed to suicide attempts (Jeyaratnam, B. (1985), in WHO (1990). More recent data from Benin and Senegal indicates that suicide accounted for approximately 5% to 20% of poisoning incidents (PAN UK 2007). "Pesticide food and drink poisoning in Africa. Food & Fairness briefing no. 4" https://secure.virtuality.net/panukcom/PDFs/food & drink exposure.pdf

[53] WHO (1990. *Public Health Impact of Pesticides Used in Agriculture*. Available at: http://whqlibdoc.who.int/publications/1990/9241561394.pdf

[54] Available at: https://secure.virtuality.net/panukcom/PDFs/food & drink exposure.pdf

[55] London, L., and Bailie, R.(2001). "Challenges for improving surveillance for pesticide poisoning: policy implications for developing countries", *International Journal of Epidemiology*, 30: 564-570

[56] US AID and FEWS NET (2007). *Annual Harvest Analysis Report for the 2006/2007 Production Season*. Available at: http://www.fews.net/docs/Publications/1001479.pdf

of 11.5.[57] In Uganda, The Republic of Uganda, National Environment Management Authority (2010) calculate that each farmer loses 24.6 days per year due to pesticide poisoning, including 9.4 days annually due to respiratory diseases and 15.2 days annually for skin infections.

We conservatively assume that farmers who experience serious incidents lose a maximum 21 work days per year, with seven days spent in hospital;[58] those who experience moderate incidents lose two-thirds of the maximum, or 14 days per year, and those who experience minor incidents lose one third of the maximum, or seven days per year. These costs are distributed as follows: 1.2 % of users experienced serious incidents that required hospital treatment, 11.6% experienced moderate incidents requiring trained medical treatment, and 62% experienced a minor incident for which no trained medical attention was sought.

5.3.5 Daily Agricultural Wage

The daily agricultural wage is used to estimate the costs of days of work lost for serious, moderate and minor incidents of pesticides poisonings. In Zambia, the daily wage was estimated from government data on average monthly rural labour income and calculated to be USD 3.27 in 2005.[59]

To compare, in Mali the "unit cost per person for replacement of labor (man-days)" based on "actual average costs in rural Mali" was calculated to be USD 2.00[60,61,62] in 2005 (Ajayi et al 2002). In Uganda the daily agricultural wage was given as USD 5.18 in 2005/2006 for agricultural workers in the private sector, using information from the National Household Survey, 2007. For the purpose of this study the Zambian daily wages were used, adjusted by PPP.

5.3.6 Average Cost of Outpatient Health Care

In Bwalya (2010), the cost of medical treatment of USD 7.40 in 2005 was given as "the average cost of treating an illness at health center" and calculated from a study on costing the essential health care package in Zambia. This study (Kabaso et al 2006),[63] estimates "the cost of treating each illness episode and captures such costs as cost of medical supplies including medicines, non-medical supplies, human resources and capital costs". As the Basic Health Care Package in Zambia[64] offers essential healthcare services at five standard types of health facilities: Health Post; Health Centre; and the 1st, 2nd and 3rd Level Referral Hospitals, we assume that the given cost of medical treatment in Zambia does not include costs of hospitalization.

[57] Calculated from Table 7.4 (Ajayi et al 2002) for the given minimum, average and maximum estimates of "replacement of labor (man-days)" for 18,000 cotton workers

[58] To compare, WHO-Choice indicates that the "average length of stay" in a Primary level hospital is 7.15 (days).

[59] Using the given 2005 exchange rate of K 4700 per one USD (Bwalya 2010).

[60] The year is of data is not specified in Ajayi et al (2002) and the referenced study Camara et al (2001) is not readily available for verification. We assume the given man-day labor replacement cost to be from 2000.

[61] The given man-day labor replacement cost of 1250 CFA was converted to USD using the mid-year exchange rate for 2000 (www.xe.com) and adjusted for inflation to 2005 (www.imf.org).

[62] The World Bank provides data on the percent of population with poverty headcount ratio at USD 2 a day (PPP) (% of population). These data are provided for only nine countries in sub-Saharan Africa and there are only some correlations between the percentage of population at USD 2 a day and the percent of agricultural labour force.

[63] Not readily available for verification.

[64] Republic of Zambia, Ministry of Health, 2005. *National Health Strategic Plan 2006-2010*. Available at: http://www.who.int/nha/country/zmb/Zambia_NH_Strategic_plan,2006-2010%20.pdf

5.3.7 Average Cost of Inpatient Hospitalization Care

From WHO Choice we find that the unit costs per inpatient day at a primary hospital are approximately twice as great as those for a 20 minute visit at a health centre (with 100% population coverage) in both WHO Global Burden of Disease Regions AFR D and AFR E.[65] For each country included in the extrapolation, we multiply the GDP (PPP) adjusted average cost of outpatient health care (Zambia baseline USD 7.40) by two. To compare, results from Ajayi et al (2002) indicate that the costs of hospitalization are 3.8 times higher than the costs of medical treatment.

5.4 Results

5.4.1 2005 Baseline Year

The costs of lost work, medical treatment, and hospitalizations due to pesticides poisonings among farm workers on small land holdings in 37 Sub-Saharan African countries are estimated to be USD 4.4 billion in 2005 (Table 8). For the countries included in this extrapolation, the average cost per capita (farm worker affected) due to pesticide poisoning was USD 35 in 2005.

These results are estimated from baseline data from Tanzania (Tomenson and Matthew 2009) and Zambia (Bwalya,2010), after rigorous comparison with other possible baseline data for quality and relevance to the study scope. Specifically, the incident data reported in Tomenson and Matthews (2009) from the Syngenta Crop Protection survey results from Tanzania were chosen because they were the only data that could be logically compared with alternate and only slightly higher survey data from Tanzania reported in Pesticides Action Network (2010). The data from Tanzania are also comparable to data from the other African countries (Morocco, Senegal, and Cameroon) included in the Syngenta Crop Protection survey.

The costs data from Zambia came from government sources, as did the Uganda agricultural wage data. In the Mali study, the costs data came from "actual average costs in rural Mali". As we aim to inform governments on their national development planning goals, the government data from Zambia was chosen as it was more conservative and comprehensive than the Uganda cost data. The Zambia costs data was adjusted for purchasing power parity gross domestic product (GDP (PPP)) for each country included in the extrapolation to reflect differences in daily wages, out-patient medical and in-patient hospital costs.

The number of farm workers on small land holdings is based on the *The World Factbook* (CIA 2012) because the discovered differences with the ILO labour statistics provide a source of uncertainty in the calculations that future precise labour statistics might minimize.

With more comparable country-specific data, ideally from official sources, these extrapolation results can improve and countries are recommended to make their own calculation based on the method described in this report.

[65] AFR D and AFR E are countries in Africa grouped by epidemiological characteristics.

Table 8: Costs of Injury to farm workers on small land holdings due to Pesticide Poisonings in sub-Saharan Africa in 2005					
	Costs of Serious Incidents (Hospitalization plus Lost Work) (USD millions)	Costs of Moderate Incidents (Medical Treatment plus Lost Work) (USD millions)	Costs of Minor Incidents (Lost Work) (USD millions)	Costs per country (USD millions)	Cost per capita (farm workers affected) (USD)
Western Africa					
Mali	3.70	10.90	25.08	39.68	22.67
Benin	4.38	12.93	29.74	47.04	25.04
Burkina Faso	10.04	29.63	68.17	107.84	26.62
Burundi	3.83	11.30	26.01	41.14	15.34
Cameroon	17.40	51.33	118.09	186.81	50.46
Central African Republic	2.47	7.29	16.78	26.54	26.86
Chad	6.76	19.95	45.89	72.60	31.32
Cote d'Ivoire	11.78	34.74	79.93	126.45	36.17
DRC	17.62	51.97	119.56	189.15	15.67
Eritrea	2.37	6.99	16.08	25.43	24.34
Gambia	1.54	4.56	10.48	16.58	42.16
Ghana	30.82	59.70	137.33	227.85	57.08
Guinea	10.67	31.47	72.39	114.52	50.83
Liberia	1.33	3.91	8.99	14.23	21.95
Mauritania	2.03	5.99	13.79	21.81	49.03
Niger	4.55	13.41	30.86	48.82	17.14
Nigeria	54.99	162.24	373.24	590.48	24.76
Sao Tomé and Principe	0.12	0.35	0.81	1.28	47.80
Senegal	10.60	31.26	71.92	113.77	39.33
Sierra Leone	1.23	3.62	8.33	13.18	17.69
Togo	3.50	10.34	23.79	37.63	33.05
Eastern Africa					
Uganda	25.51	75.27	173.16	273.95	31.91
Ethiopia	46.89	138.34	318.26	503.49	23.15
Kenya	22.97	67.76	155.88	246.61	27.21
Rwanda	6.66	19.64	45.19	71.49	26.47
Sudan	27.40	80.85	186.00	294.26	45.72
Tanzania	19.21	56.67	130.36	206.24	16.33
Southern Africa					
Zambia	6.63	19.55	44.98	71.16	22.45
Angola	21.94	64.74	148.94	235.63	51.25
Congo	2.00	5.91	13.60	21.51	27.70
Comoros	0.59	1.74	4.00	6.33	43.74
Lesotho	3.38	9.97	22.94	36.29	73.19
Madagascar	9.58	28.25	65.00	102.82	20.26
Malawi	4.76	14.04	32.31	51.11	14.64
Mozambique	13.70	40.42	92.99	147.11	27.26
Swaziland	2.13	6.28	14.45	22.86	105.87
Zimbabwe	7.14	21.07	48.47	76.68	44.73
Health costs for sub-Saharan Africa (USD millions)	422.21	1214.39	2793.67	4430.36	
Average cost per capita (farm workers affected) (USD)					34.5

5.4.2 Sensitivity Tests

The low tests are calculated using incident data from Syngenta Crop Protection (averages for Senegal, Cameroon and Tanzania) and on cost data from Mali. The high test is calculated using serious incident data from Jeyaratnam (1990), moderate and minor incident data from PAN (2010) data for Tanzania, and on cost data from Uganda and Zambia. The specific data inputs are presented below.

