Research Report February 2008

Economic Impacts of Sanitation in Vietnam

A five-country study conducted in Cambodia, Indonesia, Lao PDR, the Philippines and Vietnam under the Economics of Sanitation Initiative (ESI)

30 years wsp water and sanitation program

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Printed in 2008.

WSP-EAP
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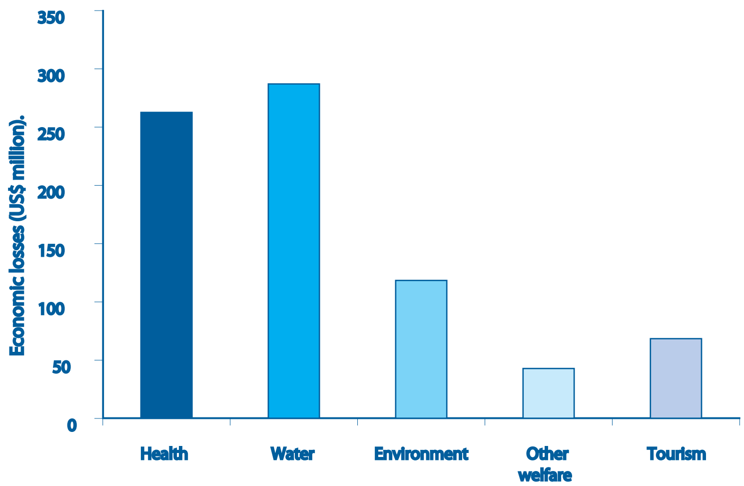
Executive Summary

Sanitation coverage in Vietnam has risen rapidly over the 14 year period 1990 to 2004: from 36% to 60%. Compared to water supply, the sanitation sector is weaker in terms of material facilities and institutions as well as management capacity. While poor sanitation and hygiene have a wide variety of negative impacts, the evidence base is weak, thus hampering the implementation of much needed investments in the sanitation sector. The urgency for such research, and not to mention investments, is only likely to grow over time. One of the reasons is that, with an average population growth of more 1.3% per annum, an additional 1 million Vietnamese will require adequate and clean sanitation facilities each year. Thus, the "Sanitation Impact" study was initiated by the World Bank to generate evidence on the impacts of the existing sanitation situation and potential improvements in sanitation and hygiene in Vietnam.

The study conducted a quantitative assessment of the impacts of poor sanitation on health, water resources, environment, tourism and other welfare indicators. The inclusion of health was based on well-established links between sanitation and disease incidence. On the other hand, water impacts were deemed important because poor sanitation is a significant cause of water pollution. This in turn leads to costly avertive behavior in response to less usable water resources. Moreover, pollution also affects the productivity of water resources by way of lower output of fisheries. Environment impact cannot be ignored since unimproved sanitation affects the quality of land, and renders it unattractive or even unusable for productive use. Other welfare impacts were included because the absence of improved sanitation affects people in terms of the time spent accessing facilities, productivity in work and school and intangible welfare impacts. Finally, tourism was included in the study because poor sanitation affects the country's attractiveness as a tourist destination.

The primary focus of this study is on human excreta, while for selected impacts other important components of domestic sanitation – gray water and solid waste – were included. In Vietnam, given that 'Sanitation' is more broadly defined in the proposal to develop a 'Unified Sanitation Sector Strategy and Action Plan' (U3SAP), some additional components of sanitation described in the strategy are included in this present study such as agricultural waste and waste water from trade villages. In measuring the impacts, the study used standard peer-reviewed methodologies. Financial and economic costs were also distinguished to improve policy interpretation of the results. For selected impacts, the analysis was conducted at the regional level and aggregated to national level.

This study has found that poor sanitation causes considerable financial and economic losses in Vietnam. Financial losses – reflecting expenditure or income losses resulting from poor sanitation are equal to roughly 0.5% of annual Gross Domestic Product (GDP), while overall population welfare losses are equal to 1.3% of GDP. The majority of economic losses are shared between health (34%), water resources (37%) and the environment (15%). The annual losses per capita equal US$9.38 or VND 150,770. The diagram below shows the annual losses by impact category.



The study estimated the economic losses of health impact to be US$262 million. Health impacts were divided into the costs of health care, productivity and premature death. The study results indicate that sanitation accounts for nearly 7 million diarrhea cases, 2.4 million cases of scabies, helminthes, hepatitis A and trachoma and 0.9 million malnutrition-related cases per annum. These diseases also cause more than 9,000 deaths per year, mostly among children. The health impacts were found to be driven mostly by the costs of premature death and treatment of disease. Of the total health economic costs of US$262 million, health care, productivity costs, and premature death are US$53 million (20%), US$4.6 million (2%) and US$204 million (78%) of the costs, respectively.

A second major impact measured in this study is the impact of poor sanitation on water resources. This study estimates the costs of poor sanitation to be more than US$287 million, including 3 sub-impacts: drinking water, domestic water uses and fisheries. The study shows that economic losses total US$197 for domestic water uses, US$27 million for fisheries and US$63 million for drinking water annually.

The impacts on the environment were divided into aesthetics and land use, but only the latter was evaluated quantitatively. The study estimated the amount of land that has been rendered temporarily unusable or unproductive for other uses for all unsanitary landfills in Vietnam as a result of unexpected buffer zones. The study estimated that more than US$118 million in the value of land is lost annually.

Other welfare impacts comprise two components evaluated quantitatively. The first - sanitation access time - includes the time it takes for users who share or do not have toilets to access a facility or suitable location. The second - life choices – includes days of females absent from school and work places due to poor sanitation. The study found that the cost of sub-optimal access to toilet facilities US$41.6 million per year, while estimates for life choices totaled US$1.3 million per annum. Other 'intangible' welfare impacts were not evaluated quantitatively, but are expected to be important, such as loss of comfort, privacy, prestige and status associated with poor sanitation facilities.

Losses to tourism were conservatively estimated to equal US$69 million annually, reflecting lower-than-optimal tourist numbers, part of which is attributed to poor sanitation.

The above impacts are related to lack of access to improved household latrines and household gray water management; for environmental impacts, the estimates include inadequate solid waste management. As a part of the expanded components of sanitation evaluated in Vietnam, water pollution from agricultural waste and trade villages were included, adding an additional US$287 million economic impacts per year. However, this figure reflects only a proportion of the total impacts of agricultural waste and waste from trade villages.

Having estimated the costs of poor sanitation, the study also evaluated the benefits associated with improved sanitation and hygiene practices. In this study, five potential improvements were examined. These are (a) better hygiene practices, (b) improved latrine physical access, (c) improved toilet system, (d) improved treatment and (e) re-use. The results indicate that improvements in treatment or disposal of waste can reduce the losses by US$355 million a year, mainly through water and tourism impacts. There is also a large benefit arising from the improved hygiene through reduced health care costs (US$228 million). The value of sanitation input and output markets are estimated at US$129 million and US$202 million, respectively.

While the benefits arising from specific sanitation options will not necessarily lead to gains which are equal to the sum of the values above, the results nonetheless suggests that the gains can be significant. Hence the different sanitation options need to be examined in terms of what impacts they have, given that single options may simultaneously have several or all of the measured benefits. Moreover, the gains are also likely to be larger when one incorporates the impacts on related markets..

The findings of this study indicate that poor sanitation has significant economic costs. Consequently, it also showed that the gains from improved sanitation can be substantial. On the basis of these findings, the study recommends the following.

First, sanitation 'players' are advised to act now, otherwise the negative impacts of poor sanitation will increase over time. The government and other stakeholders should jointly reassess the current and planned spending levels in the sanitation and related sectors, covering health, water resources, environment, rural and urban planning and development, fisheries, and tourism. Increased political importance and budget allocations should be given to sanitation. Sanitation decision makers should use an evidence-based approach to design efficient sanitation policies and implementation strategies, to increase value-for-money from public and private investments into sanitation..

Second, when financial resources are scarce, the government should give priority to the populations with no latrine, recognizing that effective demand may be low in these groups due to low incomes and poor awareness of the benefits of investing in sanitation. As well as stimulating demand through public health and latrine advocacy messages, the government should target programs, subsidies and financing mechanisms to the most disadvantaged population groups.

Third, players should broaden the scope of sanitation beyond latrines. Sanitation investments should not be made just in latrine extension programs, but in improved sludge, water and solid waste management, and in hygiene programs to raise population awareness on personal and community hygiene issues. The Unified Sanitation Sector Strategy and Action Plan is critical to boosting harmonized sanitation efforts.

Fourth, the government should focus on the easy health wins from improved sanitation, through targeting children and focusing on safe but simple latrine designs, improved excreta isolation measures, and improved hygiene practices. Given the key role of hygiene practices in health improvement, high-impact hygiene components should be integrated in the planning and implementation of sanitation programs. The Ministry of Health should (continue to) play a central role in the health aspects of sanitation programs.

To convince local decision makers such as city mayors or district officers to invest in sanitation, local studies would be more credible in convincing local decision makers that sanitation is a neglected issue and that significant improvements in population welfare can be obtained. The methodology used in this study can be equally applied to local micro-level studies as well as the national level. Furthermore, local as well as national decision makers need to be informed of the efficiency of different measures to improve sanitation. Local level cost-benefit studies inform national decision makers how to invest efficiently in sanitation.

Foreword

Vietnam, like other countries of Southeast and East Asia, is on a development path that is lifting large numbers of people out of poverty and improving access to goods and services that improve quality of life. While Vietnam has done well so far in achieving socio-economic development, some aspects of development are being forgotten in the race to economic progress. Also, the development process itself jeopardizes the quality of life of its citizens, especially vulnerable and low income groups, which in turn has unrecognized negative economic impacts.

Sanitation is one such neglected aspect of development. Among the many priorities of households as well as the government, it is often pushed down the agenda, and left as an issue to be dealt with by someone else, or not at all. Though sanitation coverage in Vietnam rose rapidly over the last 15 years, the sanitation sector is weaker than the water sector in terms of material facilities, institutions and management capacity. On current projections, the 2015 Millennium Development Goal (MDGs) sanitation target and Vietnam' own goals, the 2010 Vietnam Development Goals (VDGs), need considerable further investment to meet. Given that 'Sanitation' in Vietnam is more broadly defined in the proposal to develop a "Unified Sanitation Sector Strategy and Action Plan", boosting sanitation efforts and approaches is even more urgent.

To control and mitigate these direct impacts and externalities requires increased investment in sanitation as well as in improved knowledge, understanding and behavioral change, regulation and monitoring to maintain standards.

Hence, if all stakeholders are to be convinced that these expenditures are worth making, evidence is needed to better understand the impacts of poor sanitation now and in the future, and to detail the expected benefits from different sanitation choices.

Based on this premise, the World Bank's Water and Sanitation Program (WSP) in East Asia and the Pacific (WSP-EAP) is supporting the development of a research program "the **Economics of Sanitation Initiative"** (ESI) to generate evidence on the economic costs and benefits of different sanitation-related options. The research under this program is initially being conducted in Cambodia, Indonesia, Philippines and Vietnam.

The first major activity of the Economics of Sanitation Initiative is to conduct a 'Sanitation Impact Study', to examine the economic and social impacts of unimproved sanitation to the population and economy of Vietnam, as well as the potential benefits of improving sanitation. They will be further supported in decision making following the completion of the second study of ESI, a 'Sanitation Options Study', which will examine the cost-effectiveness and cost-benefit of alternative sanitation improvement, financing and management options in a range of settings.

While the Water and Sanitation Program has supported the development of this program, it is an 'initiative' in the broadest sense, one in which many people and institutions have become involved and have actively contributed (see 'Acknowledgements' section and Annex C for details), with a high sense of country and regional ownership.

Abbreviations

ADB	Asian Development Bank
BOD	Biochemical Oxygen Demand
CBA	Cost-Benefit Analysis
COD	Chemical Oxygen Demand
DHS	Demographic and Health Survey
DO	Dissolved Oxygen
EAP	East Asia and the Pacific
EASAN	East Asia Sanitation Conference
Ecosan	Ecological Sanitation
ESI	Economics of Sanitation Initiative
FAO	Food and Agriculture Organization
FDI	Foreign Direct Investment
FY	Financial Year
GDP	Gross Domestic Product
GNP	Gross National Product
GSO	General Statistics Office of Vietnam
HH	Household
HRQL	Health-Related Quality of Life
IPD	In-patient Day
JMP	Joint Monitoring Program (WHO, UNICEF)
Kg	Kilograms
MARD	Ministry of Agriculture and Rural Development
MDG	Millennium Development Goal
MOC	Ministry of Construction
MOH	Ministry of Health
MONRE	Ministry of Natural Resource and Environment
NGO	Non-Governmental Organization
NRWSSS	National Rural Water Supply and Sanitation Strategy
OECD	Organization of Economic Cooperation and Development
OPV	Out-patient Visit
SEAR-B	WHO Southeast Asia region epidemiological strata B
SEI	Stockholm Environment Institute
STC	Short Term Consultant
UNEP	United Nations Environment Program
UNICEF	United Nation Children's Fund
UNITAR	United Nations Institute for Training and Research
VDG	Vietnam Development Goal
VHLSS	Vietnam Household Living Standard Survey
VNHS	Vietnam National Health Survey
WB	World Bank
WHO	World Health Organization
WSS	Water Supply and Sanitation
WPR-B	WHO Western-Pacific Region epidemiological strata B
WSP	Water and Sanitation Program
WTP	Willingness To Pay

Acknowledgements

The Sanitation Impact Study was conducted in four countries: Cambodia, Indonesia, the Philippines and Vietnam. A study is ongoing in Lao PDR. The study was led by the East Asia and Pacific office of the World Bank's Water and Sanitation Program (WSP), with the contribution of WSP teams in each of the participating countries. The study took one year to complete, and has undergone two major peer review processes.

Guy Hutton (WSP-EAP Regional Senior Water and Sanitation Economist) led the development of the concept and methodology for the Economics of Sanitation Initiative, and the management and coordination of the country team. The study benefited from the continuous support of other WSP-EAP staff. Isabel Blackett was the Task Team Leader; and Jema Sy, Brian Smith, Almud Weitz and Richard Pollard provided input to the concept development and study execution. Bjorn Larsen (WSP Consultant) contributed to the study methodology and provided the figures for malnutrition-related health effects of poor sanitation.

The country team in Vietnam consisted of Pham Ngoc Thang (WSP Consultant and country lead) and Hoang Anh Tuan (WSP Consultant). WSP staff in Vietnam country office provided valuable management, technical support and peer review: Nguyen Thanh, Mike Seager, Nguyen Diem Hang and Nga Kim Nguyen.

The ESI has been financed by the regional component of the Sustainable Sanitation in East Asia (SUSEA) program, which is funded by the Swedish International Development Agency (SIDA). The Philippines study received co-funding from the USAID Environmental Cooperation-Asia (ECO-Asia) program. WSP and the report authors are grateful to the funding agencies for supporting this study.

Elena Strukova, Caroline van den Berg, Anjali Archarya, and Tracey Hart reviewed the methodology study before its implementation. Peer reviewers of the Vietnam country draft report were: Samuel Leibermann, Doan Hong Quang, Pham Khanh Toan (Ministry of Construction), Nguyen Viet Anh (University of Civil Engineering), Nguyen Kim Thai (University of Civil Engineering), Nguyen Van Thuan (Australian Agency for International Development), and John Collett (Plan International). The Vietnam study benefited from peer review conducted simultaneously on other country reports as well as the synthesis report. Peer reviewers of the synthesis draft report were (World Bank staff unless otherwise stated): Eddy Perez, Anjali Acharya, Pete Kolsky, Elena Strukova (consultant), Bjorn Larsen (consultant), and Peter Feldman (Plan International). Peer reviewers of the Cambodia country draft report were: Hilda Winarta (UNICEF), Jan Lam (SNV), Chea Samnang (Ministry of Rural Development), Ruud Corsel (Niras-Scanagri, Vietnam), and Oun Syvibola (Plan International). Peer reviewers of the Philippines country draft report were: Jema Sy and Andy Robinson (consultant).

WSP and the country team appreciate the inputs of local stakeholders from the relevant governmental authorities, donor agencies and NGOs. A complete list of key informants is given in Annex C.

Reference for citation

Economic impacts of sanitation in **Vietnam**. Thang P, Tuan H, Hutton G. World Bank, Water and Sanitation Program. 2008.

This technical report is available in shortened form from WSP offices and from http://www.wsp.org/pubs/index.asp.

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Table of Contents

List of Tables

List of Figures

List of Boxes

Table of Basic Country Data, Vietnam (latest year)

Variable	Value
Population	
Total population (millions)	84.2
Rural population (millions)	61.4
Urban population (millions)	22.8
Under 5 population (% of total)	8.85%
Under five mortality rate (per 1000)	19
Female population (% of total)	51%
Urban population (% of total)	26%
Annual population growth (2005-15)	1.0%
Population below poverty line	29%
Currency	
Currency name	Dong
Year of cost data presented	2005
Currency exchange with US$	16,080
Exchange rate year	2007
GDP per capita (US Dollar)	723
GDP per capita (PPP)	3,300
Sanitation	
% improved rural	50%
% improved urban	92%
% urban sewage connection treated	14%

1 Introduction

1.1 Human development and sanitation

Pollution caused by human activity is not a new issue or problem – it has been around as long as man himself. However, as human populations have become more concentrated and located in vulnerable land or coastal areas, the ability of man to pollute has increased substantially. A major cause of pollution is due to waste products, including waste from human living activities, industrial and agricultural waste.

Like other Asian countries, Vietnam faces severe population pressures, with high population density, especially in coastal areas. Environmental concerns and economic development are not aligned towards sustainable growth. Of 122 countries evaluated for environmental sustainability, Vietnam ranked at 114^{th,} and with respect to environmental systems[1], Vietnam ranked at 108th [1]. Vietnam along with other Southeast Asian countries is reported to have the worst water pollution, with "very severe" ranking for fecal coliforms, biochemical oxygen demand and lead, and severe for suspended solids [2]. The quality of water bodies is being increasing polluted as a result of economic development and lack of proper disposal or treatment of sewage and wastewater, and many rivers reaching severe levels of water pollution [3]. Water pollution and water-borne diseases remain key issues in Vietnam, with inadequate water supply and sanitation listed as major causes. Indeed, severe disease and premature mortality are some of the most direct and devastating impacts of poor sanitation and hygiene, with the poor, children and women affected disproportionately.

1.2 Sanitation in Vietnam

Unarguably, sanitation is lagging behind other global development goals. In 2004, 59% of the world's population had access to improved sanitation, which represents a 10% increase from 49% global coverage in 1990. However, due to population growth, the unserved global population has decreased only marginally from 2.7 to 2.6 billion over a 14 year time period [4]. Official sanitation coverage data from the WHO/UNICEF Joint Monitoring Program (JMP) are tabulated below for Southeast Asian countries, and for other world regions, comparing the MDG base year (1990) with the most recent coverage data (2004). Annex Table D1 provides JMP definitions of improved and unimproved water and sanitation.

Based on JMP statistics for 2004 Vietnam has the best access statistics for urban sanitation of all the lower income countries in the region, although this does not reflect adequate treatment and disposal of wastes. All the middle and high income countries in the region, such as Singapore, Thailand and Malaysia, have higher coverage figures. Despite an impressive growth in sanitation coverage of more than 60% since 1990, only 50% of rural households have access to improved sanitation in the year 2004.

1 5 indicators: air quality, water quantity, water quality, biodiversity and terrestrial systems

Table 1. Improved sanitation coverage statistics for Southeast Asian countries versus other developing world regions (%)

Country	*Rural*		*Urban*		*Total*	
	1990	2004	1990	2004	1990	2004
SOUTHEAST ASIA						
Cambodia	-	8	-	53	-	17
Indonesia	37	40	65	73	46	55
Laos	-	20	-	67	-	30
Malaysia	-	93	95	95	-	94
Myanmar	16	72	48	88	24	77
Philippines	48	59	66	80	57	72
Singapore	-	-	100	100	100	100
Thailand	74	99	95	98	80	99
Timor-Leste	-	30	-	66	-	33
Vietnam	30	50	58	92	36	61
TOTAL	**40**	**56**	**70**	**81**	**49**	**67**
OTHER REGIONS						
East Asia	7	28	64	69	24	45
South Asia	8	27	54	63	20	38
West Asia	55	59	97	96	81	84
Oceania	46	43	80	81	54	53
Latin America & Caribbean	36	49	81	86	68	77
North Africa	47	62	84	91	65	77
Sub-Saharan Africa	24	28	52	53	32	37
CIS	63	67	92	92	82	83

Source: http://www.wssinfo.org/

Table 2 presents data in chronological order from four major national surveys in Vietnam (Demographic & Health Survey, Vietnam National Health Survey, Vietnam Household Living Standard Survey, and World Health Survey), compared with JMP statistics for 2002 and 2004.

According to GSO VHLSS [5], urban and rural access to and sanitation in 2004 is 89% and 50%, respectively, with overall access of 61%. However other studies indicate lower levels of access. For example, the Vietnam MDG Report from 2004 shows figures for urban and rural sanitation at 68% and 11.5%, respectively, with overall access of 25%. WHO-UNICEF Joint Monitoring Program (JMP) shows that urban and rural access to sanitation in 2002 is 84% and 26%, respectively [6]. It is important to note the difference in the definition of improved sanitation between internationally-cited JMP statistics (see Annex Table D1) and national statistics. The JMP defines improved sanitation as the proportion of the population that has access to house connections (sewers), septic tanks, and improved pit latrines. According to JMP, unimproved sanitation includes public toilets, pit latrines, open defecation and other facilities, while the Vietnam General Statistics Office (GSO) classifies different types of toilet facility, but without distinguishing between improved and unimproved [5].

Table 2. Comparison of sanitation types and coverage values (%) measured in different national surveys in Vietnam

Survey	Improved sanitation (%)			Unimproved sanitation (%)			
	House sewer connection, Septic tank (Flush/ pour-flush)	Ventilated improved pit latrine, pit latrine with slab, composting toilet	Total	Public or shared toilet, Pit latrine without slab	Open (No facilities)	Other	Total
Demographic & Health Survey 1997							
Rural	6.0	9.4	15.4	58.4	26.2	na	84.6
Urban	67.4	7.3	74.7	16.9	8.3	na	25.2
Total	17.7	9.0	26.7	50.5	22.8	na	73.3
Vietnam National Health Survey 2001 - 2002							
Rural	13.8	15.1	28.9	48.3	21.3	1.5	71.1
Urban	70.8	8.2	79	12.4	8.2	0.4	21
Total	28.4	13.3	41.7	39.1	18.0	1.2	58.3
Joint Monitoring Program 2002							
Rural	na	na	26.0	na	na	na	74.0
Urban	na	na	84.0	na	na	na	16.0
Total	na	na	na	na	na	na	na
Vietnam Household Living Standard Survey 2002							
Rural	14.3	29.8	44.1	na	18.5	37.4	55.9
Urban	73.5	11.5	85.0	na	4.9	10.1	15.0
Total	30.2	24.9	55.1	na	14.8	30.1	44.9
Vietnam Household Living Standard Survey 2004							
Rural	20.5	29.5	50.0	na	16.3	33.7	50.0
Urban	80.8	8.8	89.6	na	3.2	7.2	10.4
Total	37.2	23.8	61.0	na	12.6	26.4	39.0
Joint Monitoring Program 2004							
Rural	na	na	50.0	na	na	na	50.0
Urban	na	na	92.0	na	na	na	18.0
Total	na	na	61.0	na	na	na	39.0

na – not available

In addition, there are considerable disparities in sanitation coverage between different regions. In general, sanitation coverage in the North West, the Central Highlands and the Mekong River Delta are much lower than in the rest of the country. The coverage in those regions is 22.8%, 42.9% and 31.4% respectively. Annex Table D2 provides further information on sanitation coverage in different regions of Vietnam.

In terms of other aspects of sanitation, there are fewer data available. One aspect where there are data, solid waste management, indicates relatively poor sanitation levels in Vietnam. Only 60% of solid waste from urban areas and industrial zones is collected and disposed of in dumpsites, and only 12 out of 61 cities and provincial capitals have engineered or sanitary landfills [7]. Data on solid waste disposal practices of households reveal only 22% of households have their solid waste collected by garbage truck, with over 50% of households burning their rubbish, 20% burying it, and 13% throwing into a river [8].

Table 3. Solid waste disposal practices of household by urban and rural areas (%)

Location	Garbage truck	Burning	Burying	Throwing to river	Throwing to animal closure	Other
Rural	6.8	63.0	23.0	15.0	16.7	18.9
Urban	71.0	20.0	7.5	6.3	4.1	2.8
Total	**21.9**	**52.9**	**19.4**	**12.9**	**13.7**	**15.1**

Source: [8]

The coverage of sewerage and drainage services in urban areas is estimated to be about 40-50% (from 0% in some small towns to 70% in some big cities) [9]. In addition, agricultural waste is also a growing problem. Agricultural chemicals are used by a high proportion of farners, covering large areas of land. As a result, many contaminants from agricultural land (mud, alum, fertilizer, pesticide, etc.) have been carried to water sources.

During the last decade, the Government and the donor community have focused mainly on improving access to water supply. The sanitation sector has been given greater attention in recent years due to the fact that wastewater and solid waste are becoming urgent issues in urban areas, industrial zones, and trade villages as a result of urbanization and industrialization processes. In general, in comparison with water supply, the sanitation sector is weaker in terms of material facilities and institutional support, as well as institutional implementation capacity. Current trends shows that it remains difficult to meet the sanitation MDG sanitation target in Vietnam, and the development goals of the Vietnam government (VDGs) [9].

In addition to excreta, urban areas and industrial zones in Vietnam generate some 20,000 tons of solid waste every day of which only 60% is collected and disposed of. In big cities, the problem related to the landfills – which are often little more than open dumping ground – also needs to be urgently and properly dealt with to avoid protests raised by the local residents.

There are about 1,450 cottage/trade villages in Vietnam, which are concentrated in Red River Delta (67.3%), central area (20.5%) and southern area (12.2%) [10]. Vietnamese trade villages can be divided into: agricultural product processing villages, weaving and dying villages, fine arts and craft villages, recycling villages, construction material villages and other professional villages. These cottage villages generate a substantial amount of solid waste from their production activities. Annex Table D13 provides further information on numbers of cottage villages in Vietnam.

According to current estimates, the government targets for service provision by 2010, which reflect the MDGs on water supply and sanitation, will require investment in the order of US$8.8 billion [6]. Sanitation requires US$4.2 of this total, US$3.8 billion in urban areas and US$0.4 billion in rural areas. If the budget contribution to urban water supply and sanitation remains at the level of the last 10 years, this source will be able to finance only about 4% of urban needs during 2004-2010. With respect to rural water supply and sanitation, according to the NRWSSS, users are responsible for all the investment and operation and maintenance costs of the rural water supply and sanitation facilities, with government grants supporting only the poor. With the current mix of overseas development aid and government funds, around 25% of urban and rural needs can be funded.

The reasons for public underinvestment in sanitation in Vietnam are many, and include the low political profile of sanitation in terms of government prioritization and funding, limited tax revenue, the lack of recognition of the many costs to society of poor sanitation, and a higher demand for investments in domestic water supply. As well as lack of top-down investment in the sector, the opportunities for attracting private sector engagement in the financing and provision of sanitation services are not sufficiently enabled, especially the potential for contribution by small-scale entrepreneurs. To date, most sanitation investment has been by household self-provision. Sanitation in Vietnam is predominantly a private good with the majority of households investing in septic tanks or latrines. The financing source in rural areas has been predominantly community and household contributions, whereas public investment is mainly in the big cities.

As a result, this sanitation impact study is important for a number of reasons. First, this is the first attempt to measure the real impacts of poor sanitation in Vietnam. Second, the results of the study can be used to raise the awareness of all stakeholders, including government, private sector and donor agencies with regards to the urgency of boosting sanitation efforts and approaches. Finally, this study will hopefully stimulate further research in the area.

1.3 Measuring the economic impact of sanitation

Until now, many of the consequences of poor sanitation are understood at a general level, but few impact-specific and location-specific data exists to support assertions that poor sanitation imposes a considerable burden on society. Without such information, policy makers are unable to act. Furthermore, while some impacts of sanitation are now better understood, such as health impacts, many of the stakeholders that need to become convinced of the importance of sanitation are not directly concerned with health. Hence a range of potential impacts need to be examined and presented so that stakeholders see the multiple negative impacts of sanitation, and thus become convinced that concerted action is needed from several sectors. This sub-section seeks to briefly elaborate some of the economic impacts associated with poor sanitation, and on the other side of the coin, some economic benefits associated with improved sanitation.

1. Population health

One of the major arguments commonly used for improving sanitation is reduction in disease incidence, and the various health-related benefits. There are many diseases associated with poor sanitation and hygiene practices, among them diarrhea, dysentery, cholera, salmonellosis, shigellosis, typhoid fever, hepatitis A, trachoma, and some parasitic diseases (ascariasis, trichuriasis, hookworm, schistosomiasis). Disease and poverty are linked in a vicious circle, and hence disease reduction can lift populations out of poverty, or prevent them from falling into poverty [11]. Less disease means less treatment seeking costs as well as a gain in healthy time, leading to more time for productive or leisure activities, which have a direct welfare impact [12, 13]. When productive time gained leads to a net increase in economic activities, it can contribute to economic growth and poverty reduction. Disease reduction also leads to savings for society, such as health care and other state benefits for chronic sufferers.

2. Water resources

The 2003 United Nations Report "Water for people, Water for life" states that many rivers, lakes and groundwater resources are becoming increasingly polluted, and that human waste is one of the most frequent sources of pollution [14]. In Southeast Asian countries, a significant proportion of human waste is flushed directly into water resources due to low coverage of sewage treatment for piped sewerage, or else human waste eventually finds its way into water resources through open defecation, leaking septic tanks or seepage from pit latrines. As a result, levels of suspended solids in rivers in Asia have risen by a factor of four over the last three decades and Asian rivers have a higher biological oxygen demand and bacterial content than the global average [14]. The results of polluted water on human activity are many: previously safe drinking water sources are rendered unusable, and water becomes less productive or usable for agricultural uses including fish production, for industrial as well as for domestic uses. According to the Asian Development Bank, the threat to fish production is especially important, given the economic importance, subsistence value as well as nutritional value of fish in the Southeast Asian region.