Low test (1): USD 1.4 billion in 2005

- Syngenta Crop Protection average incident data for Senegal, Cameroon and Tanzania: 1.9% serious; 12.4% moderate; 40.37% minor
- Mali cost data:
  - ☐ Daily wage: USD 2.00;
  - ☐ Days of work lost: 14 to serious incidents; 9.3 to moderate incidents; 4.6 to minor incidents;
  - ☐ Medical cost per incident: USD 1.79; and
  - ☐ Hospital cost per incidents: USD 6.80.

Low test (2):[66] *USD 1.6 billion in 2005*

- Syngenta average incident data for Cameroon and Tanzania: 1.55% serious; 10.95% moderate; 54.35% minor
- Mali cost data:
  - ☐ Daily wage: USD 2.00;
  - ☐ Days of work lost: 14 to serious incidents; 9.3 to moderate incidents; 4.6 to minor incidents;
  - ☐ Medical cost per incident: USD 1.79; and
  - ☐ Hospital cost per incidents: USD 6.80.

Moderate test: USD 4.4 billion in 2005

- Syngenta incident data for Tanzania: 1.2% serious; 11.6% moderate; 62% minor
- Zambia cost data:
  - ☐ Daily wage: USD 3.27;
  - ☐ Days of work lost: 21 to serious incidents (with one third, or 7 days, spent in hospital), 14 to moderate incidents; 7 to minor incidents;
  - ☐ Medical cost per incident: USD 7.40; and
  - ☐ Hospital cost per incident: USD 15.08.

[66] Senegal data were omitted as the minor incident rate reported to be 12%, compared to 46.7% for Cameroon and 62% for Tanzania. In Morocco, the minor incident rate was reported to be 63.2%.

High test: USD 8.1 billion in 2005

- Jeyaratnam (1990) for serious incident data: 3%
- PAN (2010) data for Tanzania for moderate incident data: 28%;[67] and minor incident data: 69%
- Uganda cost data:
  - ☐ Daily wage: USD 5.18; and
  - ☐ Days of work lost: 24.6 to serious incidents; 16.4 to moderate incidents; 8.2 to minor incidents.
- Zambia cost data:
  - ☐ Medical cost per incident: USD 7.40;and
  - ☐ Hospital cost per incident: USD 15.08.

The sensitivity test shows that the costs of inaction for small land holdings in sub-Saharan Africa lies between USD 1.4 billion-8.1 billion in 2005, with a value for the moderate level of USD 4.4 billion in 2005. The value for the moderate level will be used in the following future risk scenario.

5.4.3 Limitattions of the Study

The study has been limited to the acute health and lost work costs of injury resulting directly from working with pesticides on small landholdings. As such, its does not attempt to estimate other costs likely to be substantial, including costs of bystander effects, lost livelihoods and lives, environmental health effects, and other chemicals effects, such as effects on farm animals and long term effects of chemical exposure.

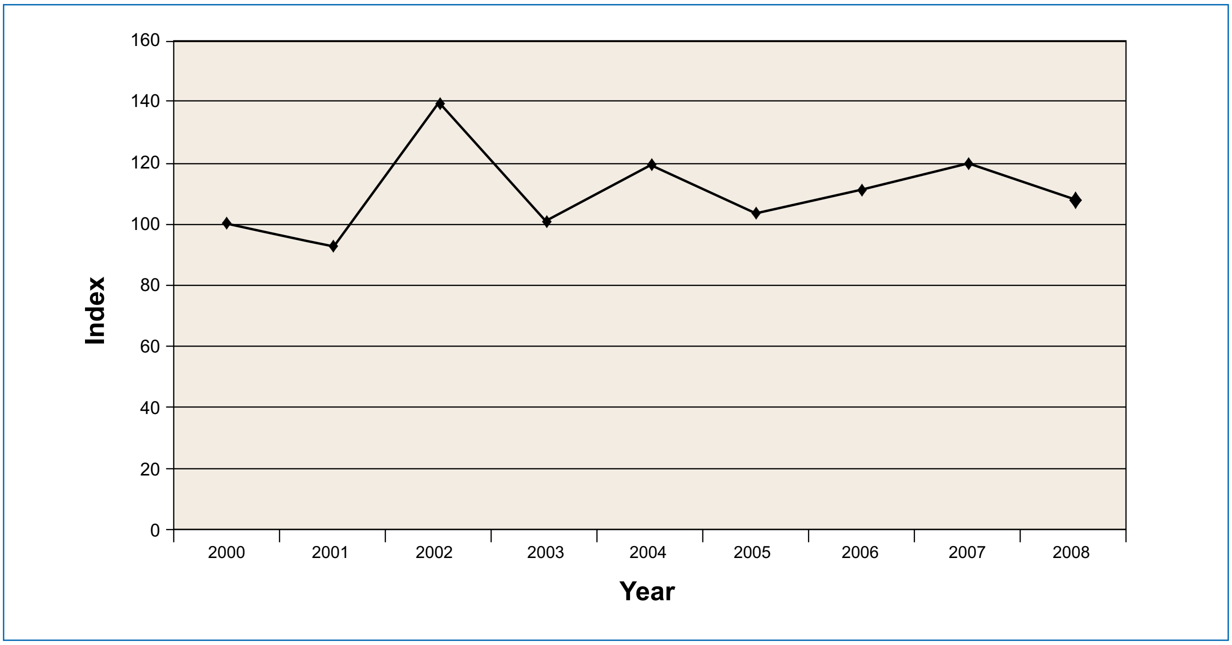
5.5 Future Risk Scenario

If we take the moderate USD 4.4 billion dollar figure for 2005 and assess it through to 2020 (i.e. using the SAICM 2020 goal as the policy context), the sub-Saharan Africa region can anticipate health care costs associated with pesticides to approximate USD 66 billion from 2005-2020 inclusive (i.e. USD 4.4 billion multiplied by 15 years). This holds all key variables constant, including pesticide use volumes for 2005 and sound management of chemicals capacities within the agricultural sector.

However, as can be seen in Figure 4 below, using available World Bank[68] data for the years 2000 to 2008, a pesticides import index was developed as a reasonable surrogate for volumes used in the region since indigenous chemicals production remains low.[69] We assume a direct relationship between volumes of pesticides used and health effects. In charting the growth in costs from 2005 to 2008 and holding

[67] 28% of farmers affected went to the hospital for treatment (PAN 2010).
[68] World Bank Data. Available at: http://data.worldbank.org/
[69] Pesticides trade refers to the value of all types of pesticides (put up in forms or packings for retail sale or as preparations or articles), provided to (exports) or received (imported) from the rest of the world. Differences between figures given for total exports and total imports at the world level may be due to several factors, e.g. the time lag between the dispatch of goods from exporting country and their arrival in the importing country; the use of different classification of the same product by different countries; or the fact that some countries supply data on general trade, while others give data on special trade.

Figure 4: Pesticides Imports Index

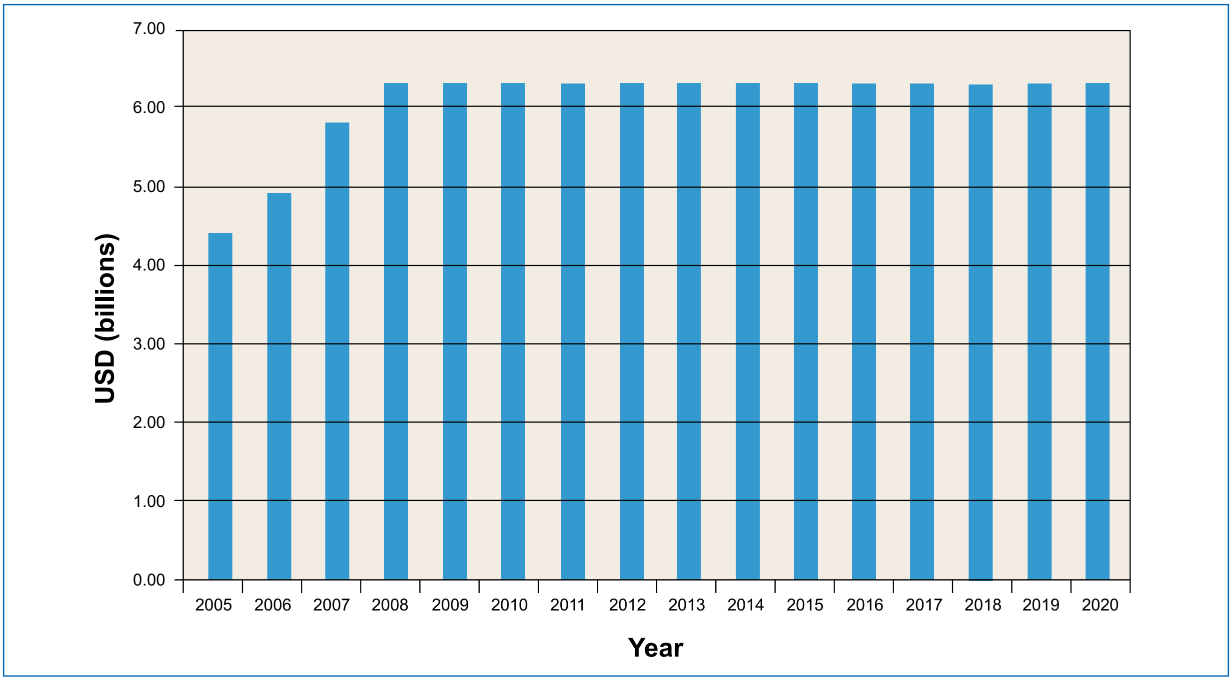


Source: World Bank Data

costs constant from 2008 to 2020, (Figure 5, below), the accumulated costs of inaction to the sub-Saharan Africa region increase from USD 66 billion to USD 97 billion for 2005-2020 (Figure 6, below). If instead the pesticides imports index is projected from 2000 to 2020, we find a declining rate of increase from what was actually measured for 2000-2008, and much greater costs of injury. However, these costs would require careful adjustments for inflation, interest and discounting. Furthermore, the pesticides imports index could be varied to capture likely scenarios due to uncertainties.

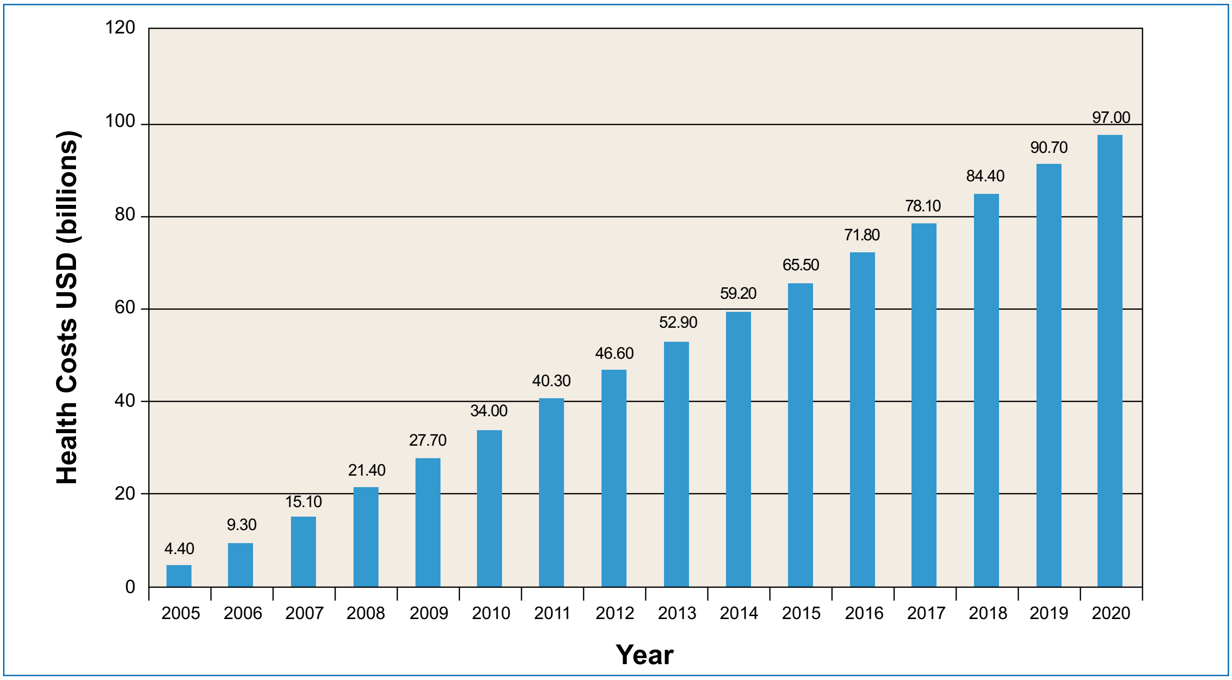
This future risk scenario estimate assumes that the link between pesticides imports and costs of inaction (a ratio set for 2005 in the analysis) remains substantially unchanged to 2020. However, as pesticides imports and use volumes increase, costs could reasonably be assumed to become proportionally higher; the chemicals management challenge will become bigger in terms of volumes that need to be managed safely throughout the chemical lifecycle in an agricultural sector dominated by dispersed, small and financially-challenged farming operations. Of course, this increase might in turn be offset by improved sound management of chemicals capacities within a country as a whole. There are some important initiatives taken to improve the pesticides management, but enhancing chemicals management capacities within the agricultural sector in sub-Saharan Africa is likely not to keep pace with the growth in pesticides or the historical legacy of accumulated costs (e.g. obsolete pesticides, lingering health issues from previous incidents, water and soil degradation, etc.).

Figure 5: Costs of Injury to Smallholder Pesticide Users in Sub-Saharan Africa, 2005 To 2020



Source: Calculations made in this report

Figure 6. Accumulated Costs of Injury to Smallholder Pesticide Users in Sub-Saharan Africa from 2005 to 2020



Source: Calculations made by the authors of this report.

5.6 Benchmarking the Scale of Costs in a Development Assistance Context

In the 37 sub-Saharan African countries characterized by small scale agriculture based economies included in this extrapolation, the average health expenditure in total (public and private) per capita was USD 71 (in 2004)[70] and the average net Official Development Assistance (ODA) in all sectors received per capita was USD 56 (in 2005).[71] As noted above, the average cost of inaction per capita (farm workers affected by pesticides) was USD 35 in 2005 in the countries included in the extrapolation. This reveals a very considerable scale of costs of inaction related to pesticides, not taking into account environmental costs, economic development/sustainability costs, inflation, or the cost of money. As previously noted, the extrapolation also does not consider costs (or benefits) of all other categories of chemicals, organic and inorganic.

Total ODA to the Health Sector in sub-Saharan Africa in 2009 was USD 10.3 billion (Annex 4). However, if targeted aid for the HIV AIDs epidemic is excluded, total assistance for basic health services is closer to USD 4.8 billion.[72] Our conservative projection of the 2005 estimate to 2009 shows costs of injury due to pesticide poisoning in sub-Saharan Africa to be USD 6.3 billion. The costs of inaction related to current pesticide use alone are greater than the total ODA to general health care in sub-Saharan Africa. Clearly, investment in the health sector alone cannot decrease the burden of disease from pesticide poisonings; more importantly, investment in health is being supplanted by the external and often hidden health costs of pesticides and agricultural production. Furthermore, ODA to the Water Sector in sub-Saharan Africa (i.e. water is a major receiving environment for pesticides although aid is primarily directed at water supply and sanitation) amounted to USD 2.8 billion in 2009[73] (Annex 5); this is less than half the pesticide health related costs in the same year.

[70] UNDP Human Development Report 2007/2008, Table 6. Available at: http://hdr.undp.org/en/media/HDR_20072008_EN_Indicator_tables.pdf
[71] UNDP Human Development Report, 2007/2008, Table 18. Available at: http://hdr.undp.org/en/media/HDR_20072008_EN_Indicator_tables.pdf
[72] (OECD 2011). Development at a Glance. Statistics by Region. *2.Africa*. Available at: http://www.oecd.org/dataoecd/40/27/42139250.pdf
[73] Ibid.

TOXIC MERCURY WASTE IMPORTED TO SOUTH AFRICA FOR PROCESSING © DAVID LARSEN / AFRICANPICTURES.NET/STILL PICTURES

6. Filling the Gaps in Knowledge

The review of the literature not only revealed high costs of inaction, but it also exposed key gaps in knowledge. Most of the effects and costs presented are underestimates and could be improved with better data collection and assessment. This section presents the key gaps in knowledge and proposed approaches to filling these gaps.

6.1 Gaps in Knowledge

Based on this review, key gaps in knowledge include the health, environmental and development planning costs of highly hazardous/high volume commodity, household, pharmaceutical chemicals, minerals and metals. Many of these gaps in knowledge extend into the gaps in scientific data and reporting of the effects of chemicals of high concern. These gaps should be filled in all UN regions (no data was uncovered for Oceania, Middle Africa, the Caribbean and Central Asia), and in key development sectors such as mining, waste, leather and textiles.

6.1.1 Chemicals and Chemicals Categories

The varying issues addressed and the limited groups of chemicals included in the range of available studies makes existing data difficult to capture in the chemicals categories as defined in the study scope (Annex 1).

Other than the often cited 2003 paper by the Commission of the European Communities concerning REACH, establishment of a European Chemicals Agency and regulation on POPs. No other studies were identified from the literature reviewed for this report that specifically report on quantified or monetized health, environmental and development planning effects of the POPs category of chemicals included in the Stockholm Convention, which was adopted in 2001 and came into force in 2004.[74]

Commodity, Bulk, High Production Volume (HPV) and Industrial Chemicals

To the extent that 'environmental', 'industrial' and 'air' pollution is due to commodity, bulk, HPV, and industrial chemicals, we have limited health, environmental and development planning effects data to inform financial decision making for sound management of the chemicals industry. Information on the chemicals effects in the unique climatic, social and economic systems of developing countries is scarce.