3. Environment

The release of human waste into the environment has other effects besides water pollution, given the smells emanating from feces and urine, the widespread wish to avoid it, and the associated degradation of land where human waste accumulates. As well as human waste as a source of pollution, another major source of environmental pollution is that of solid waste. The use of open land as a public toilet and open garbage dump affects the quality of land, and renders it unattractive or even unusable for productive use. Even in East Asian countries where municipalities are responsible for collecting solid waste, solid waste collection is not commonly done, or inadequately done. Households and often the commercial sector respond by managing waste disposal themselves, and thus solid waste is commonly disposed of in the street or in other unofficial dumping grounds which are not managed properly.

This presents a threat to those disposing of waste as well as those living in the vicinity of the dumping area. Waste grounds are inhabited by stray dogs, rats or other animals, which are diseased and pose a threat to human health. Even where there is a private or public agency taking care of disposal, it is often not performed according to plan. In cities, waste carts stay on the streets for many days, with resulting smell and unsightliness for local inhabitants and tourists.

4. User preferences

Lack of or poor sanitation facilities has implications for access time and convenience related to toilet-going, which have a number of direct as well as indirect welfare effects. Intangible welfare effects related to the comfort and privacy of having a private and clean place to meet toilet needs is an often underrated negative impact of unimproved sanitation. Also, closer sanitation facilities in the home or compound leads to time savings for those who previously regularly accessed public latrines or an isolated spot in the open field or bush [15]. Time savings can be used for other productive or leisure activities, and thus have an economic value. Furthermore, the presence of improved sanitation facilities in educational establishments has shown to affect the rate of school attendance, especially for girls [16]. This effect may also be present in workplaces, where women's ability to participate in the labor force is reduced due to poor conditions of toilets and no separate female toilet options.

5. Earnings from tourism and foreign direct investment

Tourists are sensitive to their environment, and are less likely to choose destinations which are dirty or where the risk of disease is high. Countries may be losing tourist revenues due to the degraded environment and high infectious disease rates among the general population, as well as actual or perceived health risks to tourists. Hence any initiative to attract more tourists to a country will need to consider the part sanitation plays in this [17-19]. Likewise, foreign companies may also take into account the general environmental conditions and health of the local workforce in making location decisions.

6. Opportunities for use of outputs of sanitation

Where human waste is used as fertilizer and soil conditioner, the availability of nutrients from human excreta can lead to the replacement of chemical fertilizer, which saves costs. Furthermore, where fertilizer was not being used optimally before, the nutritional content and economic value of crops may increase. Also, there are long-term benefits of reducing the use of chemical and mineral fertilizers, especially taking into account the fact that some fossil resources are in increasingly short supply (e.g. phosphorous). Alternatively, families with livestock may instead invest in a biogas reactor, which provides biofuel for cooking, space heating and can even be used for lighting where other improved sources (electricity) are not available.

7. Stimulus to the local economy of sanitation input markets

Given the needs of sanitation programs for human labor and materials, sanitation programs will have a number of economic effects at local level. Economic impacts – revenue, employment and profit – and with effects up the supply chain, will be for small local entrepreneurs as well as larger, non-local companies. There is also a potential for improving livelihoods of poor people, largely through health improvement and employment generation [20].

8. Macroeconomic effect and overall economic growth

Economic growth results from the combination of many of the benefits listed above. The main effects are likely to be through lower disease rates, increased time availability, easier access to and reduced treatment of suitable water sources for domestic, agricultural and industrial use, and more tourism and foreign direct investment. The production and sale of sanitation options can also give a stimulus to the local economy through local employment; and re-use of human (and animal waste) can lead to cost savings and higher productivity at household level. Property prices also may rise due to better living standards brought by improved sanitation. However, the overall effects on the economy such as GDP growth are highly uncertain.

1.4 Study aims

The **goal** of the Economics of Sanitation Initiative (ESI) is to provide decision makers in Vietnam with evidence for making more informed decisions on sanitation. The **target audience** is primarily national level policy makers with influence the overall allocation of resources to sanitation, including central ministries (Ministry of Planning and Investment, Ministry of Finance), line ministries (MOC, MARD, MONRE, MOH) and external funding and technical partners (multilateral, bilateral and non-government agencies). The study disaggregates impacts by regional groupings for Vietnam, as well as providing a rural-urban breakdown. However, to inform local decisions, further studies are needed that disaggregate at provincial, city, and district levels, and below.

ESI is organized into two main overlapping studies:

1. 'Sanitation Impact' study.
2. 'Sanitation Options' study

The primary aim of the current **'Sanitation Impact'** study is to generate evidence on the negative impacts of existing sanitation coverage levels and hygiene practices at national level for five countries: Cambodia, Indonesia, Lao PDR, Philippines and Vietnam. The study uses information collected from government and donor statistics and reports, and from the scientific literature, to present a selected range of impacts associated with poor sanitation and hygiene. Results are presented at national level as well as sub-national level for the most recent year for which complete data are available, being 2005. Costs are distinguished according to whether they are financial or economic, and are disaggregated by different impacts and key population groups such as children and women. Separate reports and policy briefs have been produced for each country (www.wsp.org/pubs/index.asp).

Once the Sanitation Impact study is published and disseminated, and the results discussed among sector partners, they will need to know exactly *how* to act. Decision makers will need to know which sanitation improvements provide the best value for money, what the overall costs and benefits are, and who is willing or able to finance the improvements. Hence a second **'Sanitation Options'** study is planned to measure and compare the different costs and benefits of alternative sanitation options, and present them in different forms to promote and enable rational decision making by a range of actors (e.g. national and local governments, donors, private companies, NGOs, communities, and households). This second study will select specific contexts where sanitation improvements are being made, and measure the specific costs and benefits in each context where the study is conducted of a range of relevant water and sanitation improvements.

2 Study Methodology Overview

The five country Sanitation Impact studies all followed a standardized peer reviewed methodology [21]. Differences in the quality and level of detail of data in the five countries required adaptations to the methodology to arrive at the same output data on economic impacts. However, the findings of the five country studies are still largely comparable [22].

This section describes:

1. The levels and units of analysis (2.1).
2. Which aspects of 'sanitation' are included in this study (2.2).
3. How impacts are classified and which are included and excluded in the study (2.3).
4. An overview of how the different economic impacts of unimproved sanitation are measured (2.4).
5. The methods used for predicting the economic benefits associated with improved sanitation ('Impact mitigation') (2.5).

Annex A describes the detailed methods for estimating the economic impacts of unimproved sanitation, and how methodological weaknesses and uncertainty in input variables are evaluated in sensitivity analysis.

2.1 Levels and units of analysis

The primary aim of this study is to describe and quantify sanitation impacts at national level, in order to inform policy makers about the overall negative impacts of poor sanitation and the potential benefits of implementing different types of sanitation improvement. The ultimate usefulness of these overall economic impacts of poor sanitation is to serve as the basis for estimation of what impacts can be mitigated from improving sanitation. It is key to note in the interpretation of the results of this study that the gains from improving sanitation will be less than the losses from unimproved sanitation, given that (a) sanitation interventions do not have 100% effectiveness to reduce adverse health outcomes associated with poor sanitation, (b) poor sanitation is one of many causes of water and environmental pollution.

The aim of the study is to present impacts in disaggregated form, to aid interpretation and eventually policy recommendations. Geographical disaggregation of results is presented for some types of economic impact at the regional level. Rural/urban disaggregations are made for impacts where feasible. Furthermore, health impacts are disaggregated by age groups for selected diseases and descriptive gender analyses are conducted for selected impacts.

The study uses a modeling approach and draws almost exclusively on secondary sources of data. The study presents impacts in terms of both physical units, and converts these to monetary equivalents using conventional economic valuation techniques. Results on economic impact are presented for a single year – the latest available data were for 2005 for most variables, while for some variables 2006 was the latest year. Overall impacts are presented in terms of per capita impacts in United States Dollars. Results are also presented in international dollars[2] (I$) to enable cross country comparisons of the *relative* impact of poor sanitation. For those impacts where quantification in economic terms is not feasible using secondary data sources, the impacts are examined and reported descriptively.

Table 4 below shows the population size and provincial make-up of each region of Vietnam. It indicates that about 73% of the population in Vietnam is concentrated in rural areas. The urbanization rate of Vietnam is lower than that in other South East Asian countries, but still equates to approximately 1 million people officially recognized as moving to urban areas each year.

2 International dollars (I$) take into account the different value of the United States Dollar in each country, by comparing the price of a pre-defined bundle of goods in each country to a reference country, the United States.

Table 4. Population size and provincial make-up of regions in Vietnam (year 2005)

Region	Population size			Provinces contained
	Urban	Rural	Total	
Red River Delta	4,484	13,555	18,039	Hanoi; Vinh Phuc; Bac Ninh; Ha Tay; Hai Duong; Hai Phong; Hung Yen; Thai Binh; Ha Nam; Nam Dinh; Ninh Binh
North East	1,768	7,590	9,358	Ha Giang; Cao Bang; Bac Kan; Tuyen Quang; Lao Cai; Yen Bai; Thai Nguyen; Lang Son; Quang Ninh; Bac Giang; Phu Tho
North West	357	2,208	2,566	Dien Bien; Lai Chau; Son La; Hoa Binh
North Central Coast	1,455	9,165	10,620	Thanh Hoa; Nghe An; Ha Tinh; Quang Binh; Quang Tri; Thua Thien - Hue
South Central Coast	2,123	4,927	7,050	Da Nang; Quang Nam; Quang Ngai; Binh Dinh; Phu Yen; Khanh Hoa
Central Highlands	1,337	3,422	4,759	Kon Tum; Gia Lai; Dak Lak; Dak Nong; Lam Dong
South East	7,328	6,132	13,460	Ninh Thuan; Binh Thuan; Binh Phuoc; Tay Ninh; Binh Duong; Dong Nai; Ba Ria - Vung Tau; Ho Chi Minh city
Mekong River Delta	3,566	13,701	17,268	Long An; Tien Giang; Ben Tre; Tra Vinh; Vinh Long; Dong Thap; An Giang; Kien Giang; Can Tho; Hau Giang; Soc Trang; Bac Lieu; Ca Mau
Total	**22,418**	**60,701**	**83,120**	**64 provinces**

Source: [23]

2.2 Scope of sanitation

In conducting an impact study of poor sanitation, it should be clear what aspects of sanitation are being assessed given that 'sanitation' has relevance for many aspects of life. Furthermore, what actually constitutes *improved* sanitation will vary across countries and cultural contexts. In the international arena, the sanitation target adopted as part of the Millennium Development Goals focuses on the disposal of human waste, thus leading to a narrower understanding of the term 'sanitation'. However, this present study recognizes that other aspects of sanitation are relevant to the impacts being measured in the present study, especially in Vietnam, where a broader definition is gaining ground. Hence, while the primary focus of this study is on human waste aspects, other important components of domestic sanitation – gray water and solid waste - have been included. For some impacts, the implications of animal waste and other agricultural waste and waste of small scale cottage industry are also evaluated. In addition, the health implications of poor hygiene as they relate to human waste are assessed. In Vietnam, 'Sanitation' is more broadly defined in the proposal to develop a "Unified Sanitation Sector Strategy and Action Plan", with preliminary support from all major stakeholders in the sector. Therefore, in addition to the standardized components for the five-country study, some additional components of sanitation described in the strategy are included for the first phase of this present study: (1) agricultural waste and (2) trade villages. Agricultural waste includes animal waste, crop waste, and fertilizer. Pesticides, an important part of agricultural wastes and a cause of major negative health impacts like cancer, will be analyzed in later stages.

While it is understood that sanitation in Vietnam is more often even more broadly defined than the components listed above, it was not possible to apply a comprehensive definition in this present study due to time and resource constraints. Hence, issues such as storm water and drainage, flood control measures, hospital waste, large-scale industrial waste, and broader environmental health such as food hygiene, air pollution and vector control, were not included. Table 5 summarizes the aspects of sanitation included and excluded from this study.

Table 5. Aspects of sanitation included in the present 'Sanitation Impact' study

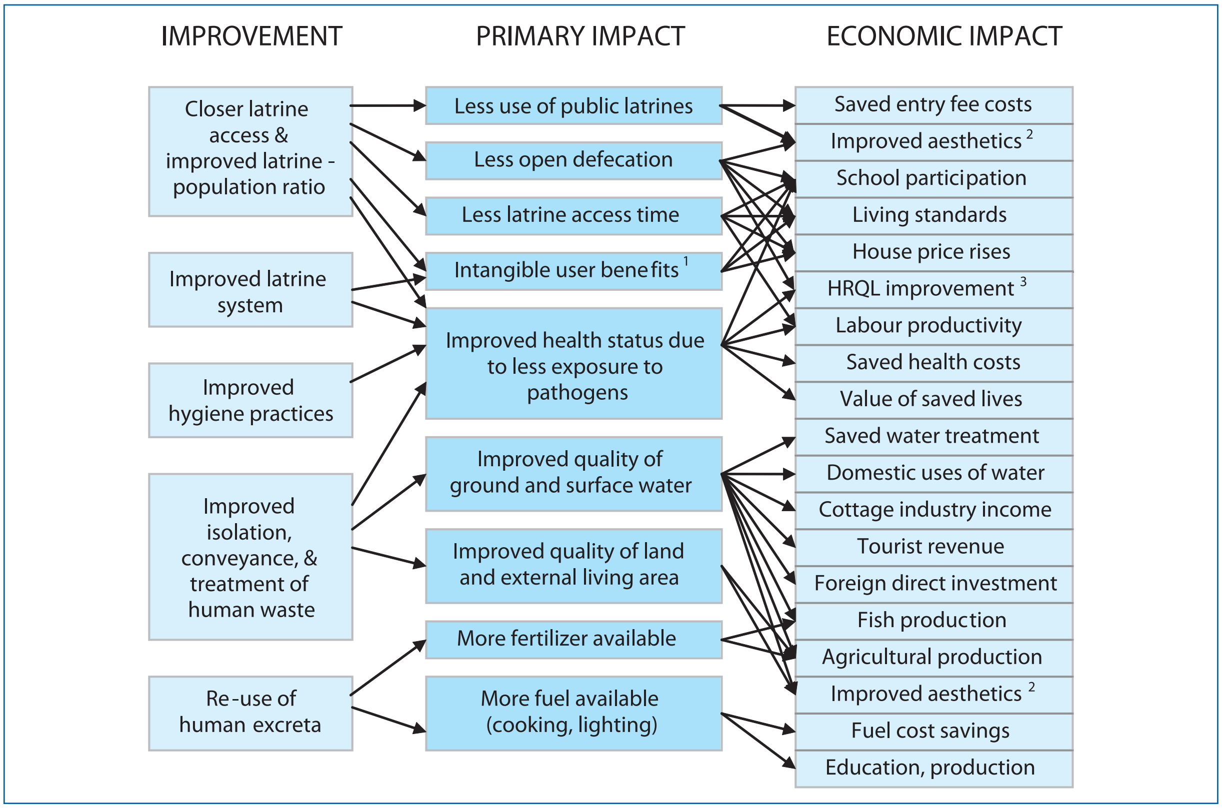
Included	Excluded

• Practices related to human excreta:
  • Quality, safety and proximity of latrine system
  • Disposal or treatment of excreta and impact on the (inhabited) outdoor environment
  • Hygiene practices
• Practices related to disposal or treatment of gray water
• Practices related to disposal or treatment of household solid waste
• Practices related to use or disposal of animal excreta
• Practices related to use or disposal of agricultural waste
	• General flood control measures
	• Large-scale industrial effluents, toxic waste and medical waste
	• Air pollution unrelated to human excreta
	• Vector control
	• Broader food safety

2.3 Impact identification and classification

Poor sanitation has many actual or potential adverse effects on populations as well as national economies. Conversely, measures for improving sanitation mitigate those negative impacts, hence stimulating economic growth and reducing poverty. Several impacts were introduced briefly in Chapter 1. Figure 1 presents a range of possible impacts of sanitation, as they relate to five key aspects of human excreta management: latrine access, latrine system, hygiene practices, waste disposal, and waste re-use. The major links are shown with arrows.

Figure 1. Primary and economic impacts associated with improved sanitation options (human excreta)



[1] For example: comfort, convenience, security, privacy
[2] For example: visual effects and smells
[3] HRQL: health-related quality of life

Based on the exhaustive set of impacts shown in Figure 1, a shortened list of negative impacts of poor sanitation to be included in the present study was selected, shown in Table 6. These impacts are classified under five main categories: health impacts, water resource impacts, environmental impacts, user preference impacts, and tourism impacts. Table 6 also provides further justification for inclusion of these impacts in the study, showing the presumptions based on preliminary evidence of importance [24] and discussion with country partners. Annex A provides further background on these impact categories.

Table 6. Justification for choice of impacts included in the study

Impact	Link with sanitation	Justification for inclusion in the present study
Health	- Poor sanitation and hygiene cause diseases, which lead to a range of direct and indirect economic effects	- Scientific evidence is available on the causal pathways between unimproved sanitation/hygiene and the causative disease pathogens/hosts - Health information systems, household surveys and economic studies testify to the diseases suffered by the population and the associated costs of disease
Water	- Released human and animal excreta pollutes water resources which affects its usability or productivity and leads to costly averting behavior and/or production impact	- Unregulated sewage release into water bodies is a proven significant contributor to inland (and marine) water resource pollution - Water is treated or purchased by households, and undergoes costly treatment by piped water providers for domestic and commercial purposes - Households hauling water themselves travel further to access a cleaner, safer water supply - Fish are unable to reproduce and survive in heavily polluted water. At lower levels of pollution, fish numbers are affected by oxygen depletion and micro-bacteria - Humans are affected when they eat fish that have been exposed to raw sewage
External environment	- Neighborhoods with poorly managed sanit-ation are less pleasant to live in, and population welfare is thus affected	- Land and building prices are highly sensitive to environmental factors - Poor people tend to live on marginal land - As income rises, households are willing to pay more for better sanitation services
User preferences	- Poor sanitation results from cultural barriers, low awareness, lack of design options, low income, and lack of home ownership - Poor sanitation in institutions affect life choices, or lead to absenteeism at school or the workplace	- Household members have to spend time accessing toilet in the open (nature) or queuing to use shared or public facilities - Privacy and convenience are underestimated 'intangible' aspects in sanitation choices - There exists an income gradient in latrine ownership - Sanitation is more important to people who lack voice in household or community decisions – women and children
Tourism	- Poor sanitation affects the attractiveness of tourist destinations and tourist arrivals; and can lead to holiday sickness	- Tourism is an important source of national income and employment, offering high returns on investment - The most popular tourist destinations have clean environments, good toilet facilities, and a lower risk of getting sick

Based on available evidence, the major anticipated impacts of poor sanitation were on health and water resources, and therefore greater focus was given on data collection for these impacts. Hypothesized economic impacts such as saving entry fee which is related to public toilet users, house price rises due to improved sanitation, and foreign direct investment were not examined in this present study, either due to anticipated low importance or data limitations.

Table 7 details the sub-impacts examined under health, water resources, external environment, user preferences and tourism. The columns indicate the five key components of sanitation assessed (refer to Table 6) for the different impacts. Human excreta management is relevant for all impact areas. Poor hygiene mainly affects health. Gray water and animal excreta mainly affect water resources. Solid waste mainly affects mainly health, water resources, the external environment and tourism (not all of these are evaluated due to lack of data). Also, potential impacts of improved sanitation – the stimulation of local markets for sanitation inputs (labor, materials) and the reuse of waste for productive purposes – are also included in Table 7. In Vietnam, additionally storm water, agricultural waste and waste from small commercial enterprises were assessed for their impact on water resources only.

Table 7. Categorization of impacts measured in the present study [1, 2]

Impact	Sub-impacts	Human waste	Hygiene practices	Gray water	Solid waste	Storm water	Animal and agricultural waste
1. Health	Health status	√	√				
	Disease treatment cost	√	√				
	Productive time lost	√	√				
	Premature death	√	√				
2. Water resources	Water quality	√		√		√	√
	Drinking water	√		√		√	√
	Fish production	√		√		√	√
	Domestic uses of water	√		√		√	√
3. External environment	Aesthetics	√			√		
	Land use and quality	√			√		
4. User preferences	Intangible aspects	√					
	Time for toilet access	√					
	Life choices	√					
5. Tourism	Tourist numbers	√	√		√		
	Tourist sickness	√	√				

[1] A tick shows which impacts were measured in this study. The absence of tick does not indicate that no empirical relationship is anticipated; only that it was not evaluated in this study.

[2] The broader definition of sanitation in Vietnam was excluded here, but the additional components – storm water, agricultural waste and small-scale industry – have implications mainly for water resources.

2.4 Estimation methods for financial and economic costs of poor sanitation

Policy makers are interested to understand the nature of the economic impacts being measured. For example, do the impacts have immediate implications for expenditure and incomes by households or governments, or are the effects non-pecuniary or longer-term in nature? The answer will naturally affect how the results are interpreted, and what level of support there will be for impact mitigation measures. Hence, while recognizing the difficulties in distinguishing different types of economic impact, this present study attempts to distinguish broadly between two different types of impact – financial and economic:

- Under **financial** costs, those costs which are most likely to affect quantified indicators of economic activity in the short term were included. Financial costs include changes in household and government spending as well as impacts likely to have real income losses for households (e.g. health-related time loss with impact on household income) or enterprises (e.g. fishery loss). It should be noted that, while these 'financial' costs affect economic activity indicators in the short term, these impacts are not expected to directly affect Gross Domestic Product, due to substitution effect, transfer payments, and so on.

- Under **economic** costs, other costs were added to the above financial costs to approximate the overall population welfare impact of poor sanitation. These include the longer-term financial impacts (e.g. less educated children, loss of working people due to premature death, loss of usable land, long-term tourist losses), as well as non-financial implications (value of loss of life, time use of adults and children, intangible impacts).

Table 8 describes which cost components were included for financial and economic definitions of cost for each sub-impact. It should be noted that costs were those attributed to poor sanitation using an attribution factor (variable by impact). Some costs were non-quantified, as indicated in Table 12. The detailed methods of impact estimation are described in Annex A.

Table 8. Financial and economic costs due to poor sanitation measured in the present study

Impact category	Sub-impacts evaluated	Financial costs attributable to poor sanitation	Economic costs attributable to poor sanitation
1. Health	Health care costs	Marginal health seeking costs, including patient transport, medication cost in public sector, and private sector tariffs	Full costs of health seeking, including full health care and patient transport costs
	Productivity costs	Income loss due to lost adult working days due to sickness	Welfare loss due to adult and child sickness time
	Premature mortality	Short-term household income loss due to adult death (1 year)	Discounted lifetime income losses for adult & child death
2. Water resources	Drinking water costs	Financial costs of water treatment and distribution	*Financial* + Time spent hauling water from safe water sources
	Domestic water uses	Additional expenditure sourcing water from non-polluted sources	*Financial* + Time spent hauling water from less polluted sources
	Fish losses	Lost sales value due to reduction in fish catch	Lost sales value due to reduction in fish catch
3. External environment	Land quality	-	Economic value of land made unusable by poor sanitation
4. User preferences	Time loss	-	Welfare loss due to adult & child latrine travel/waiting time
	Work/school absence	-	Temporary absence of women from work and girls from school
5. Tourism	Tourism costs	-	Revenue loss from low occupancy rates and failure to exploit long term potential tourist capacity

2.5 Impact mitigation

Having estimated the financial and economic costs of poor sanitation, from a policy viewpoint it is important to know by how much these costs can be reduced by implementing improved sanitation options. Indeed, while this study initially presents total costs attributed to poor sanitation, it is unlikely that this total value can be averted by improving sanitation.

While there are many types and configurations of sanitation improvement available, this present study aims to estimate potential benefits obtainable for a selected number of *features* of sanitation improvements. This study provides an initial tentative estimate of the likely gains possible from improving sanitation using different options. It is the aim of the second study of ESI to estimate the costs and benefits of specific sanitation options, which are the most relevant policy options in each country context.

Table 9 shows the five main features of sanitation improvement (in columns) assessed in this study, and the relevance of these for each sub-impact category (in rows). The features are described in the table footnotes. The impact mitigation estimation methods are described in Annex A6.

Table 9. Potential benefits of different sanitation improvement options

Impacts	A	B	C	D	E	F
	Latrine physical access[1]	Improved toilet system[2]	Hygiene practices[3]	Waste treatment or disposal[4]	Waste reuse[5]	Tourism
Health		√	√	√		
Water resources				√		
Environment						
Aesthetics		√		√		
Land quality		√		√		
User preferences						
Intangible effects	√	√	√			
Access time	√					
Life choices	√	√	√			
Tourism				√		√
Sanitation markets						
Sanitation inputs	√	√	√	√	√	√
Sanitation outputs					√	

[1] Close and improved latrine for those using open defecation; improved population:toilet ratios through increased coverage of latrines (less queuing time)
[2] Improved position or type of toilet seat or pan; safe, private and secure structure: walls / door / roof; improved & safe collection system (tank vault, pit); improved ventilation; improved waste evacuation
[3] Availability of water for anal cleansing; safe disposal of materials used for anal cleansing; hand washing with soap; toilet cleaning
[4] Improved septic tank functioning and emptying; sealed top of pit latrine to withstand flooding; household connection (sewerage) with treatment; sewers with non-leaking pipes and a drainage system that can handle heavy rains; wetlands or wastewater ponds
[5] Urine separation, composting of feces, hygienization; use of human excreta products in commercial aquaculture, composting (fertilizer); biogas production (anaerobic digestion)

2.6 Uncertainty

This study has faced several challenges in attempting to both meet scientific criteria and present evidence that is useful for national as well as local policy makers. In order to provide timely evidence on sanitation impact, the present study is based on entirely secondary information collected from a variety of sources, and combined with assumptions where necessary input data were missing. Therefore, in order to fill the gaps in evidence, several innovative and not previously tested methodologies were developed for this present study. Quantitative information were combined using the methodology outlined above and in Annex A to estimate the impacts of poor sanitation and the potential benefits of improving sanitation. A number of impacts were excluded from quantitative estimation, which are described in Table 12. Three major types of uncertainty surround the quantitative figures presented in this study:

(1) Uncertainty in the input values for the estimation of overall economic impacts, such as in the epidemiological variables (for health) and economic variables such as market prices and economic values. In fact, there is a severe lack of data available from routine information systems or research studies to feed into the quantitative model. Hence, in the absence of these data, relationships were modeled and assumptions made.

(2) Uncertainty in the attribution of the overall impact to poor sanitation. For example, when there are multiple sources of pollution, a portion of the overall economic impact estimated must be apportioned to the component of pollution being examined (e.g. domestic waste contribution to overall water pollution). A second example is the importance of poor sanitation in keeping away tourists from a country.

(3) Uncertainty in the actual size of impact mitigation achievable.

The variables with greatest importance for the quantitative results were evaluated further in one-way sensitivity analysis by varying a single input value over a reasonable range, to assess the impact on overall findings. Alternative values used in the sensitivity analysis are provided in Annex A7.


29L-2317

3 Economic Impact Results

Section 3.1 presents a summary of the overall national level impacts of poor sanitation. Sections 3.2 to 3.7 provide further details of the specific sub-impacts of poor sanitation. Section 3.8 presents estimated economic gains from improved sanitation. Section 3.9 presents the sensitivity analysis results.

3.1 Summary of economic impacts of poor sanitation

3.1.1 Overall impacts

This study has found that poor sanitation causes considerable financial and economic losses in Vietnam. Financial losses – reflecting expenditure or income losses resulting from poor sanitation average 0.5% of annual GDP, while overall population welfare losses average 1.3% of GDP. The majority of economic losses are shared between health (34%) and water resources (37%), and environment (15%).

Table 10 summarizes the economic impacts of poor sanitation. It shows that the estimated overall annual economic losses from poor sanitation are US$780 million. The results indicate that most of the economic losses are explained by water costs (37%), followed by health impacts (34%). The costs on environment, tourism, and other welfare impacts contribute 15%, 9% and 6% to overall economic losses, respectively. The annual losses per capita are US$9.38 or VND 150,770.

Table 10. Financial and economic losses due to poor sanitation, by impact type

Impact	Financial losses			Economics Loss		
	Value	Per capita[1]	Percentage	Value	Per capita[1]	Percentage
Unit	*US$million*	*US$*	*%*	*US$million*	*US$*	*%*
Health	**52.1**	**0.62**	**17.9%**	**262.4**	**3.12**	**33.6%**
Health care costs	**50.7**	0.60	17.4%	53.1	0.63	6.8%
Productivity costs	**1.1**	0.01	0.4%	4.6	0.06	0.6%
Premature death costs	**0.3**	0.00	0.1%	204.7	2.43	26.2%
Water resources	**239.6**	**2.85**	**82.1%**	287.3	**3.41**	**36.8%**
Drinking water	**49.1**	0.58	16.8%	62.5	0.74	8.0%
Fish production	**27.4**	0.32	9.4%	27.4	0.32	3.5%
Domestic water uses	**163.2**	1.94	55.9%	197.4	2.34	25.3%
Environment	**-**	**-**	**0.0%**	118.9	**1.41**	**15.2%**
Land use	**-**	-	0.0%	118.9	1.41	15.2%
Other welfare	**-**	**-**	**0.0%**	42.9	**0.51**	**5.5%**
Time use	**-**	-	0.0%	41.6	0.49	5.3%
Life choices	**-**	-	0.0%	1.3	0.02	0.2%
Tourism	**-**	**-**	**0.0%**	68.6	**0.81**	**8.8%**
Tourist numbers	**-**	-	0.0%	68.6	0.81	8.8%
TOTAL	**291.7**	**3.46**	**100.0%**	**780.1**	**9.26**	**100.0%**

[1] Per capita refers to the total value divided by the total population

Under the broader definition of sanitation, impacts of trade villages and agriculture on water resources was evaluated. The study estimated that a further 40% of biological oxygen demand (BOD) originates from these sources, causing further impacts of US$287 million per year.

Table 11 shows the rural-urban breakdown for the aggregate financial and economic costs of poor sanitation. The majority of assigned impacts are in rural areas (49.1%), due largely to the significantly greater rural populations. Considerable shares of total impact (27.5%) could not be assigned due to lack of input data disaggregated by rural-urban setting for land loss, fish losses and losses to tourism.