In developed countries, attention has focused on the lack of data:

- In 1998, the United States Environmental Protection Agency (US EPA) HPV Challenge was established after studies by civil society, government and industry found that baseline data on health effects were not publicly available for many high production volume chemicals, while deep concerns about the vast array of untested chemicals in use were emerging. Of about 2,800 high production volume chemicals, the US EPA study determined that complete health and environmental effects data were publicly available for only about 7% of these chemicals.[75]

- The OECD Existing Chemicals HPV Programme was established in 1991 to systematically investigate existing chemicals in a co-operative way, and to focus on HPV chemicals based on the assumption that production volume is a surrogate for data on occupational, consumer and environmental exposure. The International Council of Chemicals Association (ICCA) joined the OECD in this effort in 1998.[76] The OECD Global Portal to Information of Chemical Substances (eChemPortal) provides access to existing hazard information and assessments[77] and can assist all countries wherever these chemicals are produced or used. As more and more chemicals are being produced in non-OECD countries, priority attention is needed to ensure that adequate health and safety information is available (OECD 2008).[78]

The US and OECD HPV programs can assist economists in assessing environmental, health and development planning effects.

Pharmaceuticals

The scientific information on pharmaceuticals effects on environment, including in drinking water, and thus on health, are emerging. However, cost data on the environmental and health effects of pharmaceuticals, particularly on biodiversity, remain uncovered.

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[74] See http://treaties.un.org/pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-15&chapter=27&lang=en
[75] US EPA HPV Challenge. Available at: http://www.epa.gov/hpv/pubs/general/rtkfaqs.htm#unsafe%20chemical
[76] OECD, on-line. *From the HPV Chemicals Programme to the Cooperative Chemicals Assessment Programme*. Available at: http://www.oecd.org/chemicalsafety/risk-assessment/historyfromthehpvchemicalsprogrammetothecooperativechemicalsassessmentprogramme.html
[77] OECD, on-line. *OECD Cooperative Chemicals Assessment Programme*. Available at: http://www.oecd.org/document/56/0,3746,en_2649_37465_47378552_1_1_1_37465,00.html
[78] "The *OECD* Environmental *Outlook to 2030*". Available at: www.oecd.org/dataoecd/29/33/40200582.pdf

Minerals and Metals

In this study, some quantified and monetized data are available on metals, notably mercury and lead, but data are still very limited, particularly at the national level. Health, environmental and development planning effects data with respect to harmful anthropogenic emissions of minerals and metals largely remain to be uncovered.

Agricultural Chemicals

Clearly, more comprehensive information is available in the agro-chemicals category: in addition to significant quantified and monetized data covering health effects, data on the benefits of alternative actions are available.

6.1.3 Health, Environment, and Development Planning Effects

Health Effects

The data uncovered in this study mostly pertains to acute health effects. Data on the chronic effects of harmful chemicals (for example, the human health effects from pesticides (Prüss-Ustün et al 2011)), appear to be very limited. One reason for this may be that chronic effects need to be measured across time and global scientific efforts towards this have relatively just begun. Notable are the efforts to assess occupational health costs, particularly of cancer causing chemicals in developed countries (RPA 2003; Pickvance et al 2005). Such efforts need to be considered for replication in all regions.

Environmental Effects

Although most of the data reported in this study focus on health effects that often result from chemicals emitted into the environment, few studies focus on the environmental effects of these chemicals.

Focus on environmental effects, particularly on losses to ecosystem services and biodiversity, may provide a relevant approach to link environmental, health, and development planning effects in order to estimate the global costs of inaction on the sound management of chemicals.

The TEEB initiative is the most comprehensive effort to date towards this objective. For example, a clear effect of chemicals pollution is on reefs[79] which provide immense ecosystem services and biodiversity values,[80] including coastal protection from disastrous storms and flooding. However, further investigation in this area is required to highlight cross sectoral development planning effects.

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[79] ABC News, 11 August 2011. *Pesticides hurting Great Barrier Reef: report*. "The Queensland and Federal Government's first report card on water quality in the Great Barrier Reef has found pesticides used in agriculture are causing significant problems for the reef". Available at http://www.abc.net.au/news/2011-08-13/great-barrier-reef-report/2837758

[80] TEEB shows that approximately 30% of the world's coral reefs have been lost or damaged and that one hectare alone of coral reefs provide USD 130,000- 1.2 million per year (*Science Daily* 2009. "What Are Coral Reef Services Worth? $130,000 To $1.2 Million Per Hectare, Per Year". Available at: http://www.sciencedaily.com/releases/2009/10/091016093913.htm. According to another estimate, the total net benefit per year of the world's coral reefs is USD 29.8 billion. Tourism and recreation account for USD 9.6 billion of this amount, coastal protection for USD 9.0 billion, fisheries for USD 5.7 billion, and biodiversity for USD 5.5 billion (Cesar, Burke and Pet-Soede (2003), in *Economic Values of Coral Reefs, Mangroves, and Seagrasses: A Global Compilation*. Center for Applied Biodiversity Science, Conservation International, Arlington, Va., USA. Available at: www.conservation.org/Documents/CI_Marine_CI_Economic_Values_Coral_Reefs_Mangroves_Seagrasses_compilation_2008.pdf).

Development Planning Effects

The data uncovered in this study do not provide a great deal of policy relevant information on the meso (sectoral) and macro (national) development costs of combined health and environmental effects, nor on the effects across key development sectors including energy, health, agriculture, fisheries and trade. However by analyzing and extrapolating existing data, these effects could emerge in a measured way. More efforts such as the pesticides extrapolation conducted for this study would be highly beneficial.

6.2 Approaches to Filling the Gaps in Knowledge

Expert attention is required to connect existing information for more meaningful analysis to support informed policy decisions. This section proposes the following approaches to fill the priority gaps in knowledge across the scope of the Costs of Inaction:

- Attention to the costs of ecosystem services due to chemicals

Although cost data on the effects of specific chemicals on ecosystems and biodiversity are not readily available,[81] it is possible to give an estimate, given enough resources and expertise (see for example, (UNEP FI and PRI 2010). The TEEB database of valuation literature is one of the most comprehensive works to date on valuation of environmental pollution, and intra-agency cooperation that could help fill this data gap.

Furthermore, investigation of chemicals effects on reefs, including from air pollutants and agricultural chemicals runoff, particularly in countries where no readily available data were uncovered (i.e. in the Caribbean and Oceania) could be an efficient step towards approaching a global estimate of the environmental effects of chemicals.[82]

- Methodological guidance

A consistent applied guidance of methods specified for chemical effect analysis would be valuable, especially in countries where capacities for economic analysis are just now emerging. Ideally, methodological guidance should include life-cycle analysis and approaches to combine the use of values estimated based on different methods. Given limited time and resources, efforts can be harnessed to better access existing in-country information, while at the same time building capacity for consistently collecting and analyzing policy relevant data on the health, environmental and development planning effects of harmful chemicals. Quality of life impacts, as measured by more complex methodological frameworks, must at least be quantitatively or qualitatively considered in any economic analysis of the health costs of inaction.

- Collection of unpublished/raw data

A sense emerges from the review that some raw/unpublished data exist that could be used to improve the picture of the costs of inaction on the sound management of chemicals. This especially includes data

[81] E-mail communication with TEEB authors

[82] Considerable work in this area has already been conducted by World Resources Institute (WRI), including in Belize where more complementary work under the UNDP-UNEP PI and the UNEP Chemicals LIRA-Guidance Project has and is being conducted on the sound management of chemicals. See, for example: (WRI 2008). *Belize's Coastal Capital: The Economic Contribution of Belize's Coral Reefs and Mangroves*. Available at: http://www.wri.org/publication/coastal-capital-belize and (WRI 2005). *Belize Coastal Threats Atlas*. Available at: http://pdf.wri.org/belize_threat_atlas.pdf

collected by public or private institutions and which is often not shared and/or used in a meaningful way.[83] As this *report on the Costs of Inaction on the Sound Management of Chemicals* goes forward, attention needs to be given to obtaining relevant data from public and private institutions. Data from poison control centres, such as that published in the journal, *Clinical Toxicology*,[84] could be informative on the costs of acute effects of household chemicals. Collaboration with the UNEP-WHO (Health and Environment Strategic Alliance) HESA Initiative could also be beneficial in this regard.

- Filling the sectoral evidence

In addition to the health and agriculture sectors, work is needed in other key development sectors including mining, waste management, and leather and textiles. Monetized cost data calculated at the sub-national and national levels can be carefully assessed for extrapolations to regional and ultimately global estimates of the costs of inaction on the sound management of chemicals.

The agricultural sector is the most important for many developing countries. Given the considerable amount of data uncovered on the health, environmental and development planning effects of acute pesticide poisonings, a natural priority could be to work towards determining more comparable regional and ultimately global costs of pesticide use.[85] Moreover, pesticides use is the only issue for which data on the benefits of alternative actions is emerging. This is illustrated in cases where we witness gains in productivity with reduced pesticide use and good agricultural practices (as for example, those from Belize and Uganda conducted under the UNDP-UNEP Partnership Initiative). This type of analysis is now seriously needed in a development planning context as it allows for more fulsome cost-benefit analyses and comparison of various options for informed decision making at the sectoral level as intensive agriculture expands to meet the food needs of a growing population.

The identified gaps in data for chemicals, their health, environmental, and development planning effects, and proposed approaches to filling these gaps have led to proposed next steps for the costs of inaction, presented in Section 7.

[83] As demonstrated, for example, in the Health and Environment Strategic Alliance. See, in particular: UNEP-WHO (2010) *Environmental Determinants and Management Systems for Human Health and Ecosystem Integrity in Africa. Final Synthesis report on the Situation Analysis and Needs Assessment for Implementation of the Libreville Declaration on Health and Environment in Africa*, especially pp. 20 onward. Available at: www.unep.org/roa/hesa/Events/2ndInterMinisterialConference/ConferenceDocumentsPreSessionDocuments/tabid/6851/Default.aspx

[84] See *Clinical Toxicology*. Available at: http://informahealthcare.com/ctx

[85] Worldwide, the application of 3 million metric tons of pesticides results in more than 26 million cases of non-fatal pesticide poisonings (In Encyclopedia of Pest Management. D. Pimentel (ed), New York: Dekker. pp. 3-6). Of all the pesticide poisonings, about 3 million cases are hospitalized and there are approximately 220 000 fatalities and about 750 000 chronic illnesses every year (Hart and Pimentel, 2002) (Pimentel D.,2005. Environmental and Economic Costs of the Application of Pesticides Primarily in the United States. Environment, Development and Sustainability, 7: 229-252. Available at: http://www.beyondpesticides.org/documents/pimentel.pesticides.2005update.pdf)

7. Proposed Next Steps

Based on the data assessed in this COI report, the following actions can be taken to improve the global picture on the costs of inaction on the sound management of chemicals.

7.1 Guidance on Valuing Ecosystem Services

The COI Report notes that very little data was found to highlight the benefits of ecosystem services to national development planning from cost-effective domestic investments in sound chemicals management across key economic development sectors. General methodologies for quantifying and monetizing information for numeric analysis when market values do not already exist are plentiful. However, the application of these methodologies to the unique technical aspects of chemical effects on human health, the environment and economic development/sustainability has not received focused consideration, especially with respect to practical as opposed to abstract theoretical applications. As such, policy analysts, chemical management practitioners, and like-minded academics who might be encouraged to strengthen comparable analyses on the economic costs of unsound chemicals management, do not know where to start, or undertake poorly designed studies.

Practical, useable guidance is needed to assess and value the costs and benefits of ecosystem services regarding how these services can be affected by chemicals management. Such guidance needs to address key outstanding questions in approach and methodology for valuing ecosystem services for the sound management of chemicals.

ROADSIDE PESTICIDE SALES IN BURKINA FASO © JOERG BOETHLING/STILL PICTURES

7.2 Incorporating Chemicals Management into Development Planning

There is now broad international consensus that mainstreaming is extremely important for strengthening sound chemicals management regimes at all levels of governance. A key driver for mainstreaming is collection/analysis of data and information on the costs of inaction and benefits of action on improved chemicals management for the three pillars of environment (ecosystem services), public health and national development/economic sustainability.

Mainstreaming guidance developed under the UNDP-UNEP Partnership Initiative must now move to the next step with practical examples of chemicals management issues, strategies and language that can be incorporated into typical economic sector chapters of national development plans. This will substantially assist developing country environment officials who have made their way around the national development planning table with their mainstreaming research results, albeit without applied examples of exactly how the results can be phrased and placed in economic sector chapters of the national development plan. Work should focus on economic sectors, specifically agriculture, mining, leather and textiles, and waste management, that are critical to the security of most developing countries that are experiencing increasing volumes of chemicals produced, used and disposed, and increasing penetration of chemicals intensive products into national economies.

7.3 Cost-Benefit Analysis of Pesticides Management in Two African Countries

Demonstration is required to *assess costs of inaction* in context of and relative to: (a) *the costs of actions* to improve sound management of chemicals that are practical and achievable; and (b) *the benefits of actions*, including preventing future costs and enhancing the current or potential benefits of chemical use through practical changes in prevailing practices. This work should provide a practical, replicable demonstration for all countries of this type of cost-benefit economic analysis and its relevance for policy making.

Testing current mainstreaming guidance as developed by UNEP, cost of inaction information can be used in a complete cost-benefit analysis. The pesticides extrapolation conducted for this study provides a demonstration for countries regarding how health costs can be calculated to feed into a more fulsome cost - benefit analysis of pesticides use, including environmental effects.

7.4 The Costs of Mercury Elimination in Artisanal and Small-Scale Gold Mining

Practical methods are required to better clarify key international chemicals management policies such as for mercury. The Intergovernmental Negotiating Committee (INC) to prepare a Global Legally Binding Instrument on Mercury discusses, among many other issues, the specifics of mercury control strategies in Artisanal and Small-Scale Gold Mining (ASGM). The sooner we demonstrate that practical methods are possible, the sooner policy making can be better informed by costs of inaction and benefits of action data.

Practical economic analysis techniques could further clarify the economic rationale for action, and the costs and benefits of measures that: (a) prohibit specific mercury use practices in ASGM; (b) promote practices that reduce releases of and exposure to mercury in ASGM; and (c) prevent import or recovery, recycling or reclamation of mercury or mercury compounds for ASGM.

7.5 Linking to the Proposed African Surveillance System on Environment and Health

This proposed project advanced by WHO and UNEP aims at setting up an integrated health and environment surveillance and information management system that will enable African countries to establish evidence based policies and make sustainable decisions on environmental management and related disease burdens. This is a long-term goal that will be achieved through stepwise, gradual intersectoral and multidisciplinary approaches. The initiative has five objectives:

- **Objective 1:** To develop, field test and roll out a set of standardized indicators for an integrated surveillance of environment risk factors and associated health effects;

- **Objective 2:** To develop and validate standardized tools and protocols for data collection, collation, analysis and interpretation;

- **Objective 3:** To identify relevant national institutions and strengthen their capacities, including skills and infrastructures to apply the above tools to generate the required information for decision makers and project managers;

- **Objective 4:** To generate on a regular basis the state of environment and health reports; and

- **Objective 5:** To establish a coordination mechanism to share information related to the implementation of Multilateral Environmental Agreements of particular interest to human health as well as management of trans-boundary environmental issues of relevance to human health.

One of the first steps in the proposed African Surveillance System on Environment and Health is to identify standardized indicators for the proposed integrated surveillance system. UNEP anticipates that the proposed next steps for the costs of inaction work, particularly on *Valuing Ecosystem Services: Guidance on Assessing the Costs and Benefits of Investments in Sound Chemicals Management and Incorporating the Environment and Public Health Costs and Benefits of Chemicals in National Development Planning: A Prototype for Agriculture, Mining, Leather and Textiles, and Waste Management* will make substantial contributions to identifying these indicators.

8. Concluding Observations

FREE WATER PUMP IN MANILA ©HARTMUT SCHWARZBACH / ARGUS/STILL PICTURES

The Costs of Inaction report presents readily available quantified and monetized data on the health, environmental and economic development effects of harmful chemicals. While the information remains incomplete and for the most part underestimated, this concluding section highlights that the available data can be very useful to raise political awareness of the benefits stated in economic terms of providing resources to advance the integration of chemicals management into national development plans.

8.1 The State of Economic Information for Sound Management of Chemicals

The primary obstacles to implementation of sound chemicals management laws, policies and institutions are barriers to mobilizing political action, including availability of and provision for resources, accessibility and capacity to assess and utilize techniques and technology, and lack of infrastructure development as it applies to chemicals management. A greater understanding of the economic costs and benefits of chemicals management can help to overcome these obstacles.

In addition to the many benefits that chemicals bring, there are some unintended costs. We all intuitively understand that and we can see verifiable costs in the economic data discussed in this report and highlighted in Section 8.2 below. Monetary and quantitative units are the main language of our political leaders and chief financial decision makers. The available economic information on costs of inaction to human health, the environment and economic development has gaps, but demonstrates clearly the need for greater political concern and enhanced financial inputs into sound chemicals management.

Improved economic information could generate greater demand for action on chemicals management. Our range of tools for assessing economic benefits and costs of chemicals use, which have traditionally focused on the substantial revenue and job benefits of the chemicals industry, must expand to include environmental, health and economic development/sustainability costs. The costs and benefits of chemicals use must, in turn, be compared with the costs and benefits of sound chemicals management.

Continued progress in this area would enhance prospects for more clearly understanding producer, user and government responsibilities and initiatives. This, in turn, can lead to improvements in market-based instruments that complement traditional government regulation to address chemicals products and emissions. Approaches to chemicals management will need to consider new types of strategies that target broad spectrum gains (for example, strategies that span substances and sectors), and system-wide approaches to complement measures defined in national and international legal and institutional infrastructures, see *Box 6*. However, this is unlikely to be a vigorous agenda without substantial improvement in economic justification.

Still, available economic information is not without some strong messages for sound chemicals management. These messages occur against a backdrop of population growth that will place increased strain on sustainable development and basic resources. UN population estimates predict that the world's population will increase to 8.9 billion in 2050. The growth rate of 1.46 percent forecast for developing nations is nearly six times that of developed nations. The implications for infrastructures, including with respect to chemicals management, of higher population growth combined with increased chemicals intensities in developing nations, include increased systems stress that warrants immediate attention to preventive actions.

Box 6: UNIDO Chemical Leasing Programme

A voluntary instrument like the service based Chemical Leasing model is a good example for a market driven business approach for sound chemicals management. It reduces ineffective use and overconsumption of chemicals, improves occupational health and safety conditions and helps companies to enhance their economic performance. It includes value-oriented instead of volume-oriented pricing and decouples the payment from the consumption of chemicals. This results in better chemicals management and encourages innovation. The United Nations Industrial Development Organization (UNIDO) has launched a global programme and promotes chemical leasing in 10 developing and transition countries in close cooperation with the respective National Cleaner Production Centres.

Source: http://www.chemicalleasing.com/index.htm

This study set out to answer four key questions as a first step to putting a figure on the costs of inaction on the sound management of chemicals (Section 1.1). We can now put draw some conclusions, put forward in the following section (Section 8.2), which contains some key figures on the costs of inaction on the sound management of chemicals.