Table 11. Financial and economic losses due to poor sanitation, by area

Impact	Financial losses			Economic losses		
	Value	Per capita[1]	Percentage	Value	Per capita[1]	Percentage
Unit	*US$ million*	*US$*	*%*	*US$ million*	*US$*	*%*
Health costs	**52.1**	**0.62**	**17.9%**	**262.4**	**3.12**	**33.6%**
Rural	41.0	0.49	14.0%	192.1	2.28	24.6%
Urban	11.1	0.13	3.8%	70.4	0.84	9.0%
Water costs	**239.6**	**2.85**	**82.1%**	**287.3**	**3.41**	**36.8%**
Rural	116.8	1.39	40.0%	155.3	1.84	19.9%
Urban	95.5	1.13	32.7%	104.6	1.24	13.4%
Non-assigned	27.4	0.32	9.4%	27.4	0.32	3.5%
Environment	**-**	**-**	**0.0%**	118.9	**1.41**	**15.2%**
Other welfare	**-**	**-**	**0.0%**	42.9	**0.51**	**5.5%**
Rural	-	-	0.0%	35.4	0.42	4.5%
Urban	-	-	0.0%	7.5	0.09	1.0%
Tourism	**-**	**-**	**0.0%**	68.6	**0.81**	**8.8%**
TOTAL	**291.7**	**3.46**	**100.0%**	**780.1**	**9.26**	**100.0%**
Rural	157.7	1.87	54.1%	382.9	4.55	49.1%
Urban	106.6	1.27	36.6%	182.4	2.17	23.4%
Non-assigned	27.4	0.32	9.4%	214.8	2.55	27.5%

[1] Per capita refers to the total value divided by the total population

3.1.2 Other non-quantified impacts of poor sanitation

As well as quantified, monetized impacts, there are a number of other key impacts which have not been valued in this present study, and which should be taken into account in interpreting the quantitative impacts discussed above. These non-monetized impacts include suffering from disease, intangible aspects of environmental impacts (aesthetics) and user preference, time loss from seeking private place for urination (especially women), loss from marine fisheries, the non-use value of clean water resources such as 'existence' and 'bequest' values, and the losses to wildlife from polluted water resources and an unclean environment. Other impacts with less clear linkages with poor sanitation include the use of water for irrigation purposes and hence agricultural productivity, the impact of poor sanitation on foreign direct investment, and impact of unimproved sanitation (and running water) in institutions which affect life decisions of the population, especially the decision of women to take employment and of girls to enroll in or complete school. Table 12 shows a longer listing of excluded impacts of poor sanitation from the quantitative analysis, and elaborates on the likely links to sanitation.

Table 12. Description of importance of non-quantified impacts of poor sanitation

Impact	Excluded items	Link with poor sanitation
1. Health	Quality of life	Sanitation-related diseases cause pain and suffering beyond the measurable economic effects. Disability-adjusted life-years (DALY), which attempt to capture quality of life loss, indicate that sanitation-related diseases contribute significantly to national disease burden estimates.
	Informal treatment seeking and home treatment	This study has largely missed the large proportion of disease cases – especially for mild disease – which are treated at home or by consulting an informal care giver. These costs are largely unknown, but potentially significant.
	Other sanitation-related diseases	The following disease and health conditions have been excluded: 1. Helminthes and skin diseases (Cambodia, Philippines) 2. Malnutrition and the costs of supplemental feeding 3. Reproductive tract infections for women bathing in dirty water 4. Dehydration resulting from low water consumption from lack of access to private latrines (especially women) 5. Specific health problems suffered by those working closely with waste products (sanitation workers, dump scavengers) 6. Health impacts due to flooding (physical, psychological) 7. Education impacts of childhood malnutrition 8. Food poisoning due to contaminated fish (e.g. E Coli) 9. Animal and insect vectors of disease (e.g. rodents, mosquitoes) 10. Animal health related to human sanitation 11. Avian influenza
2. Water resources	Household water use	Household time spent treating drinking water, including boiling, maintaining rain water collection systems, replacing filters, etc.
	Fish production	The study excluded the following 1. Non-recorded marketed freshwater fish 2. Farmed freshwater fish (Indonesia) 3. Marine fish 4. Subsistence fishing losses 5. Nutrient losses from less fish capture and effect on spending
	Water management	Economic losses associated with flooding from lack of drainage
	Irrigation	Polluted surface water may lead to extraction of scarce groundwater, or use of polluted water has implications for plant growth, animal health, and eventually human health
	Other welfare impacts	1. 'Non-use' value of clean water resources such as 'existence' and 'bequest' values 2. Wildlife use of water resources
3. External environment	Aesthetics	Welfare loss from population exposure to open sewers / defecation
	Land value	Economic value of land made unusable by poor sanitation (Cambodia, Philippines)
4. User preferences	Intangible impacts	Welfare loss from lack of comfort, privacy, security, and convenience of unimproved sanitation; effects on status & prestige
	Time loss	Time for urination, especially women
	Life decisions and absence from daily activities	Poor sanitation in schools and the workplace affect daily attendance, especially of girls and women 1. Loss of time from temporary absence of women from workplace (Cambodia and Philippines) 2. Welfare loss from school absence (Cambodia and Philippines) 3. Work decisions and early drop-out of girls from school (all countries)
5. Tourism	Tourist sickness	Expenditure by tourists becoming sick and welfare loss of sick tourists (Cambodia, Philippines).

Impact	Excluded items	Link with poor sanitation
6. Other	Foreign direct investment	1. Companies selecting investment locations may be influenced by, among other factors, by the sanitation situation in a country; tangible secondary evidence is however very limited. 2. Macroeconomic impact.

Together, the quantified and non-quantified financial and economic losses will affect the overall economic situation in a country, including economic growth. The main effects are likely to be through sickness time and income loss associated with premature death, and household expenditure on health care and clean water, including water treatment. The production and sale of sanitation options can also give a stimulus to the local economy through local employment. The re-use of human (and animal) excreta can lead to cost savings and enhanced household and farmer production. Property prices also may rise due to better living standards brought by improved sanitation. However, given the weak empirical evidence on the direct economic effects of improved sanitation, this study did not move beyond a partial equilibrium analysis to examine redistributive effects. Therefore, the empirical link between poor sanitation and macro-economic indicators such as gross domestic product (GDP) is still not known.

3.2 Health impacts

Table 13 reports the estimated cases and deaths per year from selected diseases which are attributable to poor sanitation. It shows that diarrhea has the most number of cases at 7.05 million. Diarrhea is also the main cause of death from poor sanitation and hygiene, accounting for 4,576 deaths per year. Malnutrition-related diseases, in particular acute lower respiratory infection (ALRI), account for an estimated 1,475 deaths per year, followed by malaria with 631 deaths per year.

Less serious diseases (scabies, helminthes, hepatitis A) appear to account for only a small proportion of the total. There are no reported cases from official statistics of mortality from these diseases. Collectively these account for only about 5.4 percent of the number of cases. However, their collective influence on the quality of life cannot be ignored. The prevalence of trachoma is still high as it is endemic in Vietnam. The proportion of cases actually seeking treatment for most diseases is only a small fraction of total cases, thus incurring lower health care costs than would be the case if all cases sought formal health care.

Table 13. Summary health impacts by disease

Disease	Total cases		Total deaths
	Seeking formal treatment[1]	All cases	
Diarrheal diseases	933,559	7,050,762	4,576
Helminthes	27,000	203,918	-
Trachoma	864,747	864,747	-
Scabies	234,388	1,370,042	-
Hepatitis A	5,170	39,050	-
Malnutrition	960,400	960,400	-
ALRI (Pneumonia)	43,095	325,474	1,475
Measles	-	-	335
Malaria	2,382	17,990	631
Total	**3,075,048**	**10,864,924**	**7,016**

[1] Includes the estimated cases reporting to government facility or formal private provider

Table 14 presents the total costs of health care related to treatment seeking for diseases related to sanitation and hygiene. Diarrhea diseases contribute the largest proportion of health costs. The second is malnutrition-related diseases.

Table 14. Total health care costs by disease

Disease	Financial costs				Economic costs				
	Public clinics	Private clinics	Self-treatment	Total	Public clinics	Private clinics	Self-treatment	Transportation and other costs	Total
Diarrhea diseases	2,259,111	1,826,878	21,868,529	25,954,518	1,871,579	1,910,823	18,297,982	5,687,659	27,768,042
Helminths	45,328	51,929	174,859	272,116	18,870	38,430	94,932	167,640	319,871
Trachoma	16,919,153	-	-	16,919,153	16,015,147	-	-	1,036,781	17,051,928
Scabies	596,515	726,144	2,611,375	3,934,034	418,750	635,453	2,074,376	1,126,304	4,254,884
Hepatitis A	23,901	30,494	377,322	431,718	22,735	30,212	357,547	31,577	442,071
ALRI (Pneumonia)	163,629	208,286	2,532,814	2,904,730	154,667	206,888	2,377,754	252,642	2,991,950
Malaria	11,018	14,055	255,729	280,802	10,464	13,904	246,405	14,779	285,551
Total	**20,018,656**	**2,857,786**	**27,820,629**	**50,697,071**	**18,512,211**	**2,835,710**	**23,448,996**	**8,317,381**	**53,114,298**

Table 15. Total productivity costs by disease[1]

Disease	Financial costs[2]			Economic costs, by age group				
	Age group 15+		Total	Age group 0-14		Age group 15+		Total
	Urban	Rural		Urban	Rural	Urban	Rural	
Diarrhea diseases	258,690	700,443	959,133	698,464	1,891,196	336,297	910,576	3,836,532
Helminths	1,612	4,365	5,977	4,353	11,785	2,096	5,674	23,908
Trachoma	12,025	49,270	61,295	68,542	280,841	15,632	64,051	429,067
Scabies	497	1,346	1,843	14,935	40,438	646	1,750	57,769
Hepatitis A	6,430	17,410	23,840	17,361	47,008	8,359	22,633	95,361
ALRI	15,106	30,120	45,226	40,786	81,324	19,638	39,156	180,904
Malaria	2,009	6,220	8,230	3,416	10,575	2,612	8,087	24,690
Total	**296,370**	**809,175**	**1,105,544**	**847,856**	**2,363,167**	**385,281**	**1,051,927**	**4,648,231**

Notes. Data are 2004 US dollars. CHC: community health care clinic.
[1] Value of time is approximated using the average compensation of employees
[2] Financial costs reflect the estimated lost earnings of working adults

Table 15 presents the estimated total productivity costs related to days off daily activities for diseases related to sanitation and hygiene. As expected, diarrhea diseases make up the largest proportion of these costs (67%). A direct financial impact can be estimated by assuming a proportion of working adults lose income if time is taken off sick.

Table 16 presents the total costs of premature death from diseases related to sanitation and hygiene. The value of premature death is based on human capital approach (see section A1.4). Financial costs reflect a single year of income loss from premature death of an adult, while economic costs reflect discounted future earnings of all premature deaths.

Table 16. Total costs of premature death, using human capital approach

Disease	Financial costs (US$)	Economic costs, by age group (US$)		
	Age group over 15	Age group under 15	Age group over 15	Total
Diarrheal diseases	318,120	124,310,687	7,023,014	131,333,701
ALRI	-	44,326,423	-	44,326,423
Measles	-	10,064,828	-	10,064,828
Malaria	-	18,951,791	-	18,951,791
Total	**318,120**	**197,653,729**	**7,023,014**	**204,676,743**

Figure 2 shows the variation in economic cost of premature death by using different values for premature death. It shows that the current estimates are lower than those generated using the willingness to pay approach, using adjusted values of premature death from US and European studies. Given the extrapolation from higher income economies to Vietnam, an income elasticity of unity (1.0) cannot be assumed. At income elasticity assumptions of below 1, the value f premature death increases.

Figure 2. Economic cost of premature death at different values for premature death

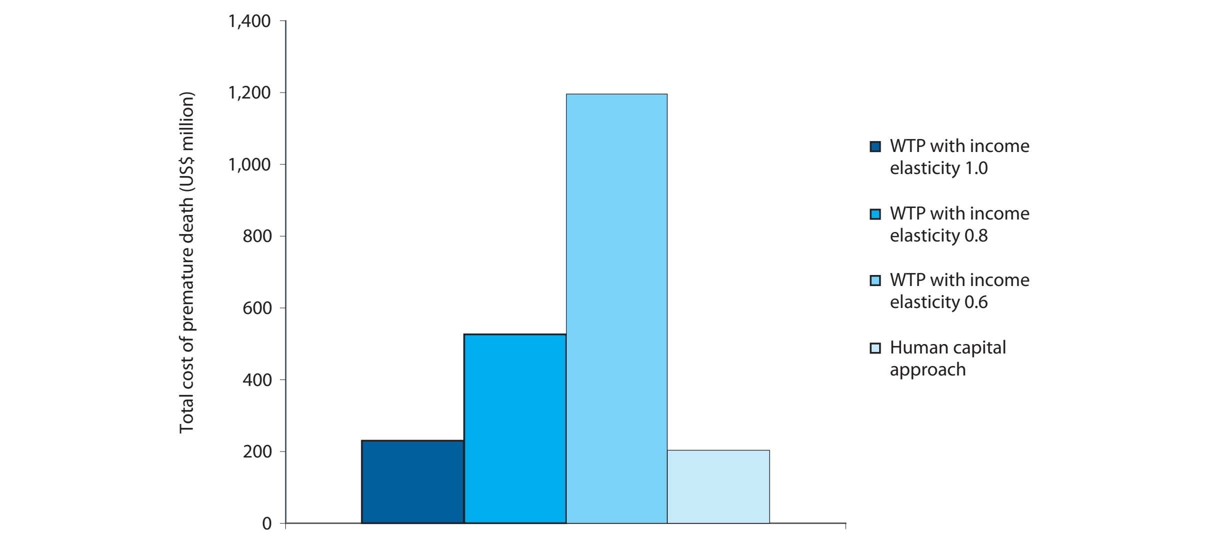


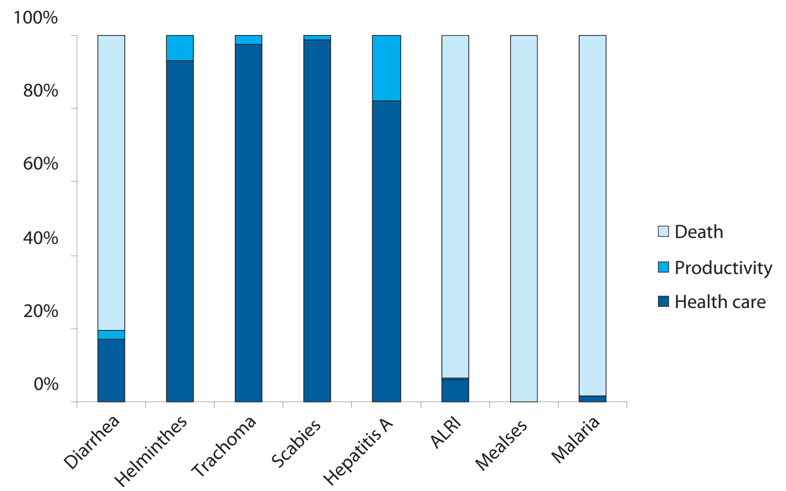
Table 17 presents the estimated economic costs of the health impacts of poor sanitation and hygiene in Vietnam. It shows that total economic costs to health are US$262 million per year, in which health care costs account for 16%, productivity losses account for 4% and the remaining 80% are due to premature death.

Table 17. Total health-related costs (US$ thousand)

Disease	Total financial costs				Total economic costs			
	Health care	Prod-uctivity	Death	Total	Health care	Prod-uctivity	Death	Total
Diseases directly related to poor sanitation								
Diarrhea diseases	25,955	959	7,023	33,937	27,768	3,837	131,334	162,939
Helminths	272	6		278	320	24		344
Trachoma	16,919	61		16,980	17,052	429		17,481
Scabies	3,934	2		3,936	4,255	58		4,313
Hepatitis A	432	24		456	442	95		537
Diseases indirectly related to poor sanitation								
ALRI(Pneumonia)	2,905	45		2,950	2,992	181	44,326	47,499
Measles							10,065	10,065
Malaria	281	8		289	286	25	18,952	19,262
Total	**50,697**	**1,106**	**7,023**	**58,826**	**53,114**	**4,648**	**204,677**	**262,439**

Figure 3 shows the contribution of different costs to overall cost, by disease. The main contributor to health-related economic costs of diarrhea, ALRI, measles, and malaria is premature death. For other diseases (helminthes, trachoma, scabies and hepatitis A), health care costs are the major contributor followed by productivity costs, as no deaths are reported from these diseases.

Figure 3. Contribution of different costs to total cost, by disease



3.3 Water resource impacts

The economic impacts of polluted water resources depend on three main factors: the extent of water resources in the country, the release of polluting substances in water resources, and the actual or potential uses of water in the country. Table 18 presents a summary of the water resources in Vietnam.

There are 9 major rivers in Vietnam, which are the Bang Giang-Ky Cung River, Thai Binh, River Red River, Ma River, Ca River, Thu Bon River, Ba River, Dong Nai River and the Mekong (Cuu Long) River. These major rivers account for 90% of the total area of river basins in Vietnam and their within-border area is around 80% of the total area of the country.

Table 18. Water resources in Vietnam

No.	River	Basin Area (km²)			Average Annual Water Discharge (billion m³)			Water availability (total)	
		External	Internal	Total	External	Internal	Total	Thousand m³/km²	m³ /person
1	Bang Giang – Ky Cung	1,980	11,280	13,260	1.7	7.3	9	798	9,070
2	Thai Binh		15,180	15,180		9.7	9.7	1,550	5,160
3	Red	82,300	72,700	155,000	45.2	81.3	126.5		
4	Ma	10,800	17,600	28,400	5.6	14	19.6	1,110	5,500
5	Ca	9,470	17,730	27,200	4.4	17.8	22.2	1,250	8,290
6	Thu Bon		10,350	10,350		20.1	20.1	1,940	16,500
7	Ba		13,900	13,900		9.5	9.5	683	9,140
8	Dong Nai	6,700	37,400	44,100	3.5	32.8	36.3	877	2,980
9	Mekong	726,180	68,820	795,000	447	53	500	7,265	28,380
10	Others		66,030	66,030		94.5	94.5	1,430	8,900
Vietnam		**837,430**	**330,990**	**1,167,000**	**507.4**	**340**	**847.4**	**2,560**	**10,240**

Source: [25]

The main activities related to these water resources measured in this study include:

- Withdrawal for treatment to provide drinking water
- Other household uses
- Commercial and subsistence fishing

The overall picture of water quality in Vietnam is summarized below, extracted from the Vietnam Environment Monitor (2003). The eight economic regions are largely formed within the major river basins and they differ from each other in water quality. Red River Delta, Mekong River Delta and North East of Mekong regions are characterized by dense river networks and abundant surface water resources. In these regions rapid population growth, urbanization and industrialization, intensive agriculture, and water transport have resulted in worsening water quality and declining groundwater levels.

Table 19. Water quality of 8 regions in Vietnam

Region	Rivers		Ground water	Coastal Water	Issues
	Upstream	Downstream			
Red River Delta	++++	++	+++	+++	Urban and Industrial pollution, Saline intrusion, Agrochemical pollution, transport pollution risks
North East	+++++	++	++++	+++	Urban pollution, Saline intrusion, Marine transport pollution risks
North West	+++++	++++	+++++		
North Central Coast	++++	+++	++++	++++	Urban pollution, Saline intrusion
South Central Coast	+++++	++	++++	++++	Urban pollution, Saline intrusion
Central Highlands	+++++	++++	+++++	-	-
South East	++++	+	+++	++	Urban and Industrial pollution, Saline intrusion
Mekong River Delta	++++	++	+++	+++	Saline intrusion, low pH in rivers (Acid Soils) Agrochemical pollution, transport pollution risks

Note: A high score (+++++) means water is abundant or good quality, a low score (+) they are scarce or the water quality is unacceptable and out of range of standards. Assessment and scoring are based on the information of the Vietnam Environment Monitor 2003 [25]

There is increasing evidence of pollution of Vietnam's surface, ground and coastal waters. Although the quality of upstream river waters is generally good, downstream sections of major rivers reveal poor water quality and most of the lakes and canals in urban areas are fast becoming sewage sinks. Total pollution of water resources from household sources is presented by region in Table 20. Annually, approximately 2.3 million tons of feces, 46 million cubic meters of urine and 610 million cubic meters of gray water are released into inland water resources annually in Vietnam.

Table 20. Total release of polluting substances to inland water bodies

Region	Total release (volume) 2005		
	Feces	Urine	Gray water
	(tons/year)	(m^3/year)	(m^3)
Red River Delta	493,831	9,876,613	
North East	256,185	5,123,690	
North West	70,235	1,404,695	
North Central Coast	290,722	5,814,442	
South Central Coast	192,988	3,859,766	
Central Highlands	130,276	2,605,518	
South East	368,472	7,369,437	
Mekong River Delta	472,700	9,453,993	
Total	**2,275,408**	**45,508,154**	**609,876,054**

Water pollution caused by cottage or trade villages is now a very critical problem in Vietnam. The impact on surface water results from the inadequate collection of waste water and solids from food processing, wooden fine arts production and paper recycling. For ground water, the impact so far measured or documented is insignificant; there is currently no evidence linking ground water quality with solid waste from trade villages [10].

Table 21 presents water quality indicators measured in a number of water bodies throughout Vietnam, collected regularly by the Vietnam Environmental Protection Agency. It indicates different pollution levels by regions.

Table 21. Selected water quality measurements in Vietnam (in 2005)

Location	Water body location	Selected water quality indicators				
		pH	DO	BOD	TSS	Coliform
Vietnam's Standard		**5.5 - 9.0**		**<25mg/l**	**<80mg/l**	**<10,000 MPN/ 100ml**
Red River Delta						
Hong River	Lien Mac Culvert	8.42	4.78	8.85	85	500
	Lien Mac Culvert	7.39	4.57	6.08	152	900
	Van Phuc village (morning)	8.21	4.68	9.34	635	700
	Moi brigde	7.7	0.1	96	58	480,000
	Thanh Liet dam	7.55	0.3	91.2	97	410,000
	West Lake (middle)	8.3	4.02	17.2	16	1,300
Cau River	Nhu Nguyet brigde	6.89	4.25	6.13	61	1,200
Thai Binh River	Pha Lai	6.73	4.06	3.94	216	600

Location	Water body location	Selected water quality indicators				
		pH	DO	BOD	TSS	Coliform
Vietnam's Standard		**5.5 - 9.0**		**<25mg/l**	**<80mg/l**	**<10,000 MPN/ 100ml**
Nhue River	Border of Tu Liem district and Ha Dong	7.58	3.26	26.1	47	11,000
	Downstream Ha Dong bridge	7.58	3.16	37.5	41	11,000
Day River	Mai Linh bridge	6.72	1.09	36.8	29	22,000
Cam River	National Road No. 5, km 9	7.82	4.95	10.4	94	1,100
	Chua Ve port	7.71	4.17	16.9	98	2,700
North Central Coast						
Huong River	Tuan confluence	7.48	5.49	4	31.2	400,000
	Tuan confluence	7.83	5.48	4.6	32	220,000
	Sinh confluence	7.67	4.96	4	25.4	1,100,000
	Sinh confluence	7.8	5.56	1	21	250
South Central Coast						
Vu Gia - Thu Bon River	Giao Thuy	8.14	5.1	2.9	16.7	25
	Giao Thuy	7.69	5.25	0.5	16.5	21
	Cua Dai	8.11	5.73	2.4	16.7	200
	Cua Dai	7.38	5.09	1.3	12.5	500
Han River	Thuan Phuoc bridge	7.93	4.17	5.8	32	5,000
	Thuan Phuoc bridge	7.74	4.32	3.8	14	3,100
South East						
Thi Vai River	From Long Tho commune, Nhon Trach District, Dong Nai province to My Xuan commune, Tan Thanh district, Ba Ria Vung Tau	9 - 10.5	< 0.5	880	na	30,000 – 690,000

Source: VEPA (2005)

Table 22 shows the costs attributed to poor sanitation of access to drinking water, including only the daily needs per capita for drinking water. Financial costs equal US$49 million while economic costs equal US$63 million per year. The results indicate that the majority of financial and economic costs are incurred by households treating their water. An estimated 20% of economic costs reflect the time required by households to access (haul) water from less polluted water sources.

Table 22. Drinking water access costs (US$ thousand)

Water source	Financial		Economic	
	Value	%	Value	%
Purchased piped water	**1,584**	**100.0%**	**1,584**	**100.0%**
Rural	367	23.2%	367	23.2%
Urban	1,217	76.8%	1,217	76.8%
Purchased non-piped water	**66**	**100.0%**	**66**	**100.0%**
Rural	30	45.6%	30	45.6%
Urban	36	54.4%	36	54.4%
Household water treatment	**47,430**	**100.0%**	**47,430**	**100.0%**
Rural	36,956	77.9%	36,956	77.9%
Urban	10,474	22.1%	10,474	22.1%
Hauled water	**-**	**0.0%**	**13,463**	**100.0%**
Rural	-	**0.0%**	12,343	91.7%
Urban	-	**0.0%**	1,119	8.3%
Total	**49,080**	**100.0%**	**62,543**	**100.0%**
Rural	37,353	76.1%	49,697	79.5%
Urban	11,727	23.9%	12,846	20.5%

Table 23 shows the costs attributed to poor sanitation of accessing water for domestic purposes from improved water sources. Financial costs equal US$163 million while economic costs equal US$197 million per year. Again, the results indicate that the majority of financial and economic costs are incurred by households treating their water (although note that not all domestic uses require the water to be treated inside the household). An estimated 17% of economic costs reflect the time required by households to access (haul) water from less polluted water sources.

Table 23. Domestic use water access costs (drinking water excluded) (US$ thousand)

Water source	Financial		Economic	
	Value	%	Value	%
Purchased piped water	**9,476**	**100.0%**	**9,476**	**100.0%**
Rural	780	8.2%	780	8.2%
Urban	8,696	91.7%	8,696	91.7%
Purchased non-piped water	**320**	**100.0%**	**320**	**100.0%**
Rural	64	19.9%	64	19.9%
Urban	256	80.0%	256	80.0%
Household water treatment	**153,377**	**100.0%**	**153,377**	**100.0%**
Rural	78,563	51.2%	78,563	51.2%
Urban	74,814	48.7%	74,814	48.7%
Hauled water	**-**	**0.0%**	**34,235**	**100.0%**
Rural	-	0.0%	26,240	76.6%
Urban	-	0.0%	7,994	23.3%
Total	**163,172**	**100.0%**	**197,407**	**100.0%**
Rural	79,407	48.6%	105,647	53.5%
Urban	83,765	51.3%	91,760	46.4%

Being a coastal country with territorial waters triple the area of the mainland and a variety of natural aquatic resources, Vietnam has great advantages in fisheries development. In addition, Vietnam also has much potential fresh water resources including rivers, streams, lakes, reservoirs, ponds, channels, low-lying paddy-fields, etc., which provide favorable conditions for fishing and aquaculture.

According to statistics from GSO, the fisheries sector is one of the key economic sectors in Vietnam, and it maintains higher growth rate than most other economic sectors. The share of fisheries sector in the country's GDP has grown consistently from 2.9% in 1995 to 3.4% in 2000, reaching more than 4% in 2005. Aquatic products are a major source of animal protein for people in Vietnam, providing about 40% of people's dietary protein. In 2005, almost 4 million people are directly employed in the sector and nearly 10% of the population derives their main income from fisheries. Total export value of fisheries reached US$3.35 billion in 2006, accounting for over 10% of the total export earning. Fisheries remain the second most important export-oriented sector in Vietnam, after the crude oil industry.

Total fisheries production in 2006 was 3.69 million tons, in which aquaculture accounts for 1.69 million tons and 2.00 million tons from marine and inland fishing. Over time, aquaculture has gained importance, and is now more important than capture fisheries in terms of quantity, quality and production stability.

Wastewater from domestic, agricultural and industrial activities has increasingly contributed to pollution loads in water bodies. The media reports many cases showing the heavy losses of aquaculture productivity due to water pollution (see Box 1).

Box 1. Loss of caged-fish farming in Ha Nam Province

Over the period 2000-2003, from November to March, polluted water from the Nhue River to the Day River killed many fish and shrimp. Water from Thanh Liet Dam (Hanoi) during November 22 to November 26, 2003 caused heavy losses in Chau Thuy, Chau Giang, Phu Ly Commune, Ha Nam Province. Nguyen Van Nam, investing 70 million dong to raise caged fish, lost 3 tons of breed fish and 10 tons of valuable fish; Bui Quoc Ky lost 400 million dong along 2.5 km of river used to raise caged fish.

Source: The Business Forum, 2003

Table 24 presents the estimated losses to inland fisheries. On the assumption that "standard" poor sanitation contributes 40% to the pollution of rivers, the projected losses are US$27.4 million. Using the broader definition of sanitation, the attribution of losses is 80%, and the corresponding projected losses are US$54.7 million. See Annex Table D10 for more information on fish production by regions.

Table 24. Fish catch value (farm and inland catch) – actual and estimated loss, 2005

Water body name and type	Factor X [1]	Actual Fish Volume		Potential Fish Volume		Loss Value (US$ thousand)	
		Weight (1000 ton)	Value (US$ thousand)	Weight (1000 ton)	Value (US$ thousand)	Narrow definition	Broader definition
Red River Delta	70%	206.8	62,038.3	295.4	88,626.2	10,635.1	21,270.3
North East	90%	48.8	14,627.9	54.2	16,253.2	650.1	1,300.3
North West	90%	7.9	2,380.0	8.8	2,644.4	105.8	211.6
North Central Coast	90%	48.1	14,421.2	53.4	16,023.5	640.9	1,281.9
South Central Coast	90%	65.8	19,736.1	73.1	21,929.0	877.2	1,754.3
Central Highlands	90%	15.4	4,610.1	17.1	5,122.3	204.9	409.8
South East	70%	53.3	15,999.6	76.2	22,856.6	2,742.8	5,485.6
Mekong River Delta	90%	863.0	258,895.1	958.9	287,661.2	11,506.4	23,012.9
Total		**1,309.0**	**392,708.2**	**1,537.1**	**461,116.4**	**27,363.3**	**54,726.5**

Source: Fish volume [23].