The available data on the health, environmental, and development planning effects of harmful chemicals shows high costs of inaction. However, it was not easy to uncover and pull together these costs. The data are fragmentary with respect to chemicals effects studied and, with little standardization in methods used, difficult to compare and aggregate in a timely manner for effective use in policy-making processes. There is very little assessment of what findings might mean for other sectors and regions, with snapshot treatments and little consideration of future risk scenarios.

Although the available data shows high costs, there are limitations to the scope of the data uncovered. The data were found mainly in prominent areas that are chemical intensive, such as agriculture and health. However, chemicals are prominent and growing factors in all sectors of society, but we have little data to show costs of inaction on these chemicals throughout their life cycles. Even in traditional chemical intensive sectors, such as mining and leather and textiles, which are critical to economic development in developing countries, the readily accessible data remain limited.

For the majority of data uncovered, we see only a historical snapshot of the costs of inaction, with no picture of the future risk scenario. The tools are not currently in place to readily see how the costs of inaction will evolve over time. Without preventive action, and as chemicals become more complex and dispersed throughout the global economy, health and environmental costs will escalate.

8.2 Key Figures on The Costs of Inaction on the Sound Management of Chemicals

Some of the most useable information as seen from our experiences with policy making processes comes from the WHO with respect to health effects, UNEP with respect to environmental effects, and from the UNDP-UNEP Partnership Initiative with respect to development planning effects in the agriculture sector. With this information, we can begin to answer the key question:

► *What figures can be put on the costs of inaction in sound chemicals management, based on available information? How can those figures be compared to other costs?*

This study has uncovered credible and defensible data that highlights the magnitude of the costs of inaction on the sound management of chemicals and implications for national development planning.

The available information reveals vast economic consequences of unsound chemicals management. The work of the WHO (Prüss-Ustün et al 2011) and UNEP (UNEP FI and PRI 2010) provides figures on health and environmental effects that can be compared with other cost data to facilitate further analysis. Work in agrochemicals, namely from the UNDP-UNEP Partnership Initiative and the FAO, is relatively more available. It has also been possible to conduct a regional extrapolation and present a conservative but still high figure on regional health costs with clear messages for development planning.

Health

Estimates for a subset of chemicals of which the health effects have been estimated, i.e. including only chemicals involved in unintentional acute and occupational poisonings, a limited number of occupational carcinogens and particulates and lead, correspond to a total of 964,000 deaths (1.6% of total deaths) and 20,986,153 DALYs (1.4% of total DALYs) in 2004.

Experts can carefully consider monetizing some of these deaths and DALYs, using data from economic analyses of the health benefits of REACH (for example, RPA (2003) and Pickvance et al (2005)). WHO-CHOICE provides guidance on the use of DALYs as the health metric in cost-effectiveness analyses. Carefully considered adjustments between developed and non-developed country contexts are required.

Environment

From UNEP FI and PRI (2010) we have a preliminary view of the global costs of environmental effects due to chemicals. In this study, VOCs account for USD 236.3 billion and mercury emissions account for USD 22 billion of environmental costs due to human activity.

We note that these costs are at least 5.7-13% of the *annual* USD 2-4.5 trillion (or USD 2000-4500 billion) in ecosystems and biodiversity losses estimated by TEEB. With more identification of chemicals effects and costs on the environment, particularly to ecosystem services such as water purification, we could attribute an even larger percentage of the costs of ecosystems and biodiversity losses to chemicals that require sound management.

Development Planning

From key studies conducted under the UNDP-UNEP Partnership Initiative and from the FAO, data from certain sub-Saharan African countries was extrapolated to the sub-Saharan African region to estimate the costs of injury to pesticide users on smallholdings in sub-Saharan Africa to be USD 4.4 billion in 2005. This is an underestimate because it does not include the costs of lost livelihoods and lives, environmental health effects, and non-pesticide effects. A conservative projection of these costs shows that investment in health is being supplanted by the external and often hidden health costs of pesticides and agricultural production.

More similar extrapolations in key development sectors can be a cost-effective way to assess the costs of inaction on the sound management of chemicals, uncovering the costs of inaction relevant to a significant portion of GDP in the developing world.

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Annex 1: General Categories of Chemicals

The following are some key terms for categories of chemicals:

- **Commodity chemicals**: Energy products – oil refinery products and hydrocarbon gases, and also minerals, water, air, coal, and increasingly biological feed stocks – are converted into what could be characterized as "first tier" or "*primary*" building of the chemicals manufacturing. These include gases (e.g. chlorine), acids, ammonia, olefins (e.g. ethylene) and aromatics (e.g. toluene).

  These products, in turn, are used to make other chemical products that are: (1) important in their own right (e.g. ethylene oxide, acetic acid), and (2) used as a feedstock to produce other chemical products. For example, benzene is used to make synthetic resins, rubber, fibers, pesticides, fertilizers, drugs and detergents.

  Commodity chemicals are used in virtually all industrial processes, either indirectly (e.g., as bleaches, detergents, absorbents, dyes and disinfectants in industrial processes), or directly, to make a wide variety of secondary chemicals and products containing chemicals.

- **Bulk chemicals**: Because commodity chemicals form the foundation of the chemical industry, and are, therefore, are in high demand, they are typically produced in large quantities and so often referred to also as "*bulk*" chemicals. For example, globally, chlorine comprises 95% of crop protection chemicals such as pesticides, 85% of all pharmaceuticals chemical processes (as an intermediate), and 25% of medical plastics. 40% of all chlorine production typically goes to production of polyvinyl chloride (PVC), which is widely used in a many industries such as the building and construction industry. Chlorine is also used in manufacture of aluminum and pulp and paper (Chlorine Chemistry Council,2005). Other examples of bulk chemicals are benzene, ethylene, formaldehyde and propylene;

- **High-production volume (HPV) chemicals**: When bulk commodity chemicals are manufactured or imported in quantities of 1,000 tonnes per year or greater, they may also be referred to as *HPV chemicals*.

Multilateral environmental initiatives and agreements addressing chemicals and chemical issues, as well as most national chemical assessment regulations, also differentiate between industrial and agricultural chemicals, metals and pharmaceuticals.

- **Industrial chemicals** include *commodity chemicals sold by a primary manufacturer of chemicals to other manufacturing industries*, including other segments of the chemicals and chemical products sector, and also "downstream" products sold to consumers or to manufacturers of smaller-scale specialty or "niche" products. Examples of downstream products include *consumer chemicals*, such as personnel care products, and also *specialty chemicals*, such as adhesives, electronic materials and life science products;

- **Pharmaceuticals** are a subset of industrial chemicals, although they are often addressed separately in legislation, within the assessment process, etc. Pharmaceuticals have received increased attention globally as a subcategory of industrial chemicals, owing to studies that have found them in drinking water at concentrations that exceed recommended dosages and their toxic, and in some instances, known or suspected estrogenic or "gender-bending" properties;

- **Agricultural chemicals** include pesticides and synthetic fertilizers;
- **Minerals and metals** are naturally occurring chemicals. International and regional agreements to date have focused on mercury, lead and cadmium, which in addition to their high toxicity are subject to long-range environmental transport. As with persistent organic pollutants POPs), these three metals have been found in high concentrations in remote areas, including Canada's Arctic human and animal populations;
- **Existing and new chemicals**: For purposes of assessment, chemicals are divided into "existing" chemicals or those in commerce prior to a certain year, and "new" chemicals, for which companies seek approval for entry into the market place.

Annex 2: Benefits/ Avoided Costs

Global	An estimate of the global benefits (including from avoided loss in IQ) from the phaseout of leaded fuel amounts to 4% of global GDP, or USD 2.45 trillion per year, with USD 702 billion/year in benefits to developing nations and USD 1.74 trillion/year to developed nations (Tsai and Hatfield 2011).
European Union	REACH benefits for occupational skin and non-malignant respiratory diseases, in the first ten years, will be between € 0.66 billion and € 6.2 billion; or in the first 30 years, between € 21.2 billion and € 160.7 billion (Pickvance et al 2005).
Canada	In Canada, total pollution control costs for particulate matter and ozone were estimated to be USD 2.5 billion per year against a monetary benefit of USD $7.5 billion per year, using 1996 as the base year. The benefit estimated in terms of avoided mortality was about 1,800 deaths per year (Pandey and Nathwani 2003).
Hungary	In Hungary, the average total benefits of an energy saving and air pollution control program was valued at USD1.56 billion per year (with 1994 as the base year), with a cost-benefit ratio at 1 to 3.4, given a total cost of interventions of USD 0.46 billion per year. Many of the benefits resulted from reduced mortality in the elderly population and from reduced asthma morbidity costs (Aunan et al 1998).
Japan	In Tokyo, the estimated economic benefits of reductions in nitric oxide and NO_2 emissions between 1973 and 1994 were considerable: USD 6.78 billion for avoided medical costs, USD 6.33 billion for avoided lost wages of sick adults, and USD 0.83 billion for avoided lost wages of mothers with sick children (Voorhees et al 2001).
Lebanon	In Lebanon, the health and economic benefits of reducing particulate matter concentration in the air can range from USD 4.53 million to USD 172.50 million per year using a WTP approach. The major monetized benefits resulted from reduced mortality costs (El-Fadel and Massoud 2000).
United States	The estimated direct cost of enacting the Clean Air Act (CAA) in the United States is between USD 20 billion to USD 30 billion per year. The estimated total benefits that accrue in terms of human health and welfare benefits, as a direct result of that Act, includes 100,000-300,000 fewer premature deaths per year, and 30,000-60,000 fewer children each year with IQs below 70. The economic benefits of implementing the Clean Air Act between 1970 and 1990 are estimated to be between USD 5 trillion-USD 50 trillion greater than the costs (US EPA 1997a)

Annex 3: Methodologies Used to Quantify and Monetize Data

Various methodologies are used to quantify and monetize the costs of environmental and health effects of harmful chemicals. As the literature review conducted for the COI report targeted data that is relatively manageable for policy-makers to uncover, it is interesting to note that studies often did not include detailed methodological considerations. Determining the validity of data for policy-making processes is therefore not easily accomplished.