[1] See A.2.2.2 for definition of Factor X

[2] See Section 3.2 for information about broader scope of sanitation in Vietnam

3.4 Environmental impacts

In many places in Vietnam, human waste is a major cause of reduced air quality and spoiled visual appearance due to inadequate treatment and/or disposal. Like other countries in South East Asia, open and controlled dump sites are the dominant form of waste disposal in Vietnam. Only 12 out of 64 cities and provincial capitals have engineered or sanitary landfills; most were constructed during the past 4 years. The World Bank estimates that in 2004 only 17 out of the 91 landfills in Vietnam, are sanitary landfills [7]. Discussion with Ministry of Construction suggests an even lower number of sanitary landfills.

Average collection rates of solid waste in Vietnam are improving, but remain low in many cities. Spending on solid waste is just 0.18% of country GNP. Fees for collection of solid waste account for 0.5% of household expenditure [7].

Box 2. Problems with the Dong Thanh Dump Site in Ho Chi Minh City

Dong Thanh is the second biggest dump site in Vietnam, located outside Ho Chi Minh City and with an area of about 40 hectares. Due to the fact that the site is not sealed, wastewater percolates into the soil, causing underground water pollution. Many nearby residents dig and drill wells and, in a 20 km circle, are now not able to use this water because of its poor quality and obnoxious odours.

Additionally, the leachate from the landfill (mainly from the wastewater storage lakes) into the surrounding areas has caused damages to the production and living activities of the local people. Fish, pigs, chickens and ducks have died and agricultural productivity is reduced. Wastewater from the waste storage lakes (about 200,000 m3 with average chemical oxygen demand concentration of about 40,000 – 50,000 mg/l) is not treated to environmental standards and penetrates into the underground water strata.

In June 2000, persistent heavy rain caused a 6 meter high dumpsite wall to collapse. A great deal of waste and wastewater spilt out causing environment pollution and harming production and people living nearby.

Source: Institute of Environment and Natural Resources, 2004

Table 25 below presents the value of land lost based on the estimation of buffer zones required around unsanitary landfills in Vietnam. It indicates that more than US$118 million in the value of land is lost annually.

Table 25. Economic loss due to degraded and unavailable land in the unsanitary dumps

Region	Area of landfills (ha)	Area of sanitary landfills (ha)	Area of buffer zone (m^2)	Total value loss (US$)
Whole country	***780.8***	***158.3***	***170,073,731***	***118,871,905***
Red River Delta	112.4	96.3	41,162,948	25,598,848
North East	31.6	24.0	27,007,490	16,795,703
North West	41.0	-	12,836,249	7,982,742
North Central Coast	93.8	-	2,202,400	14,474,310
South Central Coast	68.5	8.0	25,344,171	15,761,300
Central Highland	43.0	22.0	5,463,962	3,397,986
South East	282.0	8.0	25,555,333	15,892,620
Mekong River Delta	108.5	-	30,501,179	18,968,395

3.5 Other welfare impacts

In a survey conducted by WSP in 2002, 7 of 12 groups interviewed (58%) considered reputation with neighbors and guests as a motivating factor to build a latrine. This factor includes the desire to be considered modern, save face with guests, and get respect from neighbors, which shows that aesthetics is an important factor of improved sanitation. [26]. No study exists on the intangible aspects of user preference impacts of poor sanitation in Vietnam. A recent study of the Vietnam National Handwashing Initiative looked into availability of factors such as sanitation, water and soap in and around the household. The study shows that there is a gap between hygiene theory and practice, explained by cultural and practical factors [27].

Table 26 shows the economic impacts on access time. It indicates total productivity losses are about US$41.6 million per annum.

Table 26. Time used accessing latrines

Area	Number of population, by age (millions)		Total time spent accessing (Million hours per year)		Economic Loss (US$ million)		
	Under 15	Over 15	Under 15	Over 15	Under 15	Over 15	Total
Rural	5.2	13.4	313.7	816.3	5.6	28.9	34.5
Urban	1.1	2.8	64.7	168.4	1.1	6.0	7.1
Total	6.2	16.2	378.4	984.7	6.7	34.9	41.6

Table 27 presents the estimated impacts of poor sanitation on school and work attendance. The table indicates estimated economic impacts of about US$4.4 million. Most of these losses are accounted by work absenteeism. Almost all of these losses are explained by absenteeism of working women.

Table 27. Impacts of poor sanitation on school of pupils and work attendance of women

Establishment	Days lost (absenteeism)	Economic value (US$)
Primary school		
Rural	43,408	6,154
Urban	16,137	2,288
Total	**59,545**	**8,441**
Secondary school		
Rural	83,697	11,865
Urban	31,114	4,411
Total	**114,811**	**16,276**
Workplace		
Rural	93,227	932,271
Urban	34,656	346,564
Total	**127,883**	**1,278,835**
Overall		
Rural	220,332	950,290
Urban	81,907	353,263
Loss	**302,239**	**1,303,552**

3.6 Tourism impacts

Tourism is an important growing industry in Vietnam with 3.6 million foreign visitors in 2006, generating about US$3.2 billion in national tourism-related revenues (equivalent to 5.2% of GDP). The industry boasted very rapid growth over the last 15 years, and the Government of Vietnam aim to maintain this trend. Table 28 provides key information on the tourism industry in Vietnam since 2002. It shows steady growth in the number of tourist as well as the industry's share in the country's GDP.

Table 28. Volume and importance of tourist sector in Vietnam

Variable	2002	2003	2004	2005	2006
Number of tourists	**15,628**	**15,930**	**17,428**	**18,978**	**21,083**
Domestic	*13,000*	*13,500*	*14,500*	*15,500*	*17,500*
International	*2,628*	*2,430*	*2,928*	*3,478*	*3,583*
Daily tourist expenditure					
Domestic	na	28.3	na	31.5	na
International	na	74.6	76.5	76.4	na
Tourist income (US$ billion)	**1.45**	**1.40**	**1.60**	**1.80**	**3.20**
GDP Vietnam	**35.06**	**39.49**	**45.66**	**52.96**	**60.97**
As % GDP	4.14%	3.55%	3.50%	3.40%	5.25%
Tourism investment					
Government expenditure	na	na	na	na	50.6
Private sector investment	na	na	na	na	1491.3
Number of hotels	na	na	na	8556	na
Employment					
Employment in tourism	2,006	2,149	2,313	2,575	3,364
As % jobs	5.08%	5.30%	5.56%	6.03%	7.67%

na – not available

Table 29 shows the economic losses associated with the gap between current occupancy rate of 70% compared with an assumed optimal occupancy rate of 80% and, over time, increased tourist infrastructure. It indicates that the economic impact of lower tourist numbers attributed to poor sanitation (5% of losses) is US$68.6 million.

Table 29. Economic impact of lower tourist numbers

Current tourism value (US$ million)	Current occupancy rate	Potential value (US$ million)		Attribution to sanitation	Annual economic loss (US$ million)
		Current	Future		
3,200.00	70%	3,200	4,571	5%	68.6

3.7 Economic gains from improved sanitation & hygiene

For policy decisions, it is not adequate to know only the economic losses associated with poor sanitation. Policy makers also need to know which of these costs can be mitigated with the implementation of different sanitation options. A number of generic features of improved sanitation options were defined in Table 7 (section 2.5) to enable estimation of costs mitigated under different options.

This study has estimated the losses associated with poor sanitation using an attributable fraction based on representative indicators of impact, which varied by impact. For example, costs of polluted water were apportioned to poor sanitation based on the contribution of poor household sanitation to overall water pollution. Likewise, a proportion of sanitation-related diseases were attributed to exposure to human excreta, given that these diseases also have other causes.

Hence, based on this methodology, the reduction in pathogens, pollution and so on through improved sanitation, should lead to partial or full mitigation of the estimated losses shown in section 3.1. Table 30 therefore presents the estimated financial and economic gains from different features of sanitation and hygiene improvements.

- Better physical access of latrines and more private as opposed to shared latrines bring US$43 million economic gain, through saving time for those whose time access is not already minimized.
- The financial and economic value of sanitation markets are US$329 million, including sanitation input (US$127 million) and output markets (US$202 million).
- Improved toilet system leads to US$17 million financial gain and US$84 million economic gain through the reduction by 32% of the measured health impacts.
- Hygiene practices bring US$23 million financial gain and US$231 million economic gain through reducing by 45% the measured health impacts.
- Treatment and/or safe disposal of human excreta leads to financial savings of US$239 million and economic savings of US$287 million due to less polluted water resources; and US$69 million gain in revenue from tourism.

Table 30. Predicted financial and economic gains from improved sanitation (US$)

	Hygiene practices		Latrine physical access		Improved toilet system[1]		Treatment or disposal		Reuse	
	Financial	Economic	Financial	Economic	Financial	Economic	Financial	Economic	Financial	Economic
Health	**23,454,331**	**228,578,177**	-	-	**16,678,635**	**83,980,567**	-	-	-	-
Health care	22,813,682	23,901,434			16,223,063	16,996,575				
Productivity	497,495	2,091,600			353,774	1,487,434				
Premature death	143,154	204,676,743			101,798	65,496,558				
Water	-	-	-	-	-	-	**239,615,968**	**287,313,098**	-	-
Drinking water							49,080,263	62,542,853		
Fish production							27,363,275	27,363,275		
Domestic uses							163,172,430	197,406,971		
Environment	-	-	-	-	-	-	-	-	-	-
Land										
Other welfare[2]	-	-	-	**42,905,844**	-	-	-	-	-	-
Intangible			-	-						
Time use			-	41,602,292						
Life choices			-	1,303,552						
Tourism[3]	-	-	-	-	-	-	-	**68,571,429**	-	-
Tourist numbers							-	68,571,429		
Sanitation markets	-	-	-	-	-	-	-	-	**127,198,499**	**329,256,078**
Input markets									127,198,499	127,198,499
Output markets									202,057,578	202,057,578
TOTAL	**23,454,331**	**230,669,777**	-	**42,905,844**	**16,678,635**	**83,980,567**	**239,615,968**	**355,884,527**	**329,256,078**	**329,256,078**

[1] Improved sanitation generally means improved physical access, improved toilet system and treatment or disposal, all of which have implications for health status (see annex table for definitions). For the purposes of reporting, the sanitation benefits are included only under improved toilet system, to avoid confusion over double-counting.
[2] User preferences discussed and presented in Chapter 4.5 are all presented here under 'latrine physical access' but some of these are also likely due to improved toilet system.
[3] Tourist numbers and sickness will also be related to hygiene practices and toilet systems used, but the benefits are reported here under treatment and disposal, as this has the major environmental implications.

Table 31 shows more results for the potential market size for sanitation inputs, based on market prices and approximate breakdown between labor, materials, equipment and non-purchased items. The table indicates that the total input market is valued at US$127 million.

Table 31. Sanitation input market values

Variable	Double Vault dehydration toilet	Pour flush toilet	Flush toilet with septic tank	Biogas system	Others	Total
Rural						
No, rural HH	2,973,131	2,821,722	5,175,451	82,587	2,711,606	13,764,497
No. with unimproved sanitation	1,486,566	1,410,861	2,587,725	41,293	1,355,803	6,882,248
% rural HH affording new sanitation facilities	30%	30%	30%	30%	30%	
No rural HH affording new sanitation facilities	445,970	423,258	776,318	12,388	406,741	2,064,674
Urban						
No urban HHs	1,152,951	1,094,236	2,006,988	32,026	1,051,534	5,337,735
No. HH with unimproved sanitation	119,907	113,801	208,727	3,331	109,360	555,124
% rural HH affording new sanitation facilities	30%	30%	30%	30%	30%	
No. rural HH affording new sanitation facilities	35,972	34,140	62,618	999	32,808	166,537
Total value (US$)	**29,971,502**	**31,289,693**	**62,607,137**	**3,330,167**	**na**	**127,198,499**
Rural	27,734,433	28,954,235	57,934,150	3,081,604	na	117,704,422
Urban	2,237,069	2,335,458	4,672,988	248,563	na	9,494,077

Table 32 below shows the potential market size for sanitation outputs, based on market prices and approximate breakdown between labor, materials, equipment and non-purchased items. According to a project on biogas in Vietnam (MARD & SNV), just 1% of total rural households in Vietnam are potential users of biogas system. The market value is estimated at US$202 million, excluding the sales of biogas carbon credits through the Clean Development Mechanism. The values are assumed to be both financial and economic gains, as use of human excreta for fertilizer (US$163.7 million) and biogas generation (US$38.31 million) are expected to lead to cost savings.

Table 32. Sanitation output market values

Variable	Fertilizer	Biogas	Total Value	
			Financial	Economic
Rural	163,702,267	38,306,331	202,008,598	202,008,598
Urban	39,692	9,288	48,980	48,980
Total	**163,741,960**	**38,315,619**	**202,057,578**	**202,057,578**

As well as the narrow definition of sanitation assessed above, a broader definition includes the re-use of agricultural waste. With regards to raw waste materials, agricultural waste in Vietnam is estimated to total 30 million tons per year, consisting mainly of rice straw, husk, and bagasse. If this amount is taken into the energy value, it is equivalent to 20 million tons of dust coal and over 9 million tons of crude oil [10]. This can become a significant source of energy once suitable policy and action plan are developed and implemented.

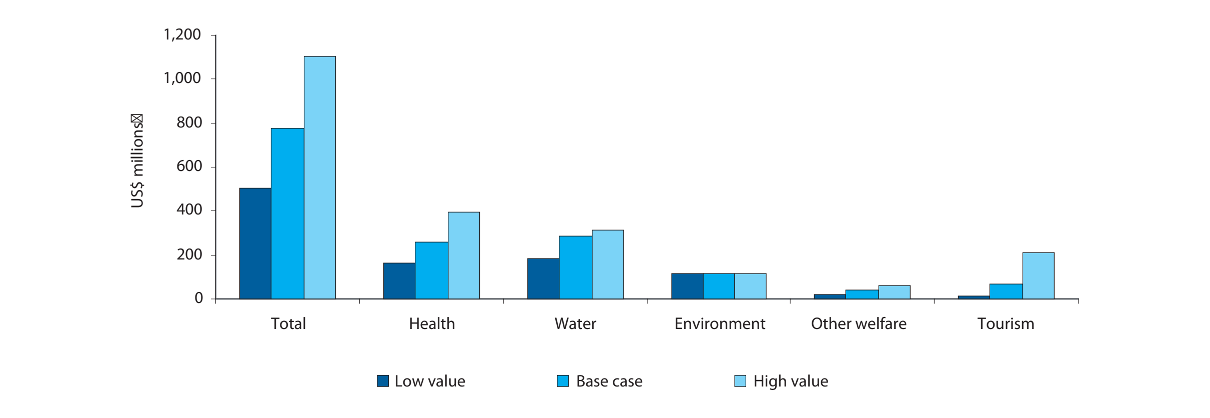
Materially, agricultural waste has not only high energy value but can also be used as inputs for agricultural production and other industries. Agricultural waste can be reused as fuel for households (rice husk, sugar cane leave, rice straw etc), mushroom shelve (rice straw), cattle feed (maize tree), and cage-stuffing materials (rice straw). In addition, if agricultural waste is well managed, it can be the material provision for paper, pressed wood (bagasse), and thermal power production.

3.8 Evaluation of Uncertainty

The present study is based on a range of secondary data and information, which were combined in a model to estimate the impacts of poor sanitation and the potential benefits of improving sanitation. Two major types of uncertainty surround the figures presented above. First, uncertainty exists in the values and assumptions used for the included variables. Second, there is uncertainty due to the fact that some impacts were not included (see section 3,1,2). The first of these was evaluated quantitatively using sensitivity analysis.

One-way sensitivity analysis was applied separately on each impact by identifying some of the key areas of uncertainty, and using lower and upper ranges on selected data inputs. Figure 4 shows the resulting ranges on the five main impacts, which are also added together to give overall lower and upper values.

Figure 4. Ranges in impacts from one-way sensitivity analysis on selected variables



4 Discussion, Conclusions and Recommendations

4.1 Discussion

The primary objective of this study is to generate evidence on the negative effects of poor sanitation in Vietnam, focusing on the impacts on health, water resources, environment, tourism and other welfare indicators. The analysis was implemented using information from government and donor statistics and reports, and from the literature. The study found that poor sanitation leads to annual economic costs amounting to US$780 million or VND 12,544 billion. This is equivalent to 1.3% of GDP 2005. Accordingly, the losses per capita are US$9.38 or VND 151,000. All these estimated economic impacts could potentially be mitigated with improved sanitation options, except the health impacts which are reduced by up to around 50%, depending on the effectiveness of the sanitation or hygiene intervention.

The most important impact this present study can have is to raise awareness of all stakeholders for the purpose of improving the sanitation awareness in Vietnam. It is recommended this will lead to new policies, adoption of new approaches, collaboration with new partners, allocation of increased financial resources, adoption of new financial mechanisms and reinforcement of human resources for sanitation and hygiene. It is hoped that this study can contribute to advocating for the 'Unified Sanitation Sector Strategy and Action Plan' (U3SAP) in Vietnam.

In using secondary data to estimate impacts, and using new methodologies, the figures presented in this study are incomplete and imprecise. However, throughout the analysis, conservative assumptions were used, and combined with the fact that several impacts of poor sanitation were excluded due to lack of data, the quantified results are an underestimate of the true impacts of poor sanitation.

Also, lack of available evidence made it difficult to conduct gender analyses on many of the variables evaluated. Although Vietnam holds a reputation throughout the region for relative gender equality and has been able to close gender gaps in key areas [28], gender inequalities are still a barrier to improvement in water and sanitation. Women currently bear the main burden of problems associated with poor water supply and sanitation, particularly in rural areas. Furthermore, women have the primary responsibility for waste management [29] and for health, hygiene and sanitation in the family. In addition, they have to take charge of the children's hygiene education and to give instructions on personal hygiene and on the use of sanitation facilities. Lack of water and sanitation facilities inconveniences women more than men – for example, women's needs for private and sanitary toilets are much higher than those of men.

The participation of women in the development of sanitation facilities is very crucial. Particular attention should be paid to gender issues and ensuring the representation of women as key decision makers in all aspects of water supply, sanitation and health management, especially in rural families. Women's views and concerns must be expressed and integrated into the design of interventions, such as special privacy, security and ergonomically requirements for both women and children.

The Joint Government - Donor Sector Review in 2005 emphasized the serious challenges facing Vietnam for sustainable sanitation [30]. This has a serious impact on the health of people, and especially affects children, the elderly and the poor who are most vulnerable to water-borne diseases. It also has a serious impact on the environment: concerns over water quality are an issue throughout the country. Furthermore, water and sanitation are clearly referenced in the Comprehensive Poverty Reduction and Growth Strategy (CPRGS) which was approved by the Prime Minister in 2001. Sanitation is seen by the Government as a contributor to ensuring growth and poverty reduction. Therefore, it is necessary to consider further integrating sustainable sanitation into the Socio-Economic Plan of the country and sub-regions, ensuring that the voice of people without water or sanitation or those living in poverty can be listened to in the decision-making process. In this way socio-economic development will be aligned with sustainable growth.

4.2 Recommendations

The central aim of this present study was to generate an evidence base to enable recommendations to be made for improved sanitation policies. This study has identified a broad range of impacts of poor sanitation, and quantified those impacts most amenable to secondary analysis. The following policy recommendations are based on eight major findings of the study:

Major finding 1. Poor sanitation causes significant losses to the national economy
This study has found that poor sanitation is significant economic losses per year in the Vietnam (1.3% of annual GDP). In addition to these quantified impacts, a range of other negative economic and social effects of poor sanitation result. By improving sanitation, a significant proportion of these socio-economic impacts can be mitigated.

Recommendation 1. Decision makers from various sectors are advised to act now
Sanitation 'players' are advised to act now, otherwise the negative impacts of poor sanitation will increase over time. The government and other stakeholders should jointly reassess the current and planned spending levels in the sanitation and related sectors, covering health, water resources, environment, rural and urban planning and development, fisheries, and tourism. Increased political importance and budget allocations should be given to sanitation. Sanitation decision makers should use an evidence-based approach to design efficient sanitation policies and implementation strategies, to increase value-for-money from public and private investments into sanitation.

Major finding 2. Poor sanitation has greater impact on the poor and vulnerable
A greater share of the socio-economic burden of poor sanitation falls on the population currently without improved sanitation – health impacts, time access, water pollution, aesthetics, and land use – hence causing inequities in society. The population group unserved with improved sanitation tends to be the poorer and more vulnerable members of society. A disproportionate share of the burden falls on women, children and the elderly, especially health burden and user preferences such as intangible welfare impacts and life decisions.

Recommendation 2. Governments must define and target the needs of priority groups
The government should give priority to the populations with no latrine, recognizing that effective demand may be low in these groups due to low incomes and poor awareness of the benefits of investing in sanitation. As well as stimulating demand through public health and latrine advocacy messages, governments should target programs, subsidies and financing mechanisms to the most disadvantaged population groups.

Major finding 3. Negative impacts result from several poor sanitary practices
Economic impacts occur not just through the use of unimproved latrines (MDG target), but also through poor hygiene practices, poor isolation of wastewater from the environment and water sources, and poor broader environmental sanitation.

Recommendation 3. Players should broaden the scope of sanitation beyond latrines
As is the aim of the current efforts to unify sanitation in the U3SAP, sanitation investments should not be made just in latrine extension programs, but in improved sludge, water and solid waste management, and in hygiene programs to raise population awareness on personal and community hygiene issues, among others.

Major finding 4. Health-related economic impacts have a significant toll on society
This study has confirmed that the major and most tangible impact of poor sanitation is an increased risk of infectious disease and premature death. This study has shown that economic losses of over US$262 million result from health care costs, health-related productivity costs and premature mortality costs.

Recommendation 4. Health aspects of sanitation programs deserve central focus
The government should focus on the easy health wins from improved sanitation, through targeting children and

focusing on safe but simple latrine designs, improved excreta isolation measures, and improved hygiene practices. Given the key role of hygiene practices in health improvement, high-impact hygiene components should be integrated in the planning and implementation of sanitation programs. The Ministry of Health should (continue to) play a central role in the health aspects of sanitation programs.

Major finding 5. High water pollution levels are partially caused by poor sanitation
The majority of human excreta eventually finds its way to water bodies; so do gray water, animal excreta, solid waste and industrial wastewater (jncluding from trade villages). Together these cause significant water pollution in study countries with associated high economic losses.

Recommendation 5. Sanitation solutions should focus on reducing water pollution
The government should urgently implement sanitation standards that reduce the release of waste matter into water resources. Low technology, low cost and effective options should be explored as a matter of priority. Focus should not be just on excreta, but also solid waste, household, agricultural and industrial wastewater. The contamination of groundwater with microbiological pathogens should be averted through better planning, increased resource allocation, and awareness raising. Water quality monitoring should be conducted to assess the extent and nature of water pollution and to inform populations of which water sources are safe to use.

Major finding 6. Sanitation is linked with sustainable development in many ways
Sanitation has a major role in sustainable development, due to its links to other development goals (e.g. MDGs). Sanitation plays a key but unrecognized role in population welfare, economic growth and poverty reduction. Impacts not fully explored in this study – in particular tourism and the investment climate – are potentially major arguments for improving sanitation in countries, and suggest the adoption of a broader understanding of the term 'sanitation'.

Recommendation 6. Several coordinated measures are needed to improve sanitation
Sanitation cannot be only the responsibility of an individual sector/ministry, nor of a single level of government. The fact that sanitation touches on many sectors and line ministries should be used as a strength rather than hampering progress, and clear roles and responsibilities need to be defined. The development of a policy and regulatory framework for environmental and health protection is crucial and imperative in the context of rapid industrialization and high economic growth in Vietnam. While further progress is needed at the highest levels to ensure political support and resource allocations for sanitation, further emphasis is needed on the implementation levels where sanitation demand must be stimulated and affordable and attractive solutions for sanitation must be available.

Major finding 7. Variability is expected in the actual impacts of poor sanitation
While the national per capita costs in rural and urban areas was not found to be dissimilar, there will exist significant variation in the impacts of poor sanitation between different geographic locations depending on sanitation coverage, demographics, environment, and practices related to health and water consumption.

Recommendation 7. Local as well as national studies should inform sanitation policy
To convince local decision makers such as city mayors or district officers to invest in sanitation, local studies would be more credible in convincing local decision makers that sanitation is a neglected issue. The methodology used in this study can be equally applied to local micro-level studies as well as the national level. Furthermore, local as well as national decision makers need to be informed of the efficiency of different measures to improve sanitation. Local level cost-benefits studies must now be performed to inform national decision makers how to invest efficiently in sanitation.

Major finding 8. Existing data sources are weak for quantifying sanitation impact
This study has used a number of available data sources, but has been limited by lack of specific information on outcomes related to sanitation. With the exception of basic latrine coverage indicators, surveys tend not to include questions related to sanitation, such as expenditure, preferences, access time, health-related time loss, sanitation and hygiene practices, and gender. Questions related to broader sanitation 'coverage' (e.g. waste disposal, environmental

quality) are largely left out. Routine government reporting systems such as health indicators and health service use, and water quality monitoring, only imperfectly capture the substantial impacts of poor sanitation. Water quality is known to be important for fish reproduction, growth and safety for human consumption, but little is known about the exact relationships, and the role poor sanitation plays.

Recommendation 8. Future survey and research work is key in monitoring progress

Surveys and government reporting systems should be assessed for extension to include behavior and outcomes related to sanitation. Selected research studies could fill important gaps in knowledge about the economic and welfare effects of poor sanitation. Further research is required on the population benefits of improved sanitation, and what levels of benefit different types of sanitation option can deliver. A gender perspective is key in understanding the effectiveness of different sanitation options. The link between poor sanitation and tourism and foreign direct investment losses is poorly understood, and merits further assessment. Studies on the value of time and the value of life will allow a better understanding of the importance of the identified health impacts.

Annexes

Annex A: Study Methods

A1. Health impact

Health impacts are usually considered to be one of the most significant impacts associated with poor sanitation and hygiene. Not only do diseases have direct implications for population welfare through health-related quality of life (HRQL), but diseases also have financial and economic impacts, which include spending on health care, loss of income or production, and in the case of premature death, the value of loss of life.

A1.1 Selection of diseases

There are many diseases associated with exposure to human waste due to poor sanitation and poor hygiene practices. These are presented in detail in Annex Table D3. Diseases related to poor sanitation and hygiene can be viral, bacterial, parasitic, protozoal, helminthes, and fungal in nature, and have many pathways: fecal-oral, fecal-skin, urine-oral, and fecal-eye; the main one being fecal-oral [31, 32]. According to the F-diagram, pathogens can be passed from the feces through fluids, fields, flies and fingers [33]. In addition, food can act as an intermediary for all of these four direct transmission pathways. The principle 'poor practices' which support heightened transmission of disease from human waste include an unsanitary toilet area, poor personal hygiene practices following toilet-going, open defecation in the fields or water sources, lack of protection or treatment of drinking water, poor food preparation practices, and lack of latrine and water-source protection in flood-prone areas.

Given the large number of diseases and health effects due to poor sanitation, this present study selected the key health impacts based on their epidemiological and economic importance. The availability of health data from national statistics, local research studies and international sources also played an important role in determining which diseases to include. Table A1 below presents data available from the national health information system in Vietnam on number of cases and deaths from key sanitation and hygiene-related diseases. Although these data are not representative of the total disease burden at national level due to underreporting, these data do provide an indication of which diseases are of most significance nationally to aid selection of diseases to include in this present study.

In addition, exposure to household solid waste, agricultural and industrial wastes can also lead to disease and premature death, from contact with toxic materials or otherwise dangerous substances. With respect to solid waste, health impact on population in the vicinity of dumps and landfills is very high. They are exposed to high levels of dust, germs, noxious substances, rodents and insect bites, which can result in various diseases like flu, dysentery, fever, tuberculosis, diarrhea, rash and scabies, asthma, pneumonia, parasites, articulation disorders and eye infections and bronchitis. The risk is even higher for waste pickers working in the dump sites. Waste pickers are exposed to bruises, factures, injuries and death. These diseases and occupational health problems are not considered in this present study due to time constraints and lack of routinely available data sources.

Table A1 shows that diarrhea diseases accounted for 964,420 cases in 2005. Diarrhea is also the major sources of death due to poor sanitation and hygiene. Malnutrition is considered as an important disease related to sanitation and hygiene since there are nearly 1,800,000 children under five years of age suffering from malnutrition. Although the prevalence of helminthes and scabies are not high compared to diarrhea and malnutrition, these diseases are included because of their obvious links to poor sanitation and hygiene.

Trachoma is endemic in Vietnam. For decades, trachoma control has been an important part of Vietnam's health agenda. Globally, it is estimated that there are 3.8 million cases of blindness and 5.3 million cases of low vision in countries known or suspected to have trachoma, resulting in $2.9 billion in lost productivity to low vision or blinding trachoma [34]. In Vietnam, through trichiasis surgery, antibiotic treatment and health and hygiene education, the national prevalence of active disease decreased considerably from 17.5% in 1975 to 7% in 1995 [35]. According to a recent study carried out in 2006 by the International Trachoma Institute (ITI) and their main partners, the MOH and the Institute for Ophthalmology, the trachoma prevalence rate is estimated at 1.76% in 2006 [35]. This study indicates that there are still districts where trachoma remains a public health problem. In the central and northern areas, trachoma prevalence is still high, especially in children.

Annex Table A1. Importance of sanitation and hygiene-related diseases, total cases and total deaths (2005)

Disease	Morbidity		Annual reported deaths
	Cases	Cases per population	
Diarrheal diseases	964,420	0.0116028	42
Helminthes (worms)[1]	24,545	0.0002953	-
Trachoma[2]	982,667	0.0118223	-
Scabies[3]	206,137	0.0024800	-
Hepatitis A	7,834	0.0000942	-
Malnutrition (under fives)	1,818,939	0.0218833	-
Diseases associated with malnutrition (under fives)	596,046	0.0071709	2,494
ALRI (Pneumonia)	488,610	0.0058784	2,476
Measles	8,160	0.0000982	-
Malaria	99,276	0.0011944	18

Source: MOH Yearbook [36]

[1] Prevalence of helminthes is sourced from the survey on soil-transmitted nematodes by Institute of Malaria, Parasitology and Entomology/ MOH in 2006-2007

[2] Prevalence of trachoma is sourced from the survey on trachoma by Department of Preventive Medicine/MOH in 2007

[3] Incidence of scabies is assumed to be 20% of reported skin disease as there is no information on scabies specifically

A1.2 Health care cost estimation

Health care costs result from diseases associated with sanitation and hygiene. In order to estimate health costs related to disease, it is necessary to compile information on disease rates for the selected diseases, treatment seeking rates, as well as health systems variables such as treatment practices and unit costs.

Health care costs can fall on both the patient and the public health system, depending on where the sick person seeks care from and the tariff rates in public facilities. Private health care is assumed to be fully financed by the patient. Nationally, total expenditure on drugs accounted for 50% of total health expenditure and the annual drug expenditure per capita was US$8.6 in 2005 [37]. Costs are both financial and economic in nature. Financial costs include the marginal cost to treat patients at public facilities (mainly drugs), patient transport costs, as well as the full costs of treatment in private clinics or self-treatment. Economic cost includes the financial costs *plus* the short-term fixed costs of public health facilities such as staff, capital items and overheads.

Annex Table A2. Treatment seeking behavior, by provider

Disease	% seeking treatment from:		Self-treatment	No treatment
	Public provider	Private clinic		
Nationwide[1]	**12.18%**	**17.32%**	**65.94%**	**4.56%**
Rural	12.33%	16.81%	66.09%	4.77%
Urban	11.64%	19.23%	65.36%	3.77%
Diarrhea diseases	**964,420**	**1,370,737**	**5,219,670**	**360,960**
Nationwide	3.00%	8.00%	66.00%	23.00%
Rural	5.00%	10.00%	50.00%	35.00%
Urban	2.00%	5.00%	70.00%	23.00%
Helminthes	**24,545**	**34,886**	**132,845**	**9,187**
Nationwide	2.00%	8.00%	70.00%	20.00%
Rural	5.00%	10.00%	60.00%	25.00%
Urban	1.00%	4.00%	80.00%	15.00%
Trachoma	**982,667**	**-**	**-**	**-**
Nationwide	100.00%	0.00%	0.00%	0.00%
Rural	90.00%	0.00%	0.00%	0.00%
Urban	10.00%	0.00%	0.00%	0.00%
Scabies	**206,137**	**292,985**	**1,115,665**	**77,152**
Nationwide	1.00%	4.00%	85.00%	10.00%
Rural	2.00%	5.00%	80.00%	13.00%
Urban	0.00%	2.00%	90.00%	8.00%
Hepatitis A	**7,834**	**11,135**	**42,399**	**2,932**
Nationwide	10.00%	18.00%	55.00%	17.00%
Rural	10.00%	15.00%	50.00%	25.00%
Urban	20.00%	20.00%	55.00%	5.00%
Malnutrition	**1,818,939**	**-**	**-**	**-**
Nationwide	100.00%	0.00%	0.00%	0.00%
Rural	70.00%	0.00%	0.00%	0.00%
Urban	30.00%	0.00%	0.00%	0.00%
ALRI (Pneumonia)	**488,610**	**694,466**	**2,644,476**	**182,875**
Measles	**8,160**	**11,598**	**44,164**	**3,054**
Malaria	**99,276**	**141,102**	**537,305**	**37,157**

Source: [8]

In order to estimate the costs of health care, it is necessary to know the total number of cases seeking health care from different providers. Given that government statistics are often incomplete, public facility treatment seeking figures were adjusted to reflect the total cases seeking care. Table A2 shows data extracted from the National Health Survey 2001 - 2002, which shows where households seek care from for different diseases. Given the lack of alternative data on treatment seeking, these figures are assumed to apply to diseases associated with poor sanitation and hygiene.

Table A2 shows that self treatment is the most common behavior, accounted for 65.9% of total cases. The treatment seeking behavior slightly varies by urban and rural areas, and by disease. Nationally, public provider treats 12.18% of total cases, while private clinics treat 17.32% of those.

Based on the number of reported cases in the public health system, and the place of treatment seeking (Table A2), the total cases seeking treatment can therefore be estimated for each disease, for each health care provider, and for each region of the country. Table A3 below presents the figures after they have been adjusted for attribution to poor sanitation and hygiene: 90% for diarrhea [31], 48% for malnutrition [32], 100% for helminthes, 80% for scabies and trachoma, and 60% for Hepatitis A. For diseases related to malnutrition, attributable fractions of disease incidence for these diseases to malnutrition are 10.4% for ALRI/pneumonia and 4.1% for malaria, using regional estimates from Fishman et al for the Western Pacific Region [38].

Annex Table A3. Estimated numbers of cases seeking care from different providers (attributed to poor sanitation and hygiene)

Disease	Attribution to Sanitation	Public sector			Private clinic	Self-treatment	No treatment
		Reported cases	% under-reported	Estimated attributed cases			
Diarrhea diseases	88%	964,420	10%	933,559	1,206,249	4,593,310	317,645
Helminths	100%	24,545	10%	27,000	34,886	132,845	9,187
Trachoma	80%	982,667	10%	864,747	-	-	-
Scabies	80%	206,137	10%	181,401	234,388	892,532	61,722
Hepatitis A	60%	7,834	10%	5,170	6,681	25,440	1,759
Malnutrition	48%	1,818,939	10%	960,400	-	-	-
ALRI	5%	784,792	10%	43,095	55,682	212,034	14,663
Malaria	2%	110,032	10%	2,382	3,078	11,720	810

In order to calculate the costs associated with the cases seeking health care, it is necessary to know the treatment practices, the proportion of cases that are admitted for inpatient stay, and the costs associated with health care. Table A3 shows these variables for treatment seekers who receive their care on an outpatient basis from public providers, formal private providers, informal care, and self-treatment. For diarrheal disease**,** information from the study on health care costs of diarrhea disease in Khanh Hoa province is used [39]. For ALRI, the costs were based on the costing exercise to establish a case-based cost tariff covering 29 diseases, a recently published study by the Ministry of Health [37]. Annex Table A5 and D4 provide more information on those studies. For other diseases, data were generated through consultations and interviews with doctors from the Ministry of Health, its institutes and hospitals. The interviews were used to identify key variables, including duration of diseases for severe and non-severe cases, medical treatment requirements and related costs. The drug cost for helminthes is based on practices by MOH/WHO helminthes program in Vietnam for the last 5 years, which use a single dose of albendazole/mebendazole in accordance with WHO guidelines.

Annex Table A4 shows the unit costs for treatment seekers who receive their care on an outpatient basis from hospitals. It indicates that the financial cost for diarrhea is US$3.76 and US$3.98 for urban and rural areas, respectively [39].

Annex Table A4. Health service use and unit costs associated with outpatient care

Provider and disease	Financial cost[1]		Economic Cost[1]					
	Urban	Rural[2]	Urban			Rural		
	Diagnostics and Medical Cost	Diagnostics and Medical Cost	Diagnostics and Medical Cost	Cost per Visit	Non-medical cost (Transport etc.,)	Diagnostics and Medical Cost	Cost per Visit	Non-medical cost
Public provider								
Diarrhea diseases	3.76	3.98	3.76	0.25	0.58	3.98	0.13	1.35
Helminthes	0.50	0.55	0.50	0.25	0.58	0.55	0.13	1.35
Trachoma	17.00	18.70	17.00	0.25	0.58	18.70	0.13	1.35
Scabies	2.00	2.20	2.00	0.25	0.58	2.20	0.13	1.35
Hepatitis A	10.00	11.00	10.00	0.25	0.58	11.00	0.13	1.35
Malnutrition	20.00	22.00	20.00	0.25	0.58	22.00	0.13	1.35
ALRI	8.00	8.80	8.00	0.25	0.58	8.80	0.13	1.35
Malaria	10.00	11.00	10.00	0.25	0.58	11.00	0.13	1.35
Private provider								
Diarrhea diseases	3.05	3.49	3.05	0.66	0.47	3.49	0.53	1.13
Helminthes	0.50	0.55	0.50	0.66	0.47	0.55	0.53	1.13
Trachoma	17.00	18.70	17.00	0.66	0.47	18.70	0.53	1.13
Scabies	2.00	2.20	2.00	0.66	0.47	2.20	0.53	1.13
Hepatitis A	10.00	11.00	10.00	0.66	0.47	11.00	0.53	1.13
Malnutrition	20.00	22.00	20.00	0.66	0.47	22.00	0.53	1.13
ALRI	8.00	8.80	8.00	0.66	0.47	8.80	0.53	1.13
Malaria	10.00	11.00	10.00	0.66	0.47	11.00	0.53	1.13
Self-treatment[3]								
Diarrheal diseases	2.68	3.00	2.68	0.20	0.40	3.00	0.17	0.92
Helminthes	0.50	0.55	0.50	0.20	0.40	0.55	0.17	0.92
Trachoma	17.00	18.70	17.00	0.20	0.40	18.70	0.17	0.92
Scabies	2.00	2.20	2.00	0.20	0.40	2.20	0.17	0.92
Hepatitis A	10.00	11.00	10.00	0.20	0.40	11.00	0.17	0.92
Malnutrition	20.00	22.00	20.00	0.20	0.40	22.00	0.17	0.92
ALRI	8.00	8.80	8.00	0.20	0.40	8.80	0.17	0.92
Malaria	15.00	16.50	15.00	0.20	0.40	16.50	0.17	0.92

(1) All cost figures reflect the cost per outpatient consultation
(2) Rural cost is estimated 10% higher than urban cost
(3) Self treatment is considered to have the same value as treated in Polyclinic/CHC
Exchange rate US$1 = VND 16,080 to local currency, on 1 June 2007

Annex Table A5 shows the same variables for inpatient care for public and formal private providers, including the proportion of cases admitted, average length of stay per patient, and associated costs per inpatient day. The same source of information is used for diarrhea disease. Financial cost is US$3.25 and US$9.25 per day for urban and rural areas, respectively, and average admission day per inpatient is US$4.55 [39]. The study assumes that no inpatient day is required for helminthes, trachoma and scabies.

Annex Table A5. Health service use and unit costs associated with inpatient care

Provider and disease	Number of cases admitted	Days admission per patient	Financial cost				Economic Cost					
			Urban		Rural		Urban			Rural		
			Diagnostics and Medical Cost	Transportation Cost	Diagnostics and Medical Cost (1)	Transportation Cost (1)	Diagnostics and Medical Cost	Bed Cost per Day	Non-medical Patient Cost (Transportation etc.,)	Diagnostics and Medical Cost	Bed Cost per Day	Non-medical Patient Cost (Transportation etc.,)
Public provider												
Diarrhea diseases	66,376	4.55	3.25	4.74	9.25	4.37	3.25	5.55	4.74	9.25	1.74	4.37
Helminths	-	-	-	0	-	-	-	-	0	-	-	-
Trachoma	-	-	-	0	-	-	-	-	0	-	-	-
Scabies	-	-	-	0	-	-	-	-	0	-	-	-
Hepatitis A	368	5.00	10.00	2.47	11.00	2.72	10.00	3.65	2.47	11.00	3.65	2.72
Malnutrition	-	-	-	0	-	-	-	-	0	-	-	-
ALRI	3,064	7.00	8.00	2.47	8.80	2.72	8.00	3.65	2.47	8.80	3.65	2.72
Malaria	169	2.00	10.00	2.47	11.00	2.72	10.00	3.65	2.47	11.00	3.65	2.72
Private provider												
Diarrhea diseases	85,764	4.55	1.37	1.00	1.51	1.10	1.37	3.65	1.00	1.51	3.65	1.10
Helminths	-	-	-	0	-	-	-	-	0	-	-	-
Trachoma	-	-	-	0	-	-	-	-	0	-	-	-
Scabies	-	-	-	0	-	-	-	-	0	-	-	-
Hepatitis A	475	5.00	10.00	2.47	11.00	2.72	10.00	3.65	2.47	11.00	3.65	2.72
Malnutrition	-	-	-	0	-	-	-	-	0	-	-	-
ALRI	3,959	7.00	8.00	2.47	8.80	2.72	8.00	3.65	2.47	8.80	3.65	2.72
Malaria	219	2.00	10.00	2.47	11.00	2.72	10.00	3.65	2.47	11.00	3.65	2.72

** Data for helminthes, trachoma and scabies not available, as usually treated on outpatient basis*
Exchange rate US$1 = VND 16,080 to local currency, on 1 June 2007

A1.3 Health-related productivity cost estimation

Disease takes people away from their occupations and daily activities, and regular sickness-related absences from school affects the ability of children to keep up with the curriculum and complete their education. Therefore, time lost from work, school or daily activities has a value.

Given that time off work is determined by the severity of the disease, as well as whether the case was treated or not, assumptions were made on the proportion of cases that are severe, and the treatment seeking behavior associated with these cases. Annex Table A6 shows the data inputs for diarrhea and other diseases.

Annex Table A6. Variables for estimating amount of time lost from disease

Disease	% cases		Days off daily activities			
			Treated		Not treated	
	Severe	Non-severe	Severe	Non-severe	Severe	Non-severe
Diarrhea diseases	4.2	95.8	5.0	2.0	2.0	1.0
Helminthes	12.2	87.8	2.0	-	1.0	-
Trachoma	12.2	87.8	3.0	-	1.0	-
Scabies	12.2	87.8	1.0	-	1.0	-
Hepatitis A	12.2	87.8	30.0	5.0	30.0	5.0
Malnutrition	12.2	87.8	7.0	5.0	7.0	5.0
ALRI	12.2	87.8	7.0	1.0	10.0	1.0
Malaria	12.2	87.8	10.0	5.0	5.0	3.0

Given that time off work has an opportunity cost, and in some instances a real financial loss, time away from daily activities needs to be given a unit value to estimate overall financial and economic losses associated with disease. A commonly applied economic valuation technique for time loss is the human capital approach (HCA), which values time loss according to what the sick person could be earning in productive employment. Even when the person would not be earning income (especially in the case of children), time for leisure and other activities can be assumed to have a value greater than zero [40-43]. A second common approach, which measures the sick person's willingness to pay to avoid disease, can more accurately reflect the welfare effects of disease, but due to lack of data on willingness to pay, this approach is not used in this study. Hence HCA is used as it is simple and it reflects the time loss component of disease.

This study distinguishes between financial and economic cost. For some adults, time spent away from productive activities will have a direct income-loss, while for others the salary may be paid for a maximum number of sick days per year. Given the self-employed and/or agricultural nature of agrarian societies of many Southeast Asian countries, loss of time from productive activities may not have immediate financial loss, but may lead to income-losses in the future unless a family member or business partner replaces their lost labor. In order to be conservative, financial cost is estimated as immediate income loss for those not paid their wage or earning an income from time lost due to sickness. For each country, this population is estimated based on the available published literature and interpretation of official statistics according to local work patterns and conditions.

For those not directly losing income, there will also be a welfare loss, which may include longer-term income-earning potential as mentioned above. In estimation of economic cost, this study recognizes the value of time lost from daily activities, whether productive working time, school time, or leisure time. Given that value of time varies according to what the person is doing with their time, economic 'welfare' losses are valued at less than the financial losses described above. Research studies have shown a whole range of results on the value of time. This present study takes the economic value of time as 30% of the unit value of time. Furthermore, this study distinguishes between the value of adults and of children's time, given that children do not generally have the same values as adults. On the other hand, children's time is not worthless, given that children are or should be at school learning and hence time away from school would mean lost education and eventually lower income levels [44]. Also, for young children of non-school age, sickness will involve more time input from a carer, and hence incur a cost. In study countries, caring for a child is mostly the mother's task and thus ill children are more likely to take the time of women than men, thus hindering women from working. Given the limited empirical work on the value of children's time, and very few precedents in terms of valuing children's time, a time value of 50% of adults time is given in this present study [45].

Annex Table A7. Variables for estimating amount of time lost from disease

Disease	% cases		Days off daily activities			
			Treated		Not treated	
	Severe[1]	Non-severe	Severe	Non-severe	Severe	Non-severe
Diarrhea	29.5%	70.5%	5.0	2.0	2.0	1.0
Helminthes	29.5%	70.5%	2.0	-	1.0	-
Trachoma	29.5%	70.5%	3.0	-	1.0	-
Scabies	29.5%	70.5%	1.0	-	1.0	-
Hepatitis A	29.5%	70.5%	30.0	5.0	30.0	5.0
Malnutrition	29.5%	70.5%	7.0	5.0	7.0	5.0
ALRI	29.5%	70.5%	7.0	1.0	10.0	1.0
Malaria	29.5%	70.5%	10.0	5.0	5.0	3.0

(1) Severe mean cases which have to taken into public or private hospital
(2) Non severe mean cases which can be treated themselves
(3) For not treated, assume no-treatment number; distribute by percentage of severe and non-severe

Table A8 shows some alternative sources of economic value, comparing GDP per capita, and average income. The annual value was converted to hourly value by assuming 8 working hours per day, and 255 working days (public holiday and annual leave subtracted). Hourly average income wages were converted to annual figures by using the reverse calculation.

Annex Table A8. Comparison of alternative sources of time value

GDP per capita		Average compensation of employees		Minimum wage	
Annual	Hourly	Annual	Hourly	Annual	Hourly
723	0.12	411	0.07	261	0.04

Sources: GDP: World Bank; Average income: VHLSS (2004) adjusted to 2005 prices using inflation rate of 6.6%.

Vietnam is still faced with a high prevalence of chronic malnutrition among the under five population and high prevalence of low birth weight babies. Besides treatment costs, evidence for the relationship between malnutrition and future productivity comes from an extensive literature spanning several fields including nutrition, physiology, economics and history, reviewed recently by Martorell [46]. The Nobel Prize-winning economic historian Robert Fogel demonstrated that about 30% of the rise in productivity in Europe during the last 200 years was directly due to improvements in nutrition [47]. The underlying mechanism for the relationship between nutrition and productivity is not well-understood. A recent UNICEF-funded study (Profiles Vietnam) indicated that low birth weight causes a loss of US$41 million in 2010, most of which is explained by long-term productivity loss [48]. However, these long-term productivity costs are not taken into account in this present study.

A1.4 Premature death cost estimation

Cost of premature death is calculated by multiplying the number of deaths by the unit financial and economic value of a death. Considerable mortality is from poor sanitation as shown in Annex Table A9 below. Diarrheal disease is estimated to cause at least 4,579 deaths annually, almost 90% of which are children under five years of age.

Annex Table A9. Estimated number of annual deaths from poor sanitation & hygiene

Disase	Age grouping		Total
	Under 5	Over 5	
Diarrheal diseases	4,136	440	4,576
ALRI	1,475	-	1,475
Measles	335	-	335
Malaria	631	-	631

Source: "Environmental Health and Child Survival: Epidemiology, Economics, Experiences," Environment and Development Series 3. World Bank: Washington DC, 2007

Premature death affects society in a number of ways, and has proven to be difficult to value with any degree of precision. As a result, economists have employed a range of methods for valuing premature loss of human life [49]. The most tangible economic impact of premature death is the loss of a member of the workforce, with implications for the economic outputs generated. Hence, this approach, what has been termed the 'human capital approach' (HCA) approximates the welfare loss by estimating the future discounted income stream from a productive person, from the time of death until the end of (what would have been) their productive life. However, this technique has been criticized for that fact that it values human life exclusively for its productive potential. Empirical evidence indeed proves that life has a value beyond the productive worth of a human, which both society as a whole and individuals are willing to pay for in order to safeguard [50, 51].

Various other methods are available to estimate this broader economic as well as inherent worth of human life:

1. Observations about actual market and individual behavior with respect to what they pay to reduce the risk of death (e.g. safety measures) or what they are willing to accept for an increase in the risk of death (e.g. wage premium for risky jobs). This approach is known as 'hedonic pricing'.
2. Stated preference from individuals exposed to risk, using interview technique. This approach is known as 'contingent valuation'.

Both these approaches estimate directly the willingness to pay of individuals, or society, for the reduction in the risk of death, and hence are more closely associated with actual welfare loss compared with the human capital approach.

The problem in valuing life is that the alternative methods can give very different estimates of the value of life, and applications of the same techniques to different contexts can also reveal very different implicit values in reducing the risk of death. For example, willingness to pay studies generally show greater value of life than the human capital approach. These variations and differences will affect the credibility of economic studies when used for policy decisions, and hence considerable care is needed in estimating and presenting the economic impact of premature loss of life to policy makers. Therefore, in order to sound more plausible to policy makers, this present study uses the more conservative human capital approach, described below. Sensitivity analysis explores the implications of alternative values for loss of human life using the willingness to pay approach.

Human capital approach

The human capital approach summates the future years of income at the average age of death. Given lack of data on exact age of death, three time points of death were used: 2 years of age for the 0-4 age group; 9 years of age for the 5-14 age group; and 40 years of age in the 15+ age group. The discount rate applied was 3%, reflecting the social rate of time preference approximated by the long-term real interest rate. Also, given that per capita income grows over time, a presumed long-term per capita income growth of 2% was applied to future incomes. Average income was taken from the average compensation of employees for each country. For the younger age groups who will not be in the work force for several years, the net present value of future earnings are further discounted to take this into account. Values are shown in Table A18.

Financial costs of premature death were approximated using the human capital approach by assuming a coping period following the loss of an adult member of the family. The coping period could be the period after which the income of the lost adult is expected to be replaced. A period of 1 year is conservatively used in this study. Therefore, the average compensation of employees for a single year is applied to the number of adult deaths to estimate the financial impact of premature death. The average annual compensation of employees used is US$411 in Vietnam.

Willingness to pay approach

Given the lack of estimates of willingness to pay for avoiding death in developing countries, and Southeast Asian countries in particular, the benefits-transfer method was applied for the willingness to pay method. This essentially involves taking value-of-statistical-life (VOSL) values from a meta-analysis of studies in developed countries and transferring the value directly using an adjustment for differences in income. While this approach has many weaknesses [52], the absence of data from developing countries justifies the use of this "benefits transfer" approach. The VOSL reported in North American and European studies is highly variable, ranging from around US$1 million to more than US$10 million [50, 53-57]. A meta-analysis of 40 VOSL studies reported by Bellavance et al in 2007 reported average VOSL of US$9.5 million and median VOSL of US$6.6 million [58], similar to the mean estimate of US$5.4 million found by Kochi et al (2006) [59]. Developing country studies are few. A study of the Indian labor market found VOSL varying from roughly US$0.14 to US$0.38 million [60]. Given the large number of studies from OECD countries, an adjusted benefit transfer is justified rather than transfer from a single study from a comparable developing country. In order to remain highly conservative, a VOSL estimate of US$2 million is used, which is significantly lower than the values presented in the meta-analyses conducted by Bellavance (2007) [58] and Kochi (2006) [59], but consistent with the mid-range in the meta-analysis conducted by Mrozek and Taylor (2002) [61]. This value also reflects the lower end of the US$2 million to US$4 million recommended by Abelson for public policy [50].

The VOSL of US$2 million is transferred to the study countries by adjusting downwards by the ratio of GDP per capita in each country to GDP per capita in the USA. The calculation is made at both official exchange rates (more conservative) as well as at purchasing power differences (less conservative), and assuming an income elasticity of 1.0. Direct exchange from higher to lower income countries implies an income elasticity assumption of 1.0, which may not be true in practice. Therefore, the benefits transfer from OECD studies was also made at income elasticity of 0.8 and 0.6. Values are shown in Table A10.

Annex Table A10. Unit values for economic cost of a premature death, in US$2005

Human capital approach[1]			Willingness to pay using benefits transfer[2]		
0-4 years	5-14 years	15+ years	IE = 1.0, at OER	IE = 0.8, at OER	IE = 0.6, at OER
25,464	30,056	15,961	33,059	75,100	170,603

[1] Low and high values are produced by using income growth of 1% and 4% (base case 2%)

[2] Low and high values are produced by using US$1 and US$4 million as VOSL (base US$2 million). IE = income elasticity. OER = official exchange rates.

A1.5 Disease burden from diseases indirectly related to poor sanitation[3]

The approach used here to estimate the indirect health effects of sanitation (via malnutrition) in children is as follows:

(a) the effect of diarrheal infections on children's nutritional status is first determined from a review of the research literature;
(b) counterfactual nutritional status is then estimated, i.e., the nutritional status that would have prevailed in the absence of diarrheal infections; and
(c) health effects of currently observed nutritional status and health effects of counterfactual nutritional status are estimated.

The difference in health effects of observed vs counterfactual nutritional status is then the indirect health effects of diarrheal infections, caused largely by poor sanitation.

Commonly used indicators of poor nutritional status are underweight, stunting and wasting.[4] Underweight is measured as weight-for-age (WA) relative to an international reference population.[5] Stunting is measured as height-for-age (HA), and wasting is measured as weight-for-height (WH). Underweight is an indicator of chronic or acute malnutrition or a combination of both. Stunting is an indicator of chronic malnutrition, and wasting an indicator of acute malnutrition. Underweight status is most commonly used in assessing the risk of mortality and morbidity from poor nutritional status.

A child is defined as mildly underweight if his or her weight is in the range of -1 to -2 standard deviations (SD) below the weight of the median child in the international reference population, moderately underweight if the weight is in the range of -2 to -3 SDs, and severely underweight if the child's weight is below -3 SD from the weight of the median child in the reference population. The standard deviations are also called z-scores and noted as WAZ (weight-for-age z-score).

Repeated infections, and especially diarrheal infections, have been found to significantly impair weight gains in young children. Studies documenting and quantifying this effect have been conducted in communities with a wide range of infection loads in a diverse group of countries such as Bangladesh ([62], [63], [64]), Gambia ([65], [66]), Guatemala ([67]), Guinea-Bissau ([68]), Indonesia ([69]), Mexico ([70]), Peru ([71]), Philippines ([72]), Sudan ([73]), and Tanzania ([74]).

These studies typically find that diarrheal infections impair weight gains in the range of 20-50 percent. A mid-point – i.e., 35 percent of children's weight deficit - is here attributed to diarrheal infections to estimate the indirect disease burden from sanitation.[6] So in the absence of weight retarding infections, the weight-for-age z-score (WAZ) of an underweight child would be approximately 40 percent greater than the observed z-score (i.e., observed WAZ*(1-0.4)).[7] For instance, if a child has a WAZ=-3, then in the absence of weight retarding infections, the child's WAZ would be -1.8.

Prevalence of underweight malnutrition rates are presented in Table A11. Current rates are for the most recent year available. None of the countries officially report the prevalence of mild underweight. Mild underweight is however

3 This section is largely based on Larsen B. Cost of environmental health risk in children under 5: Accounting for malnutrition in Ghana and Pakistan. Background report prepared for the World Bank study on malnutrition and environmental health. 2007. Washington DC: World Bank.
4 Micronutrient deficiencies are not explicitly evaluated here, but are found in other studies to have a significant cost (World Bank, 2006; Horton and Ross, 2003; Horton, 1999). Also, Alderman and Behrman (2006) find a significant cost associated with low birth weight, which in part is caused by low maternal pre-pregnancy body mass index (Fishman et al, 2004).
5 The international reference population is defined by the National Center for Health Statistics (NCHS standard), United States or by the World Health Organization's international reference population.
6 A child's weight deficit is the difference in weight between the child's observed weight and the weight of the median child in the international reference population.
7 This is calculated using the WHO Anthro 2005 software.

important in relation to increased risk of child mortality [75]. This rate was therefore calculated for Cambodia and Indonesia from the original household data in the Cambodia DHS 2005 and the Indonesia National Socioeconomic Survey 2005. For the Philippines and Vietnam, the rate of mild underweight is assumed to be about the same as in Indonesia.

Counterfactual prevalence rates of underweight, i.e., prevalence rates in the absence of weight retarding infections where calculated for Cambodia using the original household data in the Cambodia DHS 2005. This was performed through the following procedure: Counterfactual WA z-scores were calculated for each underweight child in the survey using the formula discussed above (i.e., WAZ reported for each child in the survey multiplied by (1-0.4)). Counterfactual underweight prevalence rates were then tabulated using the counterfactual WA z-scores. The results are presented in Annex Table A11. The original survey data in Indonesia, the Philippines and Vietnam were not readily available for this purpose. Counterfactual prevalence rates were therefore estimated using counterfactual rates calculated for Ghana and Pakistan [76]. These comparator countries, along with Cambodia, reflect a sufficient range of counterfactual prevalence rates to estimate such rates for Indonesia, the Philippines and Vietnam.[8]

In the absence of diarrheal infections, it is estimated that practically no children would be severely underweight and the prevalence of moderate underweight would be as low as 2-3 percent. The prevalence of mild underweight would increase significantly in Cambodia, slightly in Indonesia and the Philippines, and remain the same in Vietnam.

Various health and debilitating effects from malnutrition are documented in the research literature. This includes long term chronic illnesses from low birth weight, effects of iodine, vitamin and iron deficiencies, and impaired cognitive development (United Nations, 2004; World Bank, 2006). The focus here is on mortality and morbidity in children < 5 years associated with underweight.

Fishman et al (2004) present estimates of increased risk of cause-specific mortality and all-cause mortality in children under 5 with mild, moderate and severe underweight from a review of available studies. Severely underweight children (WA < -3 SD) are five times more likely to die from measles, eight times more likely to die from ALRI, nearly 10 times more likely to die from malaria, and twelve times more likely to die from diarrhea than non-underweight children (WA > - 1 SD). Even mild underweight doubles the risk of death from major diseases in early childhood (Table A12).

Annex Table A11. Current and estimated counterfactual underweight prevalence rates in children under 5

Prevalence	Cambodia	Indonesia	Philippines	Vietnam
Current prevalence rates				
Severe underweight (< - 3 SD)	6.6%	8.8%	8.8%[1]	3.3%
Moderate underweight (-2 to -3 SD)	29.1%	19.2%	19.2%[1]	18.6%
Mild underweight (-1 to -2 SD)	38.5%	29.3%	29.3[1]	30.0%[2]
Non-underweight (> -1 SD	25.9%	42.7%	42.7%	48.1%
Counterfactual prevalence rates				
Severe underweight (< - 3 SD)	0.07%	0.10%	0.10%	0.05%
Moderate underweight (-2 to -3 SD)	3.0%	2.0%	2.0%	2.0%
Mild underweight (-1 to -2 SD)	47.7%	32.0%	32.0%	30.0%
Non-underweight (> -1 SD	49.2%	65.9%	65.9%	68.0%

Source: Current prevalence rates – Cambodia DHS 2005; Indonesia National Socioeconomic Survey 2005 (SUSENAS); Philippines National Nutrition Surveys 2003 (ENRI); Vietnam Health Statistics Yearbook 2005 (data from National Institute of Nutrition).
[1] Moderate and severe underweight prevalence combined was 28% in the Philippines, and is not reported separately. Nor does the Philippines

8 Current underweight prevalence rates in Vietnam are very similar to rates in Ghana. Current rates in Indonesia and the Philippines are between the rates in Ghana and Pakistan.

report the prevalence of mild underweight. The combined rate of moderate and severe underweight is the same as in Indonesia. Mild, moderate and severe underweight prevalence in the Philippines is therefore assumed to be the same as in Indonesia.
[2] Vietnam does not report mild underweight prevalence rate. It is therefore assumed to be about the same as in Indonesia and the Philippines.