The methods identified ranged from sophisticated calculations of DALYs and VSL, to calculations of costs of illness including costs of lost work days and medical expenses. Similarly, monetization of environmental effects ranged from the hypothetical contingent valuation WTP methodology, to real expenses incurred for damages to health and environment, including environmental clean up and replacement of ecosystem goods and services.

The literature review produced the following relevant methodological guidance documents useful for assessing the costs of inaction on sound management of chemicals:[87]

- **Environmental Assessment Institute. (2007).** *Challenges for Economic Analysis under REACH.* Available at: http://circa.europa.eu/Public/irc/secureecha/socio-economic_analysis_committe/library?l=/reference_material/challenges_versionpdf/_EN_1.0_&a=d

- **Risk & Policy Analysts Limited. (2011).** *Assessing the Health and Environmental Impacts in the Context of Socio-Economic Analysis under REACH.* Prepared for European Commission Directorate-General Environment. Available at: http://ec.europa.eu/environment/chemicals/reach/publications_en.htm

- **UNEP. (2009).** *Supplemental Cost-Benefit Economic Analysis Guide.* Supplement to the UNDP Technical Guide for Integrating the Sound Management of Chemicals in MDG-Based Policies and Plans. Developed by Resource Futures International. Ottawa. Available at: http://www.chem.unep.ch/unepsaicm/mainstreaming/UNEP_UNDP_PI_CostBenefit.htm

- **UNEP Conference of the Parties of the Stockholm Convention on Persistent Organic Pollutants. (2007).** *Draft Guidance on Socio-economic Assessment for National Implementation Plan Development and Implementation under the Stockholm Convention.* http://www.pops.int/documents/meetings/cop_3/meetingdocs/inf8/INF8%20K0760927%20POPS-COP3.pdf

- **UNDP-UNEP Poverty-Environment Initiative. (2008).** *Making the Economic Case: A Primer on the Economic Arguments for Mainstreaming Poverty-Environment Linkages into National Development Planning.* http://www.unpei.org/PDF/Making-the-economic-case-primer.pdf

[87] See also: (1) European Commission, DG Environment (2008). *The Cost of Policy Inaction: The case of not meeting the 2010 biodiversity target*, Available at: http://ec.europa.eu/environment/nature/biodiversity/economics/teeb_en.htm; (2) US EPA (2000). "Guidelines for Preparing Economic Analyses", Available at http://nepis.epa.gov/; and (3) King, D. and Mazzotta, M. (2000). Ecosystem Valuation, Available at: www.ecosystemvaluation.org

- **WHO. (2009).** *WHO Guide to Identifying the Economic Consequences of Disease and Injury.* http://www.who.int/choice/publications/d_economic_impact_guide.pdf

These documents are helpful in understanding the most popular methodologies identified in this study, including: (1) DALYs); (2) VSL; (3) Cost of Illness; (4) Revealed Preferences; and (5) Stated Preferences. All of these methodologies have values as well as shortcomings that need to be carefully considered before comparing and aggregating data for meaningful and defensible global estimates of the costs of inaction on the sound management of chemicals. WHO (2009) provides the following notes on DALYs, VSL, and Cost of Illness methodologies, while UNEP (2009) provides notes on Revealed and Stated Preferences methodologies.

Disability-Adjusted Life Years (DALYs)

"DALYs are a common currency by which deaths at different ages and disability may be measured. One DALY can be thought of as one lost year of "healthy" life, and the burden of disease can be thought of as a measurement of the gap between current health status and an ideal situation where everyone lives into old age, free of disease and disability.

DALYs for a disease or injury are calculated as the sum of the years of life (YYL) lost due to premature mortality in the population and the years lost due to disability (YLD) for incident cases of the disease or injury. YLL are calculated from the number of deaths at each age multiplied by a global standard life expectancy of the age at which death occurs. YLD for a particular cause in a particular time period are estimated as follows:

YLD = number of incident cases in that period × average duration of the disease × disability weight.

The disability weight reflects the severity of the disease on a scale from 0 (perfect health) to 1 (death). The disability weights used for global burden of disease DALY estimates are listed elsewhere.

In the standard DALYs in recent WHO reports, calculations of YLD used an additional 3% time discounting and non-uniform age weights that give less weight to years lived at young and older ages. Using discounting and age weights, a death in infancy corresponds to 33 DALYs, and deaths at ages 5–20 years to around 36 DALYs (WHO 2009).[88]

There is much debate over the use of discounting, particularly where it is applied to children and the elderly, and on the choice of discount rate. This makes the calculation of DALYs difficult and direct interpretations, especially for the non-expert, very challenging and often beyond the capacity of organizations in developed as well as developing countries. As such, the Costs of Inaction report is not attempting to monetize lost livelihoods in this study.

[88] (WHO 2009). *Global health risks: mortality and burden of disease attributable to selected major risks.* Available at: www.who.int/healthinfo/global_burden_disease/GlobalHealthRisks_report_full.pdf

Value of Statistical Life (VSL)[89]

"By attaching the estimated value of a statistical life (VSL) to years lost to disease or injury, this approach evidently goes beyond purely market-based losses. However, the conceptual basis for calculating VSL remains contested, and despite its name, the 'full-income' approach still represents only a partial estimate of total lost economic welfare due to disease or injury. Accordingly, caution should be exercised when employing willingness-to-pay (WTP)-based techniques such as VSL, and resulting estimates of economic welfare loss should be reported separately from estimates of market losses (WHO 2009)."

As with lost livelihoods, the Costs of Inaction report does not attempt to monetize lives lost. For expert consideration, however, PPP adjustments of the best available estimates are made, mainly from developed countries, for application to appropriate developing countries and countries with economies in transition to reach meaningful regional and perhaps even global estimates.

Cost-of-illness

"A large proportion of economic studies in health completed to date employ some variant of the 'cost-of-illness' methodology (which combines the 'direct' costs of medical care, travel costs, etc. with the 'indirect' cost of lost production because of reduced working time). Our primary concerns with this widely-used approach are: 1) no consistent meaning can be given to the aggregate losses that are conventionally included (undefined quantity of interest); 2) no consistent meaning can be given to the counterfactual that is conventionally adopted; 3) no consideration is given to dynamic effects such as the contribution of depleted capital accumulation or human capital investment to diminished economic growth; and 4) reliance on a 'human capital' approach to valuing production losses due to ill-health or premature death is unrealistic in most settings (where a pool of underemployed or unemployed labour exists). Although computationally the most straightforward approach (a probable reason for its popularity), the critical conceptual shortcomings listed above mean that we conclude that it is an inadequate model for capturing the economic impact of disease or injury at the societal level, and do not recommend its use for that purpose. However, elements of the cost-of-illness calculus – in particular, those relating to direct costs – could still be used to address specific questions, such as the level of health consumption or expenditure for a given disease entity or injury category (not only at the aggregate level of the market economy but also at the microeconomic level of households, firms or government) (WHO 2009)."

Stated Preferences

UNEP (2009) describes, among other methods, stated preference methods, which refer to direct survey approaches to estimate the value placed on non-market goods or services. Such methods include contingent valuation, which relies on information typically obtained through asking individuals to state their WTP values for a hypothetical increase in provision of a public good (i.e. improved environmental quality) or avoidance of a public 'bad' (i.e. pollution), or in some cases, 'willingness to

[89] For more on Value of Statistical Life (VSL) analysis, see: (1) OECD. (2011). *Valuing Mortality Risk Reductions in Regulatory Analysis of Environmental, Health and Transport Policies: Policy Implications*, Available at: http://www.oecd.org/greengrowth/environmentalpolicytoolsandevaluation/mortalityriskvaluationinenvironmenthealthandtransportpolicies.htm, and (2) OECD. (2010). *Valuation of Environment-Related Health Risks for Children*, OECD Publishing. Available at: http://dx.doi.org/10.1787/9789264038042-en

accept' values for a public 'bad'. Findings from such research are often difficult to defend in policy making contexts. However, while contingent valuation "is the most controversial of the non-market valuation methods" it "is one of the only ways to assign monetary values to non-use values[90] of ecosystems that do not involve market purchases (UNEP Conference of the Parties of the Stockholm Convention on Persistent Organic Pollutants 2007).

Revealed Preferences

UNEP (2009) describes revealed preference methods, including cost of illness methods, which rely on existing market prices to reflect indirectly, or proxy, the value of non-market attributes of a good or service.

In this study, revealed preferences for environmental improvements from sound management of chemicals are witnessed in the costs of environmental cleanup, agriculture and fisheries market losses, water treatment and supply costs and air pollution mitigation costs. However, despite their significance, these market costs can only provide an underestimate of environmental values as many intrinsic values are often left uncaptured.

Economic valuation of health and environmental effects of unsound management of chemicals must be conducted rigorously and consistently, entailing significant time and resources for analysis based in scientific evidence. Consistency in data collection methodologies does not yet exist within and across efforts at the sub-national, national, and regional levels. As such, assessment, including identification of assumptions, comparability and aggregation of existing data are difficult.