Annex Table A12. Relative risk of mortality from mild, moderate and severe underweight in children under 5

Weight-for-age (WA)	< - 3 SD	-2 to -3 SD	-1 to -2 SD	> - 1 SD
Pneumonia/ALRI	8.1	4.0	2.0	1.0
Diarrhea	12.5	5.4	2.3	1.0
Measles	5.2	3.0	1.7	1.0
Malaria	9.5	4.5	2.1	1.0
Other causes of mortality[1]	8.7	4.2	2.1	1.0

Source: Fishman et al (2004). [1] Not including mortality from perinatal conditions.

Child underweight also increases the risk of illness. Fishman et al (2004) present estimates of increased risk in children u5 with moderate and severe underweight (WA < - 2 SD). The largest increased risk of illness is for pneumonia/ALRI. No increased risk of measles is confirmed (Annex Table A13).

Annex Table A13. Relative risk of illness from moderate and severe underweight in children under 5

Weight-for-age (WA)	< - 2 SD	> - 2 SD
Pneumonia/ALRI	1.86	1.0
Diarrhea	1.23	1.0
Measles	1.00	1.0
Malaria	1.31	1.0

Source: Fishman et al (2004).

These relative risk ratios can be applied to the underweight prevalence rates in Annex Table A11 to estimate attributable fractions (AF) of mortality and morbidity from diarrheal infections through their effect on nutritional status (underweight status).[9] The following formula is used to calculate attributable fractions of ALRI, measles, malaria, and "other causes" of mortality, and attributable fractions of ALRI and malaria morbidity incidence from diarrheal infections:

$$AF = \frac{\sum_{i=1}^{n} P_i RR_i - \sum_{i=1}^{n} P_i^C RR_i}{\sum_{i=1}^{n} P_i RR_i} \qquad (1)$$

where RR_i is relative risk of mortality or morbidity for each of the WA categories (i) in tables 2-3; P_i is the current underweight prevalence rate in each of the WA categories (i); and P_i^c is the counterfactual underweight prevalence rate in each of the WA categories (i). This formula is also called the "potential impact fraction" because it estimates the mortality or morbidity that would have been avoided for a different counterfactual population distribution (e.g., less children being underweight) exposed to those levels of risk of mortality or morbidity. For a further discussion of this formula, see Ezzati et al. (2004).

For diarrheal mortality and morbidity the AF estimation procedure would be different because there are two risk factors, i.e. the direct effect of sanitation and the indirect effect through malnutrition. As already 88 percent of

9 The attributable fraction of mortality or morbidity from malnutrition is the percent of deaths or percent of cases of illness (e.g., percent of ALRI deaths or cases of ALRI) caused by malnutrition.

diarrheal infections and mortality is estimated to originate from sanitation (or mediated from sanitation through water), the additional effect of malnutrition is minimal and is therefore ignored here.[10]

Annual cases of mortality and morbidity from diarrheal infections caused by poor sanitation, through the effect of infections on nutritional status, are estimated as follows:

$$M = c\sum_{j=1}^{j=m} AF_j M_j^0 \qquad (2)$$

where AF_j is the AF in eq. (1) for each cause of mortality or type of disease "j", M_j^0 is the current total annual cases of mortality or disease incidence in each of the categories in tables 2-3, and "c" is the fraction of diarrheal infections caused by poor sanitation (88%).

Most recent available estimates of annual cases of mortality (M_j^0) in children under-5 are presented in Annex Table A14. These estimates reflect under 5 child mortality rates in 2005, and the structure of cause-specific deaths is estimated from WHO country estimates of cause-specific mortality in 2002 (WHO, 2004a).

Annex Table A14. Estimated cause-specific annual deaths in children under 5 in 2005

Disease	Cambodia	Indonesia	Philippines	Vietnam
Diarrheal disease	7,500	25,500	9,800	4,600
ALRI	5,400	22,400	11,600	4,700
Measles	1,600	12,400	5,500	1,400
Malaria	2,900	4,900	400	1,900
PEM	900	2,800	1,000	20
LBW	4,000	36,200	7,800	5,400
Other perinatal conditions	6,800	22,400	14,900	3,800
Other causes	5,600	30,400	16,200	6,300
Total	**34,700**	**157,000**	**67,200**	**28,120**

Source: Adjusted to 2005 from WHO country estimates of mortality by cause in 2002 (WHO, 2004a), by applying child mortality rate in 2005.

Annex Table A15. Demographic and mortality data in 2005

Variable	Cambodia	Indonesia	Philippines	Vietnam
Mortality rate, under-5 (per 1,000)*	83	36	33	19
Population, total**	13,806,974	218,868,791	84,221,578	83,119,900
Number of children u5**	1,694,990	19,297,054	10,650,271	7,356,100
Estimated annual births***	369,682	4,003,538	2,202,745	1,499,715

Source: * World Bank (2007) and Cambodia DHS 2005 for child mortality; ** Country population statistics. *** Estimated from the number of children u5.

Complete records or statistics on annual cases of ALRI and malaria in children u5 are not available in any country. This is due to many reasons, including incomplete reporting and record systems, cases never treated at health care providers, and incomplete or potentially incorrect case identification and diagnostic. Annual cases therefore need to be estimated. WHO provides regional estimates of ALRI for the year 2002, the most recently available (WHO, 2004b). These data suggest that the incidence of ALRI in children u5 in Asia is on the order of 0.35 to 0.7 cases per child per year. An annual incidence of 0.35 cases of ALRI is therefore applied to Indonesia, the Philippines and Vietnam.

10 See Larsen (2007) for methodology and estimation of environmental health effects from multiple environmental risk factors in Ghana and Pakistan.

In Cambodia, which still faces more health challenges than many of the other countries in the region, an annual incidence of 0.5 is applied. Annual incidence in all children u5 is the incidence per child multiplied by the number of children (Table 50).

The incidence of malaria is likely more uncertain than the incidence of ALRI. The regional WHO data for 2002 suggest that the incidence of malaria in SEARO B is 0.07 cases of malaria per child per year. Indonesia holds a large share of the population in this region. The incidence of malaria in WPRO B is only 0.001 per child per year, as China constitutes more than 80 percent of the population in this region and has very low incidence of malaria.

A recent paper by WHO (Korenromp, 2005) estimates that the global incidence of malaria in 2004 was 6 times higher than recorded in national health information systems, and around 17 times higher in non-African countries. The estimated country population incidence in Korenromp (2005) indicates that the incidence in children u5 could range from 0.16 cases per child per year in the Philippines, 0.27 cases in Vietnam, 0.39 cases in Indonesia, and 0.8 cases per child in Cambodia.[11] These estimates are however very uncertain. A much more conservative estimate would be to assume that the incidence in children u5 in Indonesia is 0.07 cases per child per year (as reported for SEAR B for the year 2002) and that the incidence in the other countries are in the same proportion relative to the estimated incidence in Korenromp (2005). This approach gives an estimated incidence of 0.03 in the Philippines, 0.05 in Vietnam, 0.07 in Indonesia, and 0.14 in Cambodia. Using the incidence rates, annual cases of malaria in children u5 are presented in Annex Table A16.

Annex Table A16. Estimated annual cases of illness in children under 5 (thousand cases)

Disease	Cambodia	Indonesia	Philippines	Vietnam
ALRI	847	6,754	3,728	2,575
Malaria	242	1,351	298	355

Sources: Estimated from regional WHO incidence data (WHO, 2004b) and Korenromp (2005).

Applying equation (2) to the cases of mortality and illness in Annex Tables A14 and A16 provides an estimate of mortality and morbidity from poor sanitation (table 9). Mortality in children from protein-energy malnutrition (PEM) is estimated separately using the methodology in Fishman et al. (2004) and attributing a fraction of this mortality to sanitation in proportion to the effect of diarrheal infections on malnutrition. Diarrheal mortality from poor sanitation is 88 percent of total diarrheal mortality.

About 95 percent of estimated annual mortality is in children under 5. In children under 5, mortality directly attributable to poor sanitation (i.e., diarrheal mortality) constitutes 13-19 percent of total under 5 child mortality. Mortality attributable to sanitation from malnutrition (i.e., the indirect effect of infections through malnutrition) constitutes 16-20 percent of total under 5 child mortality. Total attributable mortality to sanitation is 30-37 percent of total under 5 child mortality (Annex Table A17).

For morbidity in children under 5, ALRI attributable to sanitation from malnutrition constitutes 13-19 percent of annual cases, and malaria attributable to sanitation constitutes 5-8 percent of annual cases (Annex Table A18)

11 Korenromp only present population incidence. The WHO regional data indicate that the incidence in children u5 in SEARO B is 4.5 times higher than the population incidence. This ratio is applied to the estimated population incidence in Korenromp to estimate incidence in children u5.

Annex Table A17. Percent of total under 5 child mortality attributable to poor sanitation

	Cambodia	Indonesia	Philippines	Vietnam
Directly attributable mortality to sanitation	19%	14%	13%	14%
Attributable mortality to sanitation from malnutrition	18%	18%	20%	16%
Total attributable mortality to sanitation	37%	32%	33%	30%

Annex Table A18. Percent of cases of illness in children under 5 attributable to poor sanitation

	Cambodia	Indonesia	Philippines	Vietnam
ALRI attributable from malnutrition	19%	16%	16%	13%
Malaria attributable from malnutrition	8%	7%	7%	5%

A2 Water resources

While domestic sources contribute importantly to water pollution in most developing countries, where the majority of households do not have their excreta, sewage or wastewater safely disposed of or treated. However, the presence of other sources of water pollution means that overall economic impact of polluted water cannot be attributed to poor sanitation alone. Pollutants which affect water-related economic activity include microorganisms, organics, chemicals, solids, gases and heat [77]. Pollution originates from a variety of sources:

- Households (excreta, sewage and grey water from bathing, laundry, cooking)
- Small industries (garments, dying, washing, food processing, brewery)
- Leachate from sanitary landfill for solid wastes – or more usually – dump sites
- Manufacturing industries (production or processing)
- Chemical fertilizers, pesticides, and treatment of acid-sulfate soils
- Animal waste
- Silt release following build-up behind dams
- Salinity intrusion from coastal areas

Major categories of water use include drinking water, domestic uses, crop and fish production, energy production, industry, recreation and transport. For some of these activities, good quality water is important – such as for drinking – while for other uses water quality standards are not so strict such as for agricultural and some industrial uses. Therefore, only selected impacts of polluted water are examined in this present study, with selection of uses of water where there is a strong proven association between poor sanitation and the associated costs.

A2.1 Water quality measurement

Inland water quality is affected by many variables, the two main ones being the quantity of polluting substances released and the overall quantity of water resources for absorption of the pollution load. Hence, water quality indicators will need to be interpreted based on these two variables, as well as the multitude of factors that determine these variables. Furthermore, the economic impact of polluted water depends on what productive and non-productive uses the different water resources have, or *could have* assuming improved water quality. Box31, sourced from the Vietnam National Resources Water Strategy for 2006, states the issue of pending water scarcity in Vietnam.

Box 3. Vietnam's water resources are unsustainable

The current average per capita surface water availability from the total volume of water in rivers within Vietnam is about 3,840 m3 per year. If water inflows from outside the country are included, the average per capita river water availability is 10,240 m3 per year. Taking population growth into consideration, by 2025 the average per capita surface water availability will be 2,830 and 7,660 m3 per year. According to standards of the International Water Resources Association (IWRA), nations with average per capita water availability lower than 4,000 m3 per year are considered nations with inadequate water supply.

Water resources are not evenly distributed over different regions. About 60% of river water is concentrated on the Cuu Long River delta (Mekong River). The remaining 40% is spread over nearly 80% of the nation's population and over 90% of production, trade and other service activities.

The average volume of water in 3-5 months in the wet reason makes up 75 - 85% of the total volume, while the 7 or 9 months of the dry season receives 15 - 25% of the year's water quantity.

Source: National Resources Water Strategy, 2006

Water quality monitoring is limited in Vietnam. Different organizations or agencies are interested in different uses of water, and hence measure different water quality indicators. The Ministry of Natural Resources and the Environment (MONRE) is responsible for monitoring both surface and ground waters. The Ministry of Fishery monitors water quality in aquaculture areas and the Ministry of Health is responsible for monitoring quality of drinking water.

Hydrological and Meteorological Services (MHS) of MONRE maintains a network of about 230 hydrological monitoring stations. It operates a national groundwater monitoring network with 300 regional monitoring stations and more than 600 observation wells across Vietnam. Monitoring operates upon a periodic schedule, once or twice monthly. In addition to water temperature, pH, and turbidity, other parameters are measured such as discharge, water level, ferrum, silica, calcium, magnesium, chloride, sulfate, bicarbonate, and chemical oxygen demand (COD). However, these measurements are mainly for hydrological and meteorological purposes rather than environmental purposes. With respect to monitoring water quality for environmental purpose, there are rather fewer stations under the Vietnam Environment Protection Agency (VEPA) which monitor water quality in selected water bodies. These stations measure parameters like dissolved oxygen (DO), biological oxygen demand (BOD5), COD, ammonium, nitrate, chloride, heavy metals, zooplankton, phytoplankton, oil, etc. However, as data from regular sources is not sufficient, external consultants are sometimes engaged by VEPA to carry out the monitoring and investigation of water quality in selected areas. The Government has now recognized the need to establish water quality management and environmental protection mechanism for priority river basins with a clear focus on high risk water quality and environmental problems [3].

This present study uses data from 2005-2006 water quality monitor by VEPA. Regional figures are estimated by the Consultants on basis of surveyed figures on specific water bodies.

A2.2 Contribution of poor sanitation to water pollution

Water pollution from domestic sources can be estimated from the annual release or eventual seepage of untreated feces, urine and gray water into inland water bodies. It is estimated by applying the number of population with unimproved sanitation, the proportion of sewage released to water bodies, and average human (and animal) waste production per year. Annex Table A19 presents the figures and assumptions behind the release of human waste to water bodies. Pollution load from human waste is based on 0.15 kg feces and 1.5 liters urine per person per day. The following table shows the volume of waste per produced by some animals per day.

Annex Table A19. Production of fecal matter from different sources

Producer	Fecal matter	
	Kg / day	Kg / year
Humans	0.15	54.75
Cow	18 – 25	6,570 – 9,125
Buffalo	30 – 40	10,950 – 14,600
Pig	3.5 – 7.0	1,277.5 – 2,555
Fowl	0.02 – 0.05	7.3 – 18.25

Annex Table A20. Estimated proportion of untreated sewage discharged to water bodies

% sewage discharged directly into water body	% open defecation in water courses	Septic tanks not managed properly		Leaking pit latrine	
		Total	% of which to groundwater	Total	% of which to groundwater
100%	12.7%	13.0%	10.0%	13.0%	10.0%

Source: Consultant's estimates based on National Water Quality Monitor 2005-2006 (applied to all regions)

Annex Table A21 shows the assumptions on polluting substances used for discharge per day for urban households with pipe connection. Rural households without pipe connection are conservatively assumed to have zero gray water, and the same amount of sewage.

Annex Table A21. Waste load production in grams per cap per day, subdivided by gray water and sewage, for urban households with pipe connection

Source	BOD_5	COD	N	P	TSS	Oil	Cu	Cd	Pb	Zn
Gray water	15	40	2	1.5	48	5	0.018	0.0001	0.015	0.022
Sewage	35	35	7	0.8	20	2	0	0	0	0
Total	50	70	9	2.3	68	7	0.018	0.0001	0.015	0.022

Source: [78]

Annex Table A22. Estimated BOD from domestic sources (2005)

Region	Domestic	
	BOD	%
Red River Delta	100,076	21.7%
North East	51,916	11.3%
North West	14,233	3.1%
North Central Coast	58,915	12.8%
South Central Coast	39,109	8.5%
Central Highlands	26,401	5.7%
South East	74,671	16.2%
Mekong River Delta	95,793	20.8%
Total	**461,115**	**100.0%**

Note: Data on BOD from industry and agriculture is not available

The pollution in the water bodies is generated from three sources of industry, agriculture and domestic activities. They vary between rivers and regions of the country. For the Cau River sub-basin the major pollution is caused by industrial production, craft villages and urban runoff. In the Nhue-Day River sub-basin, domestic wastewater accounts for the biggest proportion of wastewater (56%), making the Nhue - Day sub-basin different to many other basins. Industry contributes 24% of the wastewater and craft villages 4%. Major pollution in the Dong Nai River basin is dominated by domestic wastewater and industrial wastewater. [3]

In this present study, it is not possible to calculate the contribution of various sources to overall water pollution using BOD. However, it is estimated by the Consultants that domestic source contributes 40% of BOD to overall pollution of water bodies in Vietnam. If additional components of sanitation in Vietnam are included (agricultural waste and waste from trade villages), it is assumed that expanded "sanitation" contributes 80% of total BOD.

A2.2.1 Cost implications of water pollution for drinking water supply

Both water consumers and water providers treat water because water sources are not clean. More wealthy populations purchase bottled water which is either chemically treated or from a protected (mineral) source. The more polluted the water source, the more likely the household will take some form of precautionary measures, thus leading to higher unit costs of treatment. In some cases, households will not haul water from more polluted water sources if less polluted sources are available, but it may lead to time or financial costs.

Given that drinking water sources are polluted from several sources and not just from poor sanitary practices, by removing the human (and animal) waste component of polluted water, the need to treat water is not altogether removed. However, the removal of human and animal waste content from water sources may reduce the necessity for treatment or lowers the unit cost of treatment.

Annex Table A23 below shows selected drinking water quality standards. Some of the main indicators which will cause households to purchase, treat or walk further to access cleaner water are perceived or actual presence of infectious pathogens (microbial agents) and heavy metals, bad odour due to organics, turbidity caused by solids, and bad taste due to low pH and solids.

For the purposes of cost estimation, household drinking water sources are sub-divided into three categories, data for which are presented in Table A24 at national level and rural-urban breakdown.:

1. Households receive piped water supply, either from water treatment companies or from open community-managed sources. The table below shows that 19.08% of households receive piped water from water supply companies.
2. Households purchase water from other non-piped suppliers, such as tanker truck, water by the bucket, or bottled water. The table indicates that 0.5% of households purchase water from vendors.
3. Households collect water from free or low cost community or public sources. Hauled water accounts for 26.16% of total sources of drinking water. Drilled and other wells explain the rest (54.22%).

Annex Table A23. Selected drinking water quality standards

Indicator	Unit	Vietnam standard (Maximum Allowed)*	Testing Method
Color	TCU	15	TCVN 6187-1996 (ISO 7887-1985)
Taste		No special taste	By tasting
Turbidity	NTU	5	TCVN 6184-1996
pH value	Unit	6.0-8.5	TCVN 6194-1996
Hardness	Mg/L	350	TCVN 6224-1996
Ammonia (by NH4+)	Mg/L	3	TCVN 5988-195 (ISO 5664-1984)
Nitrate (by NO3-)	Mg/L	50	TCVN 6180-1996 (ISO 7890-1988)
Nitrite (by NO2-)	Mg/L	3	TCVN 6178-1996 (ISO 6777-1984)
Chloride	Mg/L	300	TCVN 6194-1996 (ISO 9297-1989)
Arsenic	Mg/L	0.05	TCVN 6182-1996 (ISO 6595-1982)
Iron	Mg/L	0.5	TCVN 6177-1996 (ISO 6332-1988)
Total dissolved solids (TDS)	Mg/L	1,200	TCVN 6053-1995 (ISO 9696-1992)
Copper (Cu)	Mg/L	2	TCVN 6193-1996 (ISO 8288-1986)
Cyanide	Mg/L	0.07	TCVN 6181-1996 (ISO 6073-1984)
Fluoride (Fl)	Mg/L	1.5	TCVN 6195-1996 (ISO 10359-1992)
Lead (Pb)	Mg/L	0.01	TCVN 6193-1996 (ISO 8286-1986)
Manganese	Mg/L	0.5	TCVN 6002-1995 (ISO 6333-1986)
Mercury	Mg/L	0.001	TCVN 5991-1995 (ISO 5666/1-1983; ISO 5666/3-1989)
Zinc	Mg/L	3	TCVN 6193-1996 (ISO 8288-1989)
Total coliform	Cfu/100ml	50	TCVN 6187-1996 (ISO 9308-1990)
E.coli or Heat resistant coliform	Cfu/100ml	0	TCVN 6187-1996 (ISO 9308-1990)

Source: Clean Water Standard (issued along with Decision No. 09/2005/QD-BYT dated 11 March 2005 by the Ministry of Health)

Annex Table A24. Sources of drinking water (% households)

Location	Piped water[1]	Other purchased water[2]	Hauled water[3]	Drilled/Dug Wells and other wells	Total
Rural	6.3%	0.3%	32.3%	61.0%	100.0%
Urban	56.9%	1.1%	7.9%	34.0%	100.0%
Total	**19.0%**	**0.5%**	**26.1%**	**54.2%**	**100.0%**

Source: [5]

[1] Piped Water = Private tap + Public Standpipe

[2] Other purchased water = Buying water (container, bottle)

[3] Hauled water = Filtered spring water + Rain water + River,lake, spring, pond + others

For all of these categories, households often treat their water for drinking purposes, even when the water sources has been protected or properly treated. In Vietnam, this figure is 30% of households, with higher rates in rural households due to lower rates of pre-treated piped water and high likelihood of contamination. Several methods exist for household water treatment, including chemical treatment, filtration, boiling, and solar disinfection. The main methods in Vietnam are boiling [8]. In addition to households, some industries also have to treat water that does not conform to the required properties for certain industrial processes. However, these costs are excluded in this present study.

Various methods are available to estimate of costs of avertive behavior to avoid drinking polluted water. The lower limit on financial cost could be reflected by identifying specific actions to remove bacteria, such as chemical treatment for piped water, open wells, and household treatment. The upper limit on financial cost of avertive behavior can be reflected by apportioning to poor sanitation a fraction of the total cost of water treatment and purchase. However, it is noted that households choose more convenient but more costly water sources for a variety of reasons, which include (but are not limited to) water pollution, convenience of access, time savings and no other available water supply. Hence the allocation of costs to sanitation has to be adjusted downwards by 50%. The economic costs of access to clean drinking water includes not only the financial cost, but also the efforts made by households to access clean water, such as walking further to access cleaner water sources, or the time taken to treat water in the home. See Annex B for algorithms for calculation of water access cost for different water sources.

The algorithms were applied at national level due to lack of regional breakdown. Data available on drinking water sources from GSO is used. Piped water price was assumed on basis of government stipulated price (VND 2,500 – VND 8,000 per m^3). Price of purchased water was assumed conservatively using data from some World Bank projects at VND 8,000 per m^3. Household water treatment practices are presented in the table below [8]. The minimum drinking water per capita per day was assumed to be 4 liters, taken from WHO sources [79]. For hauled water, the proportion of households traveling further to access cleaner water was based on populations living close to polluted water sources which are unusable for drinking water purposes (lakes, rivers and polluted groundwater); while additional journey time was taken from international studies of time for collecting drinking water since there is no secondary data available in Vietnam concerning this issue. The Global Water Supply and Sanitation Assessment 2000 Report (WHO and UNICEF 2000) indicated that an average household required a journey of more than 30 minutes to collect water per day. These time-saving figures are confirmed by the Multi-Indicator Cluster Surveys of the United Nations Children's Fund (UNICEF). A recent analysis of the responses in 23 African and Asian countries produced a similar result (G. Keast, UNICEF, 2003). A conservative estimate of 15 additional minutes per day for water collection due to pollution of local water sources is used in this study. For households, it is assumed that water treatment costs (boiling) are US$5 per m^3 in rural area and US$8 per m^3 in urban area.

The attribution to poor sanitation of the overall costs of sourcing clean water was made differently for the different costs:

- Attributable water pollution to poor sanitation: an estimate was made about this fraction due to lack of data on releases from industry, agriculture and domestic sources. Discussion with experts from WSP Vietnam estimated that a fraction of 40% can be used to this fraction.
- Attributable fraction of water purchased due to poor sanitation: given concerns of households about micro-bacteria in water available from open sources, this fraction may be higher than the fraction above. Other characteristics of water available from local sources (taste, color, cloudiness) are also taken into account, which often account for switching sources. Based on the discussion above with WSP Vietnam, this fraction is conservatively estimated at 40%
- Attributable fraction of water treated due to poor sanitation is the same as above variable.

Box 4. Water treatment costs in Dong Nai

The Dong Nai River at Hoa An Pumping station (supplying water to HCMC and Bien Hoa City) is now polluted with BOD5 concentrations at twice the standard. The price for each m3 of water after treatment increases by 4,658 VND (which is more expensive than the present price per m3 of water supply). The result will be that the price for each m3 of water after treatment is 9,077 VND/m3. Therefore, on average per day, the Thu Duc water station has additional costs of roughly 5.9 billion VND.

Source: Environment Protection Project in Dong Nai River Basin , 2003

A.2.2.2 Water quality and fish production value

Fisheries in Vietnam

Fisheries play a very important role in Vietnam in providing employment, income and food security to many people. Many Vietnamese depend upon fish as a central part of their diet from which they obtain protein and vital nutrients and vitamins. Currently, the fisheries sector employs around 4,000,000 people and contributes 4% to the country's GDP (in 2005). The fisheries sector is one of the key economic sectors in Vietnam, and it maintains higher growth rate than many other sectors.

Pollution and fish production

Pollution and river diversion have allegedly driven freshwater fisheries into collapse worldwide, and the extinction of freshwater species far outpaces the extinction of mammals and birds [80-82]. Fish populations are affected by a multitude of changes taking place due to human interventions, such as hydroelectric dams, water diversions for agriculture, flood control levees, dredging, water pollution, and habitat degradation such as logging. According to FAO, the long-term productivity of fish stocks are related to the carrying capacity of their environment, which alter as a result of natural variability and of changes induced by human activity, such as coastal habitat degradation, destructive fishing methods and pollution." (page 47, [83]). Environmental degradation has been cited as one of the key threats to inland fish producers in countries of the lower Mekong basin [84]. Of particular concern for water quality for fish production in Southeast Asia are suspended solids, dissolved oxygen, heavy metals and pesticides [85]. However, as one of the few publications on water quality and fish production in Asia notes (writing in 1986) "data on the effect of water quality on Asian species of fish are not readily accessible" (page 15, [85]). Furthermore, it is difficult to predict the exact impact of water pollution on fish production given variations between fish species and the multiple other determinants of fish production such as food availability, water depth, flow, and temperature.

Domestic sources contribute importantly to water pollution, largely through the biological oxygen demand (BOD) exerted by organic matter which reduces dissolved oxygen levels [86][12]. Fish living below a sewage treatment plant had significantly higher mortality rate than fish upstream [87-89]. Pharmaceutical discharge in urine can affect fish health directly. The scientific literature testifies, albeit incompletely, to the adverse effects of sewage release on fish reproduction and fish growth.

One key determinant of fish health which has received attention from scientists is the level of dissolved oxygen [87-97]. For example, experiments undertaken in Canada on native fish and benthic macroinvertebrate species showed that exposure to low dissolved oxygen and low temperatures caused delays in hatching of eggs, reduced mass of fish post-hatch, and depressed feeding rates and lowered survival of fish [93].

Additionally, micro-organisms contained in human and animal waste such as parasites and bacteria have a number of implications for fish health [84, 91, 92, 96, 97], as well as safety of fish for human consumption [87, 90, 98-101]. Common illnesses from contaminated fish and shell fish include typhoid, salmonellosis, gastroenteritis, infectious hepatitis, *Vibrio parahaemolyticus* and *Vibrio vulnificus* infections, paralytic shellfish poisoning (PSP), and amnesic shellfish poisoning (ASP).

A further consideration that needs to be addressed is the fact that, in many contexts, the nutrients from sewage act as a source of food for fish, and hence positively affect the production of fish. This happens both intentionally, when sewage is fed to farmed fish in a regulated way, and unintentionally when fish in open water bodies are exposed to untreated sewage disposed upstream. Vu Quyet Thang reported the positive impact of sewage and domestic waste water on fish farming in Vietnam [102], Hence, in recognizing the benefits of sewage for fish production, the impact

12 A major determinant of fish reproduction, growth and survivability is dissolved oxygen (DO). When an organic waste is discharged into an aquatic system, a biological oxygen demand (BOD) is created. BOD is a measure of the oxygen required to break down organic compounds, and high BOD levels significantly deplete the amount of dissolved oxygen in surface water. Consequently high BOD levels have a detrimental effect on the health of aquatic species that require elevated levels of DO. From human waste, damages result from direct biological oxygen demand, as well as increased growth of algae from nitrates and phosphorous contained in human waste. The algae biodegrade the nutrients, thus reducing the amount of DO available.

analysis addresses only unregulated, unintentional, pollution of water with sewage. It should be noted, though, that sewage-fed farmed fish may not be optimally managed, and negative health effects need to be recognized.

The paragraph below describes the pollution of some major river basins in Vietnam. Pollution levels of rivers in the lower reaches of the Dong Nai River Basin are the worst in Vietnam. The Thi Vai River is the most polluted in basin with a "dead" section of 10 km, and drainage canals in inner Ho Chi Minh City suffer similar levels of pollution - extremely low DO levels, and high levels of N-NH_4, mercury and zinc. The water is seriously polluted by organic substances and is a blackish brown color with fetid odors, in both high and low tidal periods. The DO value is often lower than 0.5 mg/l (Figure 2.42). With the DO value at nearly zero, biological species are unable to live. [3]

The average level of DO in Cau River is 6.5 mg/L for the section from Lien Mac to Cau Dien. From Cau Dien to downstream, level of DO reduced considerably to 4.5 mg/L. At To Lich junction, DO value is less than 1 mg/L.[3]

Methods for modeling the relationship between water pollution and fish production
Given the lack of empirical evidence linking water quality and fish production in Vietnam, this study uses innovative methods to examine the likely importance of sewage release for fish production. While the following three key links are identified, only the first is assessed quantitatively in this study:

- The proven link between sewage and dissolved oxygen levels, and the resulting impact of lowered dissolved oxygen levels on fish production[13].
- The proven link between micro-biological contents of water and fish disease, and hence survival.
- The link between micro-biological contents of water inhabited by fish and the transmission of disease to humans via fish consumption, due to inadequate de-contamination of fish prior to consumption.