In this study, most of the monetized effects reported were based on actual incurred costs, such as medical expenses, lost work days, lost market output and environmental clean-up costs. While not always forthcoming from the public and private sectors, such cost data are tangible and relatively easier to collect and compare than data from more complex methodological frameworks. As such, additional data required to fill the gaps in knowledge on the costs of inaction could cost-effectively be gathered through existing sources, while important methodological advancements continue at the academic level. Although it can only allow an underestimation of the costs to society, many of which are simply priceless, there is value in building on this type of defensible data for sound management of chemicals that impact environmental and human health.

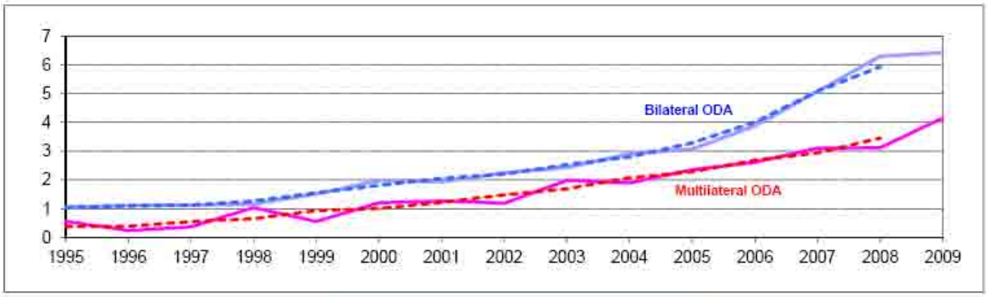
[90] Non-use values include intrinsic values such as knowing that the environment exists in its natural state.

Annex 4: ODA to Health in Africa

Health

2.3.13. Total ODA to health

USD billion, 2008 prices and exchange rates, commitments with 3 year moving averages

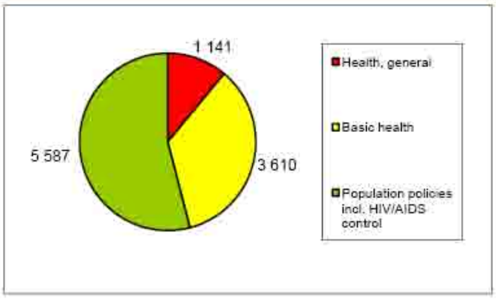


2.3.14. Top 10 recipients 2009

Top 10 donors 2009 (*commitments, USD million*)	Nigeria	Tanzania	Ethiopia	Kenya	South Africa	Malawi	Mozambique	Uganda	Congo, Dem. Rep.	Zambia	Others	Total
United States	410	281	351	523	528	56	224	283	66	227	858	**3 808**
Global Fund	471	227	215	80	-	352	12	71	78	55	872	**2 433**
IDA	276	81	81	3	-	17	45	-	-	-	106	**609**
United Kingdom	133	3	69	41	30	25	40	7	27	6	207	**590**
Canada	1	7	9	3	1	9	87	2	2	14	280	**416**
EU Institutions	-	0	-	-	-	-	-	-	71	-	236	**307**
Germany	1	37	0	4	11	10	1	2	7	2	160	**236**
GAVI	6	6	38	12	-	7	6	8	26	4	112	**225**
Denmark	-	171	1	0	0	1	6	2	-	-	8	**188**
Japan	9	5	8	8	2	3	3	3	7	7	109	**164**
Other donors	36	93	85	16	37	50	72	48	110	17	799	**1 364**
Total	1 344	912	858	691	608	531	494	426	395	332	3 748	10 339

2.3.15. ODA to health by subsector 2009

USD million, commitments



Related Millenium Development Goals

"Reduce child mortality" (Goal 4)

"Improve maternal health" (Goal 5)

"Combat HIV/AIDS, malaria and other diseases" (Goal 6)

2.3.16. ODA commitments to health

USD million

	2006	2007	2008	2009
Australia	0	2	1	15
Austria	8	8	5	7
Belgium	86	128	125	140
Canada	80	301	196	416
Denmark	121	132	29	188
Finland	30	17	13	15
France	194	71	123	76
Germany	152	119	140	236
Greece	4	4	6	4
Ireland	81	116	120	97
Italy	28	54	76	77
Japan	108	119	96	164
Korea	4	5	72	57
Luxembourg	22	28	28	26
Netherlands	318	77	336	141
New Zealand	1	1	8	-
Norway	75	97	110	57
Portugal	10	11	7	9
Spain	86	103	133	123
Sweden	148	59	72	34
Switzerland	14	30	36	22
United Kingdom	312	511	519	590
United States	1 601	2 949	4 045	3 808
DAC countries	**3 484**	**4 941**	**6 296**	**6 301**
EU institutions	241	226	256	307

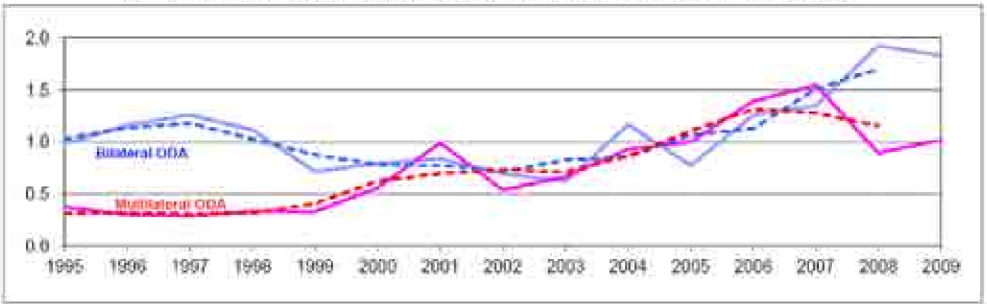
Source: OECD,2011. Development at a Glance. Statistics by Region. 2. Africa. P. 16. Available at: http://www.oecd.org/dataoecd/40/27/42139250.pdf

Annex 5: ODA to Water in Africa

Water

2.3.17. Total ODA to water

USD billion, 2008 prices and exchange rates, commitments with 3 year moving averages

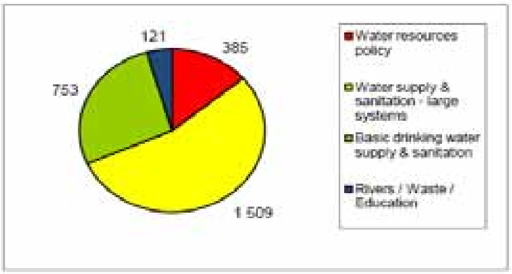


2.3.18. Top 10 recipients 2009

Top 10 donors 2009 (commitments, USD million)	Burkina Faso	Tunisia	Congo, Dem. Rep.	Kenya	Ethiopia	Senegal	Tanzania	Uganda	Mali	Morocco	Others	Total
France	3	176	-	127	1	45	-	13	20	1	134	520
EU Institutions	70	-	139	-	-	35	-	-	-	70	35	348
IDA	90	-	13	24	32	-	29	22	8	-	99	316
Germany	22	89	6	10	0	0	3	17	0	0	145	293
AfDF	-	-	-	-	-	46	-	54	-	-	185	285
United Kingdom	-	-	39	-	80	-	1	-	-	-	60	180
Japan	17	1	1	24	20	13	29	2	0	1	45	152
Denmark	84	-	-	-	-	-	-	-	64	-	3	151
United States	-	-	7	4	7	6	5	8	2	0	58	97
Netherlands	-	-	-	-	-	0	-	-	1	-	59	60
Other donors	6	0	6	11	16	9	80	8	8	23	198	367
Total	**292**	**267**	**211**	**198**	**157**	**154**	**147**	**124**	**102**	**95**	**1 023**	**2 769**

2.3.19. ODA to water by subsector 2009

USD million, commitments



Related Millenium Development Goals

"Ensure environmental sustainability" (Goal 7)

"Halve, by 2015, the proportion of people without sustainable access to safe drinking water and sanitation" (Target 10)

2.3.20. ODA commitments to water

USD million

	2006	2007	2008	2009
Australia	-	-	0	8
Austria	10	6	10	10
Belgium	62	72	73	42
Canada	4	15	32	48
Denmark	32	15	8	151
Finland	14	29	24	22
France	214	289	200	520
Germany	237	164	257	293
Greece	0	1	0	0
Ireland	15	19	23	15
Italy	5	23	94	7
Japan	133	144	181	152
Korea	2	3	3	50
Luxembourg	6	6	12	19
Netherlands	229	267	160	60
New Zealand	0	0	-	-
Norway	5	5	30	19
Portugal	1	1	0	0
Spain	16	21	58	42
Sweden	16	26	43	2
Switzerland	16	2	7	17
United Kingdom	43	41	240	180
United States	9	110	471	97
DAC countries	**1 068**	**1 258**	**1 926**	**1 755**
EU institutions	**463**	**357**	**77**	**348**

Source: OECD,2011. Development at a Glance. Statistics by Region. 2. Africa. P. 16. Available at: http://www.oecd.org/dataoecd/40/27/42139250.pdf

The Costs of Inaction work builds on the UNDP-UNEP Partnership Initiative for the Integration of the Sound Management of Chemicals into Development Planning Processes, contributes to the WHO-UNEP Health and Environment Strategic Alliance, and provides support for UNEP Guidance on the Development of Legal and Institutional Infrastructures for Sound Management of Chemicals and Measures for Recovering Costs of National Administration (LIRA-Guidance).

This document provides a practical and useful assessment of the current state of knowledge of the economic costs of inaction on the sound management of chemicals. It makes available early research findings and the evidence needed to support the argument for enhanced political action.

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