This study assesses the water quality indicators available for different freshwater locations where fish are (or used to be) farmed or caught, and assesses the various issues related to fish reproduction, fish populations, and overall fish health, and attributes estimated economic impact to poor sanitation (sewage and grey water release) as one of several sources of water pollution in those water bodies.

The focus of this study is on freshwater fish, given that dissolved oxygen is more affected in water bodies where oxygen depletion is more acute, resulting from release of untreated sewage into freshwater.

Annex Table A25 indicates that the Red River delta and South East are the two regions with lowest DO levels in Vietnam. They are the two most densely populated delta areas in Vietnam with two polluted river basins of Nhue-Day and Dong Nai. In addition, industrial zones and craft villages are highly developed in these two regions causing pollution in water bodies. DO levels are higher in the 6 other regions of the country. Levels of DO vary between rivers, between sections of a river, and a number of 'hot spots' of pollution are noted, from both industrial and domestic sources. As a result, the average level of DO may not truly reflect the pollution of water bodies, especially in hot spots of pollution.

13 Dissolved oxygen was selected as the key water quality parameter because aquatic organisms require oxygen in specified concentration ranges for respiration and efficient metabolism, and because dissolved oxygen concentration changes above or below this range can have adverse physiological effects. Even short-lived anoxic and hypoxic events can cause high mortality rates of aquatic organisms. Exposure to low oxygen concentrations can have an immune suppression effect on fish which can elevate their susceptibility to diseases for several years. Moreover, the toxicity of many toxicants (lead, zinc, copper, cyanide, ammonia, hydrogen sulfide and pentachlorophenol) can double when DO is reduced from 10 to 5 mg/L. The amount of oxygen available in the water also decreases with temperature and when plants die. Oxygen requirements increase at a higher temperature (e.g. an increase in water temperature from 10 to 20°C at least doubles the oxygen demand). The presence of other pollutants such as nitrogen and marine life overcrowding reduce DO levels. In cloudy conditions, plants use up more of the available DO. Plants proliferate with the presence of nitrate and phosphates from agricultural run-off, sewage and excess fish feed.

Annex Table A25. Fish production levels by water body and dissolved oxygen levels of water body

Water body name and type	Recorded DO (where estimated)	Fish volume (Farm and Inland Catch 2005)		Potential Fish Volume	
		Weight (tons)	Value (US$)	Fish weight (tons)	Fish value (US$)
Red River Delta	6.5	206,794	62,038,314	295,421	88,626,163
North East	7	48,760	14,627,889	54,177	16,253,210
North West	8	7,933	2,379,960	8,815	2,644,400
North Central Coast	6.7	48,071	14,421,161	53,412	16,023,512
South Central Coast	7.2	65,787	19,736,090	73,097	21,928,989
Central Highlands	8	15,367	4,610,100	17,074	5,122,333
South East	6.2	53,332	15,999,603	76,189	22,856,576
Mekong River Delta	8	862,984	258,895,083	958,871	287,661,203
Total		**1,309,027**	**392,708,200**	**1,537,055**	**461,116,387**

In Vietnam, fisheries output refers to total production volume of one or a group of aquatic species harvested or caught in a given period, comprising production of caught products and production of farmed products (aquaculture). Production of caught product (fishing) includes marine fishing and inland fishing (from rivers, streams, lagoons, or ponds). Production of farmed products includes all aquatic production from aquaculture. Aquaculture mainly comprises freshwater culture of fish and brackish-water culture of shrimp and prawn. Freshwater means water with salinity less than 0.5%. The focus of this present study is on freshwater fish caught or farmed, given that dissolved oxygen is more affected in water bodies where oxygen depletion is more acute, resulting from release of untreated sewage into freshwater. All freshwater fishes are included in this study, while products from marine fishing and culture of shrimp and prawn are excluded.

It is recognized that the impact of poor sanitation on fish stock, fish growth and eventual fish catch is extremely difficult to quantify. Coefficients linking water body pollution and yield reduction have not been developed. For a crude quantification of the possible loss in fish value due to water pollution, a modeled relationship based on assumptions is used, represented in Figure A1. The Figure shows the estimated reduction in volume of fish caught at lower levels of dissolved oxygen, for an average fish species in Vietnam.

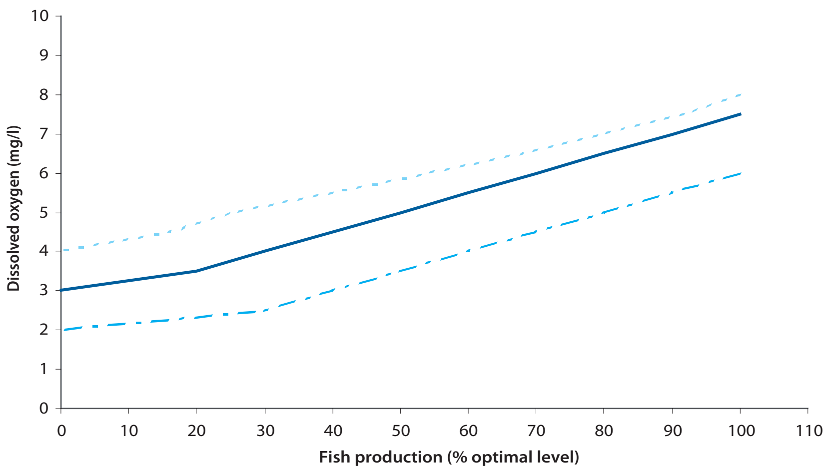
The amount of oxygen needed for the survival of fish varies with time of year and species. Oxygen needs vary even with the life stage of a species. Young species tend to be more sensitive to low oxygen conditions than adults. Also important is the duration of periods with low oxygen. Most species can survive short periods of reduced oxygen, but suffer during longer periods. According to Meck [95] and others, the minimum limiting oxygen concentrations for a fish is dependent upon its species, physical state, level of activity, long term acclimation, and stress tolerance. A research study from the USA examined the lowest DO at which different fish species survived for 24 hours, varying from 6.0 mg/L down to 3.3 mg/L [94]. Usually larger fish are affected by low DO before smaller fish. Given the lack of published studies on the empirical relationship between these two variables, the following assumptions made used based on a mixture of available scientific literature, internet sources, and expert opinion. A range is assessed in sensitivity analysis, shown by dotted line in Figure A1.

- Water with an oxygen concentration of less than 3.0 mg/l will generally not support fish. When concentrations fall to about 3.0-4.0 mg/L, fish start gasping for air at the surface or huddle around water falls or higher concentration points.
- Numerous scientific studies suggest that 4.0-5.0 parts per million (ppm) of DO is the minimum amount that will support a fish population for short periods of 12-24 hours.
- Above 5.0 mg/l, almost all aquatic organisms can survive indefinitely, provided other environmental

parameters are within allowable limits. When there are too many bacteria or aquatic animal in the area, they may overpopulate, using DO in great amounts [88].

- Levels of 6.0 mg/L and above supports spawning, and above 7.0 mg/L supports growth and activity [93, 94].
- The DO level in good fishing waters generally averages about 9.0 parts per million (ppm).

Figure A1. Modeled relationship between dissolved oxygen levels and fish production (with lower and upper range)



Notes: the upper line represents the maximum effect of reduced DO levels on fish production volume, with linear reduction from 8mg/L to 4mg/L. In the base case, the linear reduction from 7.5mg/L to 3mg/L, while for the least effect, the linear reduction from 6mg/L to 2mg/L.

In Vietnam, the Government has stipulated a Vietnamese standard on fresh-water quality for protection of aquatic lives with the acceptable level of DO is 5 mg/L. These standards define the limits of water parameters and permitted concentrations of pollutants for the protection of aquatic lives (Annex Table D9).

In order to assess likely impacts of polluted water on fish production, geographical locations of the principal fish catches and water quality indicators are matched for major selected inland water bodies. Based on the observed DO levels in these water bodies, the function in Figure 4 is applied that estimates the loss of fish catch due to lower than optimal levels of dissolved oxygen.

The current fish production levels are adjusted upwards to predict what the fish catch *would be* in the presence of optimal DO levels, using the equation shown in Annex B.

As explained earlier, it is assumed that there are 2 regional groups in Vietnam with different DO levels. The first group (Red River Delta and South East) with DO level of about 6 mg/L is assumed to operate at 70% of optimal DO level (Factor X = 70%). The second group (North East, North West, North Central Coast, South Central Coast, Central Highlands, Mekong River Delta) with higher DO level is assumed to operate at 90% of optimal value (Factor X=90%).

Impact on fish reproduction and growth due to water pollution is assessed by spatially comparing actual yields under current pollution levels and potential yields under a situation of good water quality, based on a water quality – fish production function.

The focus of the initial analysis is on fish production that is officially recorded in national statistics. Where fish catch values are available, these are recorded; where not available, financial value is estimated by applying current market prices to the average type of fish. The economic impact of low DO levels for non-recorded fish catch is also assessed, by scaling up the financial values by proportion of total fish catch accounted for by non-recorded sources. This was estimated as a factor of 1.1. Likewise for the economic estimates, the fish catch from subsistence fishing was also estimated; and the nutritional importance discussed. Since the fish catch region is based on the geographic location, it is hard to match the fish catch with the specific water bodies.

To estimate attributable impact to poor sanitation, a proportion of this loss is assigned to sewage and domestic gray water, as compared to other sources of water pollution (industry, agriculture, silt/natural erosion). This is done by estimating the proportion of BOD from these different sources. Due to the lack of reliable information on proportion of BOD from poor sanitation, it is assumed that poor sanitation contributes 40% of BOD to the water body.

A2.2.3 Water quality and domestic uses of water

In addition to the uses of surface and groundwater sources for domestic use, industrial use, fisheries and agriculture, water is an essential ingredient to many other human and non-human activities [103]. In this present study, it is not possible to conduct an exhaustive analysis of all the different uses of water. However, the following three categories were assessed for relevance:

- Non-commercial household (domestic) activities
- Leisure activities [104]
- Wildlife, covering flora and forna and animal species.

Non-commercial activities are concentrated at the household level, and include water for cooking purposes, washing clothes and kitchenware, and personal hygiene. Also, some traditional customs as well as leisure activities are closely related to water. Again, some of these require good quality water given it will be ingested, while others do not require quality water.

Activities affected by below standard water quality were assessed in the following way:

- Proportion of households and population that use untreated or unprotected surface or ground water for cooking, washing and bathing; and those that treat water to make it cleaner for domestic use. About 84% of rural households boil water before drinking. Red River Delta, North Central Coast and the low-lying provinces of the Northeast are regions with the highest rates. In the North West, South Central Coast, Central Highlands and South East, from 20% to 25% of households do not boil water before drinking. About 35% of households in the Mekong do not boil water before drinking [30]. Results from the GSO survey also indicate that regular filtration or chemical disinfection of drinking water is practiced by only a small fraction of the population. Some households commonly use aluminum sulphate to remove the particulate matter and help remove microbial pathogens [105].
- Proportion of households and population that switch water source due to the preference to have clean water for domestic activities. For example, for laundry and bathing, purchased water (via pipe or vendor) may be used rather than using local water bodies.
- Extent of other cultural and leisure activities related to water, and that require water of a minimum quality standard, including swimming.

Box 5. Small business saves on water costs in An Giang province

A small business household producing rice wine at Thanh My Tay commune, Chau Phu district, An Giang province – utilizes both clean water supplied by the provincial Water Company and water from the canal. This household has 9 people with 6 working in the business, and the demand for water is high. To reduce expenditure, they pump water from the canal into a storage tank where it is cleansed using alum. This source of water is used for bathing, washing, etc. The clean water from the piped scheme is only used for cooking.

For rice wine production, they use the cleansed river water to wash the rice, and then use water from the piped scheme during the fermentation process. This cuts costs quite significantly.

Source: National RWSS Review Survey, October 2004 .

Wildlife is dependent on water resources. For plants and trees, much of the water need is met from rainfall, and hence the issue of pollution does not come in. For some plants and trees, and most animals and water creatures, they are reliant on standing water, and hence can be affected by water polluted from the different human sources**.**

According to the MONRE statistics, Vietnam now has about 700 species of flora and fauna under the threat of extinction. Many wildlife species listed in the Red book, including tigers, rhinoceros, reptiles and especially fresh water tortoises, were on the verge of extinction, along with precious fauna like aloe wood and ngoc linh ginseng.

Exploitation of marine resources and wildlife, destruction of forests, expansion in construction and pollution are seriously threatening the country's natural resources, including bio-diversity that is vital for the country as well as for the flora and fauna.
Although it is not possible to determine the contribution of poor sanitation to the deterioration of wildlife, improved sanitation and less polluted water resources will certainly contribute to the protection of bio-diversity.

A3 Environment

The release of waste into the environment has other effects besides water pollution, given the unpleasant smells emanating from feces, urine, and other waste products [106, 107]. In countries where open defecation and unofficial dumping of waste are common, the quality of land is affected, rendering it unattractive and unusable for productive use. Unregulated waste dumping presents a threat to those disposing of waste, those living in the vicinity of the dumping area, as well as the poorest of the poor who often live off the waste (e.g. recycling activities). Waste grounds are also inhabited by stray dogs or other animals, which are diseased and pose a threat to human health. Even where there is a private or public agency taking care of disposal, it is often not performed according to plan. In cities, waste carts stay on the streets for many days, with resulting smell and unsightliness for local inhabitants and tourists. These aesthetic aspects of sanitation cause a loss of welfare for those coming into contact with the waste. However, given the lack of available data on these aspects, there is considerable uncertainty on the overall importance of these impacts.

A3.1 Aesthetics

Aesthetics is not strongly related to productivity or income. Economic evaluation studies do not usually quantify aesthetics such as smell and sight in economic terms. Instead these aspects are described as a potential additional benefit provided by sanitation programs. Studies assessing user preferences for sanitation options, including willingness to pay studies, tend to limit the focus to the physical boundaries of the household, and hence not assess impacts on the broader environment [108, 109]. Hence, findings aesthetics benefits of improved sanitation in this study are presented mainly in qualitative terms.

A.3.2 Land quality

When it has alternative uses, land is a tradable commodity. Hence, land that is used for improper, unofficial disposal of waste will be unusable for other more productive uses, and hence will reflect an economic loss to society. This present study assesses the solid waste management practices and resulting effects on land availability and land quality, and presents economic value using an economic value of land.

Solid waste management can be classified by safe and unsafe disposal practices. Unsafe practices involve open dump and semi-controlled dump with limited or no environmental control. Engineered landfill is a safe practice with basic waste accounting and some environmental control. The safest practice is sanitary landfill where waste accounting is practiced, waste placement, fencing and staff onsite, regular environmental monitoring and leachate collection and treatment. No waste pickers are allowed to work on a sanitary landfill [7].

If a landfill or dump is not sanitary, it is necessary that a "buffer zone" is established surrounding its operational portion. The distance in meters from the fence of a landfill to the nearest house is the buffer zone required to prevent the household from having seriously negative impact from waste. Within this buffer zone, land areas become temporarily unusable for other purposes, for example for constructing buildings, for agricultural use or for children's play areas.

The study estimated the amount of land that has been rendered temporarily unusable or unproductive for other uses for all unsanitary landfills in Vietnam as a result of unexpected buffer zones. A buffer zone was estimated to extend for 1,000 m around an unsanitary landfill. The number of landfills and their areas by regions were from Vietnam Environment Monitor 2004 and the Ministry of Construction data.

Annex Table A26. Unsanitary landfill and required buffer zone

Region	Population (1,000)	Area (km^2)	Unsanitary Landfills	Sanitary Landfills	Area (ha)	Buffer zone (m^2)
Red River Delta	18,279	14,812.5	21	3	112.4	41,162,948
North East	9,482	63,629.8	12	4	31.6	27,007,490
North West	2,600	37,336.9	3	-	41.0	12,836,249
North Central Coast	10,761	51,510.8	6	3	93.8	2,202,400
South Central Coast	7,143	33,069.0	12	2	68.5	25,344,171
Central Highlands	4,822	54,473.7	2	1	43.0	5,463,962
South East	13,639	34,743.1	7	3	282.0	25,555,333
Mekong River Delta	17,497	39,738.7	11	1	108.5	30,501,179
Total	**84,222**	**329,314.5**	**74**	**17**	**780.8**	**170,073,731**

Source: VEM 2004

Once the actual surface area of land affected was quantified, it is multiplied by an estimated rental value for the affected land (per square meter per year). The value taken was the rental of agricultural land, that is the lowest one among different. It is assumed at VND 10,000 per m^2 which is the standard land rental price regulated by the government.

A4 Other welfare

The type of sanitation facility a household has will have a range of impacts on population welfare. An important but difficult to quantify aspect is welfare impact on individuals and families who use a sub-standard, uncomfortable latrine or who have no latrine at all. Except for the disease impact (covered elsewhere), these less tangible aspects of human welfare have limited direct financial implications, but can be quantified as welfare losses using conventional economic techniques. More tangible impacts of sub-standard latrine or no facilities are time impacts due to journeying time or waiting due to insufficient shared or public latrines per head of population, security aspects of having no latrine or a remotely located one, especially for women and girls, as well as life decisions such as schooling or choice of employment, which may be linked to the presence of sub-standard or no latrines at schools and workplaces.

A4.1 Intangible user preferences

User preferences which could be described as 'intangible' – or difficult to quantify – include:

- Comfort & acceptability– the acceptability of the squatting or seating position; the ease to perform personal hygiene functions; the freedom from rushing to complete toilet-going due to unhygienic latrine conditions, flies and foul smelling air and pressure from other users.
- Privacy and convenience – the benefits of not being seen using the toilet; or being seen walking to access toilet facilities (women) [20].
- Security – the location of the latrine within or near to the home means that excursions to the outdoor do not need to be made for toilet-going needs, in particular at night, where there may be dangers (theft, attack, rape, and injuries sustained from dangerous animals or snakes).
- Conflict – on-plot sanitation can avoid conflict with neighbors or the community, where tensions exist on the shared facilities, or fields and rivers for open defecation.
- Status and prestige – when visitors come to the house, it gives prestige to the household to be able to offer their guests a clean and convenient toilet to use. Families may hold more social events at their house as a result of a clean latrine.

Annex Table A27 below shows the number of people in Vietnam who are experiencing sub-standard or no latrines according to the various aspects listed above (lack of comfort, lack of privacy, security threats, and conflict potential). It indicates that more than 2 million households do not have toilets. More than 3 million households have to share toilets with others.

Annex Table A27. Lack of latrine – indicators of defecation conditions

Area	No latrine		Sharing		Using own private latrine	
	Number	%[1]	Number	%[1]	Number	%[1]
Rural	1,879,526	13.50%	2,380,732	17.10%	9,662,154	69.40%
Urban	205,417	3.78%	723,309	13.31%	4,505,598	82.91%
Total	**2,167,954**	**11.20%**	**3,135,791**	**16.20%**	**14,052,991**	**72.60%**

Source: [8]

[1] Refers to the % of total households in Vietnam

See Annex Table D11 and D12 for more information about different type of latrines and number of shared latrines by regions.

A4.2 Access time

Welfare loss from increased access time due to unimproved sanitation can be due to journey time for open defecation or waiting time for shared latrine, and is estimated as shown in the algorithms in Annex B.

As there is no secondary information on this issue in Vietnam, the study assumes 10 minutes as an average additional daily time a person spends to find a private place for defecation. It is assumed that people who share latrines spend 15 more additional minutes per day for the same purpose.

The financial loss is estimated based on a proportion of adults whose time loss reflects a income loss, while the economic loss is based on the entire population and the average unit of time value for each population group (children time value is worth 50% of adult time value).

A4.3 Impact on life decisions and behavior

Running water supply and sanitary latrines in schools are a luxury in most of the developing world, and in many workplaces latrines are unhygienic, poorly maintained, and do not cater for special needs of women. The presence of hygienic and private sanitation facilities in schools has been shown to affect enrolment and attendance, especially for girls [16, 110]. Good latrine access at the workplace has implications for women participation at traditionally male-dominated employment areas. Furthermore, sanitary and adequate latrines in schools and at workplaces not only affect participation rates, but it also improves welfare of all pupils and employees.

Given the complex web of causative factors and eventual life decisions, and the many factors determining absenteeism from school or the workplace, it becomes difficult to quantify the exact relationship between poor sanitation conditions, education and work decisions, and eventual economic outcomes. Furthermore, there is no study on this issue in Vietnam so far. Hence, a number of assumptions on causal relationship have been made.

Annex Table A28 shows the results from a national survey in 2006 on the situation of toilets and running water in schools and public places. It indicates that the number of schools with adequate latrines is just between 50% and 60%, while there are still 19.9% of primary schools and 7.4% of secondary schools that do not have toilets. On the other hand, the problem of running water is less serious. There is no data on the coverage of toilets in workplaces.

Annex Table A28. Water and sanitation coverage in schools and workplaces

Establishments	With toilets		Without toilets	Running water supply or well close-by	
	"Adequate" latrines	Not "adequate" toilets		Adequate	Inadequate or none
Primary schools	50.06%	30.04%	19.90%	83.70%	16.30%
Secondary schools	60.10%	32.50%	7.40%	95.90%	4.10%
Workplaces					

Source: [111]

Annex Table A29 provides information on male and female participation rates in school and work. There is no breakdown in rates between boys and girls so the same rate is used.

Based on these data sources, the expected impacts of poor sanitation in schools and workplaces are assessed by estimating school days and workdays lost due to poor sanitation:

1. School absenteeism: a proportion of pupil absentee days is apportioned to lack of sanitation. The study estimated the number of pupils not enrolling or falling out of school due to poor sanitation assuming sanitation accounts for 2% of the total drop-out and absenteeism in schools. The number of absentee days is assumed at 10 days per pupil per year. As explained earlier, children's time is estimated at 50% of adults' time.
2. Employment absenteeism. For those people in workplaces with no or inadequate latrines, the number of days lost from work is assumed at 10 days per person per year. 1% of absentee days are apportioned to lack of sanitation.

Annex Table A29. Male / female participation rates in school and work

Variable	Female			Male			Total		
	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total
Primary school (%)[1]									
Enrolment (95.26%)	2,690	1,000	3,691	2,976	1,106	4,083	5,667	2,107	7,773
Completion (96.17%)	2,587	962	3,549	2,862	1,064	3,927	5,450	2,026	7,476
Drop-out (3.83%)	103	38	141	114	42	156	217	81	298
Secondary school (%)[1]									
Enrolment (96.3%)	3,332	1,239	4,571	3,573	1,328	4,902	6,906	2,567	9,473
Completion (93.94%)	3,130	1,164	4,294	3,357	1,248	4,605	6,487	2,412	8,899
Drop-out (6.06%)	202	75	277	217	80	297	418	156	574
Teachers (%)[1]									540
Workforce participation (%)[2]									
Agriculture	8,994	3,343	12,337	8,690	3,230	11,920	17,683	6,574	24,257
Industry	2,831	1,052	3,884	2,735	1,017	3,752	5,567	2,069	7,636
Services	4,010	1,491	5,501	3,875	1,440	5,315	7,885	2,931	10,816
Not working	888	330	1,218	858	319	1,177	1,746	649	2,395
Total workforce	**16,723**	**6,217**	**22,940**	**16,158**	**6,007**	**22,164**	**32,881**	**12,223**	**45,104**

Source: [23]

[1] *Website of Ministry of Training and Education*

[2] *GSO 2005*

A5 Tourism

Tourists are sensitive to their environment, and are less likely to choose destinations which are dirty or where the risk of disease is high. Countries may be losing tourist revenues due to the degraded environment and high infectious disease rates among the general population, as well as actual or perceived health risks to tourists. Hence any initiative to attract more tourists to a country will need to consider the part sanitation plays in this [17-19].

A5.1 Tourism and sanitation

Tourism is a booming industry, and continues to experience double-digit growth in many developing countries around the world [112], fuelled by cheapening airfare costs coupled with the realization of developing country governments and private sector of the potential economic benefits of tourism. Tourism is playing an important role in boosting the revenues of governments as well as contributing to much-needed economic growth in the developing world.

However, some countries have done better than others at exploiting the growth in tourism. Tourist preferences clearly play a key role in this: there are clearly many factors that determine tourists' choice of destination, and sanitation will be one among many. Tourist growth depends on what the country can offer such as tourist transport infrastructure, quality of accommodation and restaurants, type of experience offered (culture, climate, culinary, relaxation), and safety. Also, prices of tourist services determine the relative attractiveness of a country for foreign tourists, which is partially determined by the stability and level of the local currency. In addition to these factors, the present study presents the hypothesis that there are important but under-recognized links between tourism and sanitation. Two different sets of economic impacts are assessed in this study: (1) the sub-optimal exploitation of tourism potential in the country, which is partially related to poor sanitation; and (2) the estimated costs to tourists associated with health episodes and welfare losses resulting from poor sanitation. However, to avoid potential double-counting of disease episodes of domestic tourists, and to avoid including welfare losses of foreign tourists in national estimates, the second impact above is not included in the total cost estimates of poor sanitation in section 3.1.

Annex Table A30. Comparative sanitation and travel and tourism statistics for selected Southeast & East Asian countries (%)

Country	*Pop. Size (m.)*	*Sanitation coverage*		*Economic activity 2006*		*Growth*	
		1990	**2004**	**Demand (US$billion)**	**Jobs (million)**	**2007**	**2008-2015**
Cambodia	14.8	-	17	1.9	1.1	6.5%	5.7%
China	1,322	23	44	439.8	72	13.3%	9.6%
Indonesia	225.2	46	55	43.5	6.1	3.6%	6.4%
Korea, Republic	48.2	-	-	104.1	1.75	3.7%	5.9%
Laos	5.9	-	30	0.45	0.15	7.1%	6.0%
Malaysia	25.3	-	94	33.6	1.2	4.5%	6.6%
Philippines	82.8	57	72	16.3	7.0	7.0%	5.6%
Singapore	4.4	100	100	37.2	0.20	6.3	6.3%
Thailand	64.1	80	99	47.8	4.1	3.3%	5.5%
Vietnam	83.6	36	61	12.2	3.5	10.5%	7.8%

Source: World Travel and Tourism Council.

Tourists are often heavily influenced in their choice of destination by the availability of information (positive media) on a destination, the offer of package tours or package deals in their home country, and/or the ease of booking flights and hotels on the internet or by phone. Hence there is a self-reinforcing loop, which can – over time – lead to large resort complexes and tourist destinations such as the various coasts and islands of Southern Europe and the Caribbean, coastal areas of Thailand and Malaysia, and well known tropical islands (Zanzibar, Maldives), among others.

What role does sanitation play in a country's attractiveness for tourists? The environment is one of the key attracting elements of a tourist destination – as a popular refrain goes: "sun, sea and sand" – which are recognized factors for attracting tourists. But if the sea is brown from the pollution released by the country's rivers, if the sand or roadsides are soiled with the excreta of the local inhabitants, and if food preparation standards are low, then the tourism potential of a location is clearly limited [113]. Tourist perceptions about the sanitary conditions of a potential tourist destination are gathered from their own research and experience, as well as from the stories and perceptions circulating via travel agencies and social networks. Important aspects for sanitary conditions to tourists include, but are not limited to:

- Aesthetics of the local environment (sight, smell)
- Cleanness of water for swimming or sightseeing
- Availability of clean latrines and water, soaps and towels for personal hygiene, in accommodation, restaurants, bus stops etc.

- Expectations of getting sick either from food poisoning or environmental factors

According to the GSO statistics in 2005, 85% of foreign tourists express no interest in returning to Vietnam, which questions the sustainability of tourism development in Vietnam [114]. There are many reasons, and sanitation is one of those addressed by some stakeholders in Vietnam.

Box 6. View of a local tourist on Thanh Nien Newspaper

> According to an article on Thanh Nien Newspaper on 11 June 2004: one of three major reasons for tourists not returning to Vietnam is inadequate toilets. "There are many terribly dirty public toilets in Vietnam. I can say for sure that as long as public toilets are not improved, Vietnam cannot attract more tourists from abroad. Under current situation, there is no surprise that tourists would be afraid of returning to Vietnam."

Source: View of a local tourist on Thanh Nien Newspaper

The situation is mainly due to the lack of public toilets in Vietnam. In many places, including tourist attractions, toilets are very dirty and poorly maintained. Toilets even do not exist in some tourist areas.

A5.2 Estimation of tourist losses due to poor sanitation

Hence, while it is accepted that the standard of tourist facilities in Vietnam are improving over time, this present study assumes, based on evidence, that the sanitary standards remain sub-optimal. Hence, it is hypothesized that Vietnam could attract more tourists now and in the future: one of the aspects that must improve for that to happen is hygiene and sanitation.

Given the limited options for countries to boost tourist numbers and hotel occupancy rates from improved sanitation in the near-term, the tourist losses are not estimates as a financial cost. However, in the longer term it is assumed that study countries can not only increase the hotel occupancy rates under the existing capacity constraints of tourist infrastructure (airport, hotels, internal transport, restaurants), but also to expand the tourist infrastructure as well as making tourist destinations more attractive for tourists to accommodate significantly increased foreign tourist arrivals. Infrastructure requirements were based on mid- to long-term government targets for tourist growth and total numbers; where these were not available, realistic assumptions are made of the tourist growth achievable over a five year period until 2010. A target occupancy rate of 90% is assumed; this rate does not necessarily reflect the actual future occupancy rates expected, but enables an assumption of increased tourist flow (which may be partially accommodated by increased tourist capacity, hence occupancy stays below 90%). The attribution factor to poor sanitation is assumed to be 5%. This means that 1/20th of the low existing exploitation of tourists is due to poor sanitation, the other 19/20ths being accounted for by other infrastructural and environmental factors. The values used presented in following table.

Annex Table A31. Inputs for calculating the financial losses in tourist receipts

Parameter	
Actual occupancy (%)	60%
Potential occupancy (%)	90%
Contribution of sanitation to tourist losses	5%
Actual number of tourists (millions)	3.58
Average expenditure per tourist (US$)	1283/trip

A.5.2.1 Tourist sickness

Once the tourist is on-site, they may experience a reduction in enjoyment of their holiday experience by becoming sick due to a disease related to poor sanitation and hygiene. While having an illness episode is not only a bad experience in itself, it also eats into valuable holiday time, and may incur some expenses related to treatment. In the worst case, the return journey of the tourist is affected or they need to get emergency transport. The financial costs were estimated based on the estimated disease incidence and an assumed cost per episode. The economic cost is estimated by adding an estimated "welfare loss" from days sickness to the financial cost of sickness treatment. The welfare loss is approximated by the average holiday spending per day multiplied by the average length of incapacitation. However, it is noted that to make national estimates of economic impact of poor sanitation, losses of foreign tourists are excluded from the presentation of costs.

The General Statistics Office of Vietnam conducted a survey in 2005 to assess the health expenditures of both foreign and local tourists. On average, a foreign tourist spends US$1.1 per day on health care, while a Vietnamese tourist in Vietnam spends US$0.29 [114]. The study conservatively assumes that 20% of travelers' diarrhea is caused by poor hygiene and sanitation. An average length of episode is assumed at 3 days. The algorithm is shown in Annex B.

A6 Impact mitigation associated with improved sanitation and hygiene

A6.1 Health

The financial and economic gains from improved sanitation and hygiene will be a proportion of the total losses estimated for diseases associated with poor sanitation and hygiene. The proportion of costs avertable will depend on the expected effectiveness of the interventions employed to prevent disease. No health intervention, as implemented in practice, will be 100% effective in reducing the overall loss. However, sanitation and hygiene interventions have been proven to be effective in a number of field trials [115, 116]. Given that good quality epidemiological studies are limited in number, and have already been reviewed in previous meta-analyses, no additional country-level studies were used to estimate disease cases prevented. Hence the estimates of intervention effectiveness are based on the international literature, which includes the most up-to-date reviews on effectiveness [115-118].

The latest and most authoritative review by Fewtrell et al (2005) presented summaries of effectiveness from a meta-analysis of field trials on water, sanitation and hygiene separately, as well as together [116]. The reader is referred to the paper for details of individual studies. Table A32 below shows the summary of the meta-analysis.

Annex Table A32. Summary of meta-analysis results on WSH intervention efficacy for diarrheal disease reduction

Intervention	Number of studies included[1]	Estimate of effect (relative risk)[2]		
		Low	Mid	High
Household treatment of water	8	0.46	0.61	0.81
Water supply	6	0.62	0.75	0.91
Sanitation	2	0.53	0.68	0.87
Hygiene	8	0.40	0.55	0.75
Multiple interventions	5	0.59	0.67	0.76

Source: Fewtrell e al (2005) [116]
[1] Includes only studies of good quality, as defined by Fewtrell et al
[2] Relative risk of disease when intervention tested against baseline of no intervention (relative risk of 1)

These relative risk reductions are used to estimate expected rates of diarrhea under a situation of basic improved sanitation and hygiene practices, and carried through to estimation of health care cost, productivity and income, and premature deaths. Hence, based on the literature, the following reductions of disease incidence are predicted:

- Sanitation: % incidence reduced = 32% (range 13% to 47%)
- Hygiene: % incidence reduced = 45% (range 25% to 60%)

Note however that hygiene and sanitation interventions implemented together will not have the sum of the individual effects. The literature does not provide evidence for the proposition that two interventions are more effective than one. This point needs to be taken into account in interpreting the estimations of economic loss avoided from health interventions.

A6.2 Other economic losses due to poor sanitation

Given that the attributed costs of poor domestic sanitation have been estimated, the effect of improving sanitation will be the full losses, assuming that the interventions are fully effective in isolating human waste (at least in its harmful form) from the environment. In other words, by removing totally the pollution source, the economic losses will no longer be incurred. This is true for water resources, land resources, user preferences and tourism. However, for some environmental effects where the environment has been degraded considerably over time, there will also need to be expenditure on a clean-up operation to bring the land and water resources back to usable or fully productive condition. These costs are not estimated in this present study.

A6.3 Market for sanitation inputs

Economic impacts and with effects up the supply chain (multiplier effect), will be for small local entrepreneurs as well as larger, non-local companies. There is also a potential for improving livelihoods of poor people through sanitation programs, largely through health improvement and employment generation [20].

Given the needs of sanitation programs for human labor and materials, sanitation programs will have a number of economic effects, whether it be for small local entrepreneurs or larger companies. Table A33 presents the unit costs of different sanitation options. These unit costs reflect the cost per household per year. Financial costs are made up of purchased services (labor, materials, equipment), while economic costs also include non-purchased inputs to the sanitation option (such as household and community-provided labor). These are multiplied by the expected coverage with different sanitation options to estimate total potential market values. These sanitation improvement option figures are from a survey on the interest of people in a new latrine. [119]. Since not all households can afford a new latrine, the study assumes 30% and 1% of total households in the rural and urban areas with unimproved sanitation respectively will invest in new toilets. While on the one hand this reflects community and household spending, it represents an economic gain for those involved in providing the services and will have broader economic effects.

Annex Table A33. Unit prices of different sanitation improvement options

Variable	Double Vault dehydration toilet	Pour flush toilet	Flush toilet with septic tank	Biogas system	Others	Total
Percentage of rural households intend to build new sanitation facilities if they have money[1]	21.6%	20.5%	37.6%	0.6%	19.7%	100.0%
Unit cost (labor, materials, capital)	62	68	75	249	NA	

[1] Data is quoted from Report on Rural Sanitation 2007 (MOH and UNICEF)

A6.4 Market for sanitation outputs

Where human excreta is used as fertilizer, the availability of nutrients from human excreta can lead to the replacement of chemical fertilizer, which saves costs [120]. Furthermore, where fertilizer was not being used optimally before, the nutritional content and economic value of crops may increase. Also, there are long-term benefits of reducing the use of chemical and mineral fertilizers, especially taking into account the fact that some fossil resources are in increasingly short supply (e.g. phosphorous). Alternatively, families with livestock may instead invest in a biogas reactor, which provides biofuel for cooking, space heating and can even be used for lighting where other improved sources (electricity) are not available [121].

The reuse of human waste for fertilizer or biogas production cannot be assumed to be population-wide, given cultural attitudes towards handling and re-use of human waste, and low practical feasibility in many locations. Success often depends on local perceptions of the expected returns on re-use of human waste, whether it be for biogas or fertilizer. This study assumes this proportion as the number of households re-using human and animal feces for both biogas and fertilizer purposes. The study estimates fecal weight per year and volume of gas produced, and the economic value using existing market prices for these products.

In addition to the above, biogas can bring other benefits to the country. The reductions in greenhouse gas emissions from biogas activities are eligible to receive "carbon credits" under the Clean Development Mechanism (CDM) of the United Nations Framework Convention on Climate Change. These credits can be sold in the international market, resulting in revenues for the country. Each biogas tank is equivalent to 2 credits that can be sold at 6 Euro each. According to the biogas project (MARD and SNV), their biogas can bring about 1.8 million Euro per year from 150,000 biogas tanks. However, due to lack of reliable data, this present study does not include this benefit in total economic impact of improved sanitation.

Annex Table A34. Input values for estimation of returns to re-use of human (and animal) waste

Items	Unit	Rural	Urban	Total
Total HHs	HHs	13,922,412	5,434,324	19,356,737
% HHs applying Ecosan	%	1%	0.1%	
Number of HHs applying Ecosan	HHs	139,224	5,434	144,658
Human waste per year to be used	Kg/year	58,266,548	2,166,013	60,432,561
Animal waste per year to be used	Kg/year	8,716,835,867	0	8,716,835,867
Total waste volume to be used for biogas	Kg/year	8,775,102,415	2,166,013	8,777,268,428
% to be used as fertilizer	%	60.0%	60.0%	
Volume of fertilizer	Kg	5,265,061,449	1,299,608	5,266,361,057
Volume of gas	Kg	2,632,530,724	649,804	2,633,180,528

In terms of a market for the outputs from solid waste, the market for recyclables has a large potential for expansion. 32% of municipal waste currently placed in disposal sites in urban areas in Vietnam, or 2.1 million tons per year, consist of commercially recyclable materials such as paper, plastic, metal and glass [7]. This additional recycling could result in a substantial reduction in disposal costs and allow the sector to earn considerable additional revenue.

Composting also has high potential in Vietnam as there is a high proportion of organic matter in municipal wastes. Composting can result in reduction of disposal costs and production of a marketable soil conditioner for use in agriculture and by the public. With the development of a strong market for composting fertilizer and successful source separation, the effectiveness of centralized composting facilities could increase considerably. Composting can also reduce landfill gas emission, which can result in revenues for the country from selling carbon credits under the Clean Development Mechanism (see above).

A7 Uncertainty analysis

Tables A35 and A36 provide alternative input values to reflect data uncertainty in the present study:

(1) Uncertainty in the estimation of overall impacts, such as in the epidemiological and economic variables (Table A35).

(2) Uncertainty in the attribution of the overall impact to poor sanitation (Table A36).

Table A35 presents a selection of uncertain economic variables, and the alternative – low and high values – used in the one-way sensitivity analysis. The selection of basis for lower and upper values of hourly time valued varies by country, due to GDP per capita being higher than compensation of employees in some countries (e.g. Philippines), and lower in others (e.g. Cambodia). The hourly productive time of children was varied from zero to the full adult value. Fish production impact was varied according to the lower and upper bounds presented in Figure A1 (section A3.2.2).

Annex Table A35. Alternative assumptions and values used in one-way sensitivity analysis

Variables selected	Low estimate of impact	Base case estimate	High estimate of impact
Health			
Diarrhea incidence in children under five	Use of DHS data for under fives 70% of diarrheal cases attributed to poor sanitation	Use of DHS data for under fives 88% of diarrheal cases attributed to poor sanitation	Use of WHO regional data for under fives: < 1 year old: 6.56-10.49 1-4 year old: 2.46-3.93 88% of diarrheal cases attributed to poor sanitation
Hourly value of productive time	30% of average income	30% of GDP per capita	GDP per capita
Hourly value of productive time for children	Children given value of zero	Children given 50% value as adults	Children given same value as adults
Premature death	Human capital approach, using 2% growth and GDP per capita	Human capital approach, using 2% growth and compensation of employees	VOSL benefit transfer of US$2 million, using 0.6 income elasticity
Water			
Fish production and DO relationship	Lower range used (fish less affected by low DO)	Mid range used	Higher range used (fish more affected by low DO)
User preferences			
Time access (minutes per day)	5	10	15
Value of time	See under 'health' above		

The Table A36 below provides assumptions on the links between poor sanitation and its impacts.

Annex Table A36. Alternative assumptions for links between poor sanitation and impacts

Variables selected	Low estimate of impact	Base case estimate of impact	High estimate of impact
Health			
Diarrheal disease incidence attributed to poor S&H	80%	88%	100%
Water			
Water pollution attributed to poor sanitation (Table 15)	30%	40%	50%
Tourism			
Tourist numbers impact attributed to poor sanitation	2%	5%	10%

Annex B: Algorithms

B1. Aggregating equations

Total costs of sanitation and hygiene

$$C = CH + CW + CL + CU + CT \quad (1)$$

Health related costs of poor sanitation and hygiene

$$CH = CH\_HC + CH\_P + CH\_D \quad (2)$$

Water related costs of poor sanitation and hygiene

$$CW = CW\_Drink + CW\_Domestic + CW\_Fish \quad (3)$$

User preference losses of poor sanitation and hygiene

$$CU = CU\_T + CU\_AS + CU\_AW \quad (4)$$

Tourism losses from poor sanitation

$$CT = CT\_RL \quad (5)$$

B2. Health costs related to poor sanitation and hygiene

Total health care costs (6)

$$CH\_HC = \sum_i CH\_HC_i$$

Health care cost per disease (7)

$$CH\_HC_i = \alpha_i \cdot pop \cdot \beta_i \cdot \sum_h \chi_{ih} \cdot v_{ih} \cdot phealth_{ih}$$

Total productivity costs (8)

$$CH\_P = \sum_i CH\_P_i$$

Productivity cost of disease type i (9)

$$CH\_P_i = \alpha_i \cdot pop \cdot \beta_i \cdot dh_i \cdot ptime$$

Total cost of premature death (10)

$$CH\_D = \sum_i CH\_D_i$$

Cost of premature death per disease (11)

$$CH\_D_i = \sum_a death_{ia} \cdot \gamma_{ia} \cdot pdeath_a$$

B3. Water related costs associated with poor sanitation and hygiene

Total cost associated with accessing clean drinking water (12)

$$CW\_Drink = \sum_m CW\_Drink_m$$

Cost of accessing clean drinking water per source/treatment method (13)

$$CW\_Drink_m = h_m \cdot wdrink_m \cdot pwater_m \cdot \delta \cdot \pi_m$$

Total domestic water access cost (excl. drinking water) (14)

$$CW\_Domestic = \sum_m CW\_Domestic_m$$

Domestic water access cost by source/method (15)

$$CW\_Domestic_m = h_m \cdot wdom_m \cdot pwater_m \cdot \delta \cdot \theta_m$$

Fisheries loss (16)

$$CW \quad Fish = AFP - PFP$$

Potential fish production level (17)

$$PFP = \frac{AFP}{\varepsilon}$$

B4. Land costs

$$CL = ql \cdot pland \quad (18)$$

B5. User preference costs Algorithm

Time access cost for unimproved latrine

$$CU\_T = pop\_u \cdot taccess \cdot ptime \cdot 365 \quad (19)$$

Cost of days absent from school

$$CU\_AS = egirls \cdot \phi \cdot das \cdot pstime \quad (20)$$

Cost of days absent from work

$$CU\_AW = ewomen \cdot \eta \cdot daw \cdot pwtime \quad (21)$$

B6. Tourism losses

Lost revenues (22)

$$CT\_RL = \varphi \cdot \left(\frac{oc_O}{oc_A} - 1 \right) \cdot ta \cdot et$$

Tourist health cost and welfare loss (23)

$$CT\_HT = td \cdot \mu \cdot (pahc + pawl)$$

B7. Variable definition summary

Tables B1 to B3 present the subscripts, variables and parameters used in the algoritms in Sections B1 to B6 above.

Table B 1. Subscripts used in algorithms

Code	Description	Elements[1]
a	Age group	Less than one year, 1-4 years, 5-14 years, 15-65 years, over65
i	Disease types	Diahhrea, Cholera, Typhoid, Malnutrition related diseases, etc
h	Health care provider	Public hospital, private hospital, informal care, self-treatment
m	Treatment method	Piped water, non-piped water, home-treated, hauled water

[1] Varies by country.

Table B2. Variables used in algorithms

Symbol	Description
C	Total cost of poor sanitation and hygiene
CHC	Health costs of poor sanitation and hygiene
CH_HC	Health care costs of all diseases
CH_HC_i	Health care cost of disease type *i*
CH_P	Productivity costs of diseases
CH_P_i	Productivity cost of disease type *i*
CH_D	Premature death costs of diseases
CL	Land cost
CT	Tourism losses associated with poor sanitation and hygiene
CT_RL	Revenue losses
CT_HT	Tourist health and welfare losses
CU	Use preference losses associated with poor sanitation and hygiene
CU_T	Time access cost for unimproved latrine
CU_AS	Cost of days absent from school
CU_AW	Cost of days absent from work
CW	Water related costs of poor sanitation and hygiene
CW_Drink	Clean water drinking access costs
CW_Drink_m	Clean water drinking access cost for method *m*
CW_Domestic	Domestic water access costs
$CW\_Domestic_m$	Domestic water access cost for method *m*
CW_Fish	Fisheries production loss
$death_{ia}$	Number of premature deaths, by disease type *i* and age group *a*
dh_i	Number of days taken off work or daily activities due to disease *i*
das	Days per girl per year taken off school due to poor sanitation
daw	Days per woman per year taken off work due to poor sanitation
egirls	Number of adolescent girls enrolled in school
et	Expenditure per tourist (US$)
ewomen	Number of women in paid employment
h_m	Number of households using water source or treatment method
oca	Actual occupancy rate (%)
oco	Optimal occupancy rate (%)
pahc	Average health care cost per case

pawl	Average welfare cost per case
$pdeath_a$	Value of premature death for age group *a*
PFP	Potential fish production value
$phealth_{ih}$	Unit price of care (per visit or day) for disease type *i* at health facility *h*
pland	Unit value of land per m^2
ptime	Daily value of time
pstime	Daily value of school time lost
pwtime	Daily value of work time lost
$pwater_m$	Water price or time value per m^3 of water
pop	Population
pop_u	Population with unimproved access to sanitation
ql	Quantity of land made useable by poor sanitation
ta	Actual number of tourists
taccess	Average access time (journey or waiting) per day
td	Total diseases suffered by tourists
v_{ih}	Visits to or days for disease type *i* at health facility *h*
$wdrink_m$	Consumption per household of drinking water (m^3) from water source/treatment method *m*
$wdom_m$	Consumption per household for domestic purposes (m^3) from water source/treatment method *m*

Table B3. Parameters used in algorithms

Symbol	Description
α_i	Incidence rate per person of disease type i
β_i	Proportion of episodes attributed to poor sanitation for disease type i
χ_{ih}	Proportion of cases seeking care for disease type i and provider h
γ_{ia}	Proportion of deaths attributable to poor sanitation, by disease type *i* and age group *a*
δ	Attributable water pollution to poor sanitation
ε	Ratio of the fish production at the current DO level to fish production at the optimal DO level
ϕ	Proportion of schools with inadequate sanitation facility
η	Proportion of work places with inadequate sanitation facilities
μ	Proportion of diseases related to sanitation
π_m	Importance of averting drinking polluted water in relation to overall benefits of piped water supply; where $\pi_m = 1$ for $m \neq$ piped-water
θ_m	Importance of averting using polluted water in domestic activities in relation to overall benefits of piped water supply; where $\theta_m = 1$ for $m \neq$ piped-water

Annex C: List of Stakeholder and Person met

Annex Table C1. List of Stakeholder and Person met

Stakeholder		Person Met
Ministries or government agencies		
Health		
	Department of Preventive Medicine	Mr. Tran Dac Phu (Head of Preventive Medicine Department) Mr. Dang Quang Tan (Deputy head of Community Health Division)
	Department of Treatment	Ms. Tran Thu Thuy
	Department of Planning and Finance, Health Policy Unit	Mr. Vu Van Chinh
	National Institute of. Hygiene and Epidemiology	Ms. Nguyen Thi Yen
	National Institute of Malaria, Parasitology and Entomology	Ms. Nguyen Thi Viet Hoa
	National Institute of Nutrition	Mr. Nguyen Duc Minh
	National Institute of Dermatology and. Venerology	Mr. Nguyen Thanh
	National Institute of Ophthalmology	Mr. Nguyen Quoc Luong
Natural resource & Environment		
	Department of Environment	Mr. Ho Kien Trung
	Vietnam Environment Protection Agency	Mr. Nguyen Van Thuy, Information Centre
Planning and Investment		
	Department of Foreign Direct Investment	Ms. Le Hai Van
Fisheries		Mr. Nguyen Van Ly
Agriculture and rural development		Ms. Nguyen Phuong Lam
Construction		
	Department of Infrastructure	Mr. Nguyen Van Thai
Donors and NGOs		
WHO Vietnam		Dr. Tran Cong Dai (malaria and parasite control)
UNICEF		Dr. Marjatta Tolvanen-Ojutkangas Chief, Health and Nutrition Section Mr. Chander Badloe, Chief – Water, Environment and Sanitation Mr. Nguyen Dinh Quang, Officer – Health and Nutrition Policy
	International Trachoma Initiative (ITI)	Ms. Nguyen Phuong Mai, Chief Representative
	SNV/MARD Biogas Project	Mr. Bastiaan Teune, Advisor
	Tourism Consulting and Promoting Center (Vietnam Tourism Association)	Mr. Do Tung Lam, Director
	Vietnam Water Supply and Sewage Association	Mr. Tran Quang Hung, General Secretary
	University of Science: Research Center for Environmental Technology	Mr. Vu Van Thang

Annex D: Data Inputs

Annex Table D1. Definition of 'improved' and 'unimproved' sanitation and water supply

Intervention	Improved	Unimproved [1]

Sanitation	• Flush or pour-flush to:
	  • Piped sewer system
	  • Septic tank
	  • Pit latrine
	• Ventilated Improved Pit-latrine
	• Pit latrine with slab
	• Composting toilet
		• Flush or pour-flush to elsewhere
		• Pit latrine without slab or open pit
		• Bucket
		• Hanging toilet or hanging latrines
		• No facilities or bush or field

Water supply	• Piped water into dwelling, plot, or yard • Public tap / standpipe • Tubewell/borehole • Protected dug well • Protected spring • Rainwater collection	• Unprotected dug well • Unprotected spring • Cart with small tank/drum • Tanker truck • Bottled water • Surface water (river, dam, lake, pond, stream, canal, irrigation channels)

Source: This table reflects the updated definition of improved and unimproved sanitation and water supply presented in the 2006 JMP report [4].

[1] Defined as being unimproved due to being unsafe or costly

Annex Table D2. Sanitation coverage by region and rural/urban grouping

Regions	Improved			Unimproved Sanitation			
	House Connection, Septic tank (Flush/pour-flush)	Ventilated improved pit latrine, pit latrine with slab, composting toilet etc.,	Total	Public or share toilet, Pit latrine without slab etc.,	Open (No facilities)	Other	Total
Rural/Urban							
Rural	20.5	29.5	50.0	na	16.3	33.7	50.0
Urban	80.8	8.8	89.6	na	3.2	7.2	10.4
Region							
Red River Delta	35.1	36.5	71.6	na	3.1	25.3	28.4
North East	18.1	39.8	57.9	na	3.1	39	42.1
North West	12.4	10.4	22.8	na	5.6	71.6	77.2
North Central Coast	19.9	43.9	63.8	na	2.3	33.9	36.2
South Central Coast	62	18.9	80.9	na	0.8	18.3	19.1
Central Highland	33.9	9.0	42.9	na	2.2	54.9	57.1
South East	74.1	4.8	78.9	na	2	19.1	21.1
Mekong River Delta	28.8	2.6	31.4	na	59.1	9.5	68.6
Total	**37.2**	**23.8**	**61.0**	na	**12.7**	**26.3**	**39.0**

Source: VNHLSS 2004

Annex Table D3. Diseases linked to poor sanitation and hygiene, and primary transmission routes and vehicles

Disease	Pathogen	Primary transmission route	Vehicle
Diarrheal diseases (Gastrointestinal tract infections)			
Rotavirus diarrhea	Virus	Fecal-oral	Water, person-to-person
Typhoid/ paratyphoid	Bacterium	Fecal-oral and urine-oral	Food, water. + person-person
Vibrio cholera	Bacterium	Fecal-oral	Water, food
Escherichia Coli	Bacterium	Fecal-oral	Food, water. + person-person
Amebiasis (amebic dysentery)	Protozoa*	Fecal-oral	Person-person, food, water, animal feces
Giardiasis	Protozoa*	Fecal-oral	Person-person, water (animals)
Salmonellosis	Bacterium	Fecal-oral	Food
Shigellosis	Bacterium	Fecal-oral	Person-person. +food, water
Campylobacter Enteritis	Bacterium	Fecal-oral	Food, animal feces
Helicobacter pylori	Bacterium	Fecal-oral	Person-person. + food, water
Protozoa			
Other viruses**	Virus	Fecal-oral	Person-person, food, water
Malnutrition	Caused by diarrhoeal disease and helminthes		
Helminths (worms)			
Intestinal nematodes***	Roundworm	Fecal-oral	Person-person. + soil, raw fish
Digenetic trematodes (e.g. Schistosomiasis Japonicum)	Flukes (parasite)	Fecal/urine-oral; fecal-skin	Water and soil (snails)
Cestodes	Tapeworm	Fecal-oral	Person-person. + raw fish
Eye diseases			
Trachoma	Bacterium	Fecal-eye	Person-person, via flies, fomites, coughing
Adenoviruses (conjunctivitis)	Protozoa*	Fecal-eye	Person-person
Skin diseases			
Ringworm (Tinea)	Fungus (Ectoparasite)	Touch	Person-person
Scabies	Fungus (Ectoparasite)	Touch	Person-person, sharing bed and clothing
Other diseases			
Hepatitis A	Virus	Fecal-oral	Person-person, food (especially shellfish), water
Hepatitis E	Virus	Fecal-oral	Water
Poliomyelitis	Virus	Fecal-oral, oral-oral	Person-person
Leptospirosis	Bacterium	Animal urine-oral	Water and soil – swamps, rice fields, mud

Sources: WHO http://www.who.int/water_sanitation_health/en/ and [122, 123]

Notes to Table 15

* There are several other protozoa-based causes of GIT, including

- Balantidium coli – dysentery, intestinal ulcers
- Cryptosporidium parvum - gastrointestinal infections
- Cyclospora cayetanensis - gastrointestinal infections
- Dientamoeba fragilis – mild diarrhea
- Isospora belli / hominus – intestinal parasites, gastrointestinal infections

** Other viruses include:

- Adenovirus – respiratory and gastrointestinal infections
- Astrovirus – gastrointestinal infections
- Calicivirus – gastrointestinal infections
- Norwalk viruses – gastrointestinal infections
- Reovirus – respiratory and gastrointestinal infections

*** Intestinal nematodes include:

- Ascariasis (roundworm - soil)
- Trichuriasis trichiura (whipworm)
- Ancylostoma duodenale / Necator americanus (hookworm)
- Intestinal Capillariasis (raw freshwater fish in Philippines)

Annex Table D4. Health care unit cost studies from the Vietnam

Weighted mean values of direct and indirect costs of rotavirus-specific diarrhea in urban and rural Vietnamese health care facilities.

Aspect, type of cost, cost	Urban	Rural
	(Nha Trang) (*n* = p 60)	(Ninh Hoa) (*n* = p 30)
1. Hospitalization		
1.1 Medical direct costs		
Bed cost per day	5.55	1.74
Bed cost per visit[1]	23.85	8.34
Diagnostics and medicine	3.25	9.25
Sub-total (1.1)	**27.09**	**17.59**
1.2 Nonmedical direct costs (transport)	4.74	4.37
1.3 Indirect costs (lost wages)	4.33	9.04
Total (1.1 + 1.2 + 1.3)	**36.16**	**31.00**
2. Outpatient visit		
2.1 Medical direct costs (cost per visit[2])		
Hospital outpatient	0.25	0.13
Polyclinic/CHC	0.20	0.17
Private clinic	0.66	0.53
2.1 Diagnostics and medicine[3]		
Hospital outpatient	3.76	3.98
Polyclinic/CHC	2.68	3.00
Private clinic	3.05	3.49
Sub-total: Hospital outpatient (2.1)	**4.01**	**4.11**
Sub-total: Polyclinic/CHC (2.1)	**2.88**	**3.17**
Sub-total: Private clinic (2.1)	**3.71**	**4.02**
2.2 Nonmedical direct costs[3]		
Hospital outpatient	0.58	1.35
Polyclinic/CHC	0.40	0.92
Private clinic	0.47	1.13
2.3 Indirect costs (lost wages)[3]		
Hospital outpatient	1.11	2.75
Polyclinic/CHC	2.48	2.64
Private clinic	4.27	2.70
Total: Hospital outpatient (2.1 + 2.2 + 2.3)	**5.70**	**8.21**
Total: Polyclinic/CHC (2.1 + 2.2 + 2.3)	**5.76**	**6.73**
Total: Private clinic (2.1 + 2.2 + 2.3)	**8.45**	**7.85**

Source: Fischer et al. Health care costs of diarrheal disease and estimates of the cost-effectiveness of rotavirus vaccination in Vietnam. Journal of International Development. 2005. 192.

[1] Calculated by multiplying the bed cost per day by the mean no. of days per stay (4.3 days for Nha Trang and 4.8 days for Ninh Hoa).

[2] Hospital outpatient (urban, ; rural,), polyclinic/CHC (urban, *n*p42 *n*p15; rural,), private clinic (urban, ; rural,); cost estimates *n*p2 *n*p10 *n*p20 *n*p0; for visits to rural private clinics were extrapolated from costs for visits to urban private clinics by using 80% of the cost of a visit to a public clinic.

[3] Calculated as the average for rural hospital outpatient and polyclinic/CHC costs.

Annex Table D5: Breakdown Diseases by Morbidity and Mortality by Region

Diseases	Incidence/ Cases	Red River Delta	North East	North West	North Central Coast	South Central Coast	Central Highlands	South East	Mekong River Delta	Total
Diarrheal	*Morbidity*	209,308	108,583	29,769	123,221	81,797	55,217	156,175	200,351	964,420
	Mortality	9	5	1	5	4	2	7	9	42
Helminths	*Morbidity*	5,327	2,764	758	3,136	2,082	1,405	3,975	5,099	24,545
	Mortality	-	-	-	-	-	-	-	-	-
Trachoma	*Morbidity*	112,595	207,168	74,675	343,483	57,609	6,311	34,681	146,147	982,667
	Mortality	-	-	-	-	-	-	-	-	-
Scabies	*Morbidity*	44,738	23,209	6,363	26,338	17,484	11,802	33,381	42,824	206,137
	Mortality	-	-	-	-	-	-	-	-	-
Hepatitis A	*Morbidity*	1,700	882	242	1,001	664	449	1,269	1,627	7,834
	Mortality	-	-	-	-	-	-	-	-	-
Malnutrition	*Morbidity*	340,053	235,212	69,026	281,961	161,592	145,302	225,141	360,650	1,818,939
	Mortality	-	-	-	-	-	-	-	-	-
ALRI	*Morbidity*	60,320	51,489	13,269	39,701	29,238	34,130	174,633	85,830	488,610
	Mortality	159	179	63	121	138	107	1,454	256	2,476
Measles	*Morbidity*	1,771	919	252	1,043	692	467	1,321	1,695	8,160
	Mortality	-	-	-	-	-	-	-	-	-
Malaria	*Morbidity*	8,433	18,110	10,781	15,227	12,986	19,677	8,267	5,795	99,276
	Mortality	-	-	-	1	2	13	2	-	18
Total	*Morbidity*	784,245	648,334	205,134	835,109	364,145	274,760	638,843	850,019	4,600,589
	Mortality	168	183	64	127	144	122	1,462	264	2,536

Annex Table D6: Breakdown of Diseases by Age

Diseases	Age	Percentage	Red River Delta	North East	North West	North Central Coast	South Central Coast	Central Highlands	South East	Mekong River Delta	Total
Diarrheal	*0-4*	*75.00%*	156,981	81,437	22,326	92,416	61,348	41,413	117,131	150,264	723,315
	5-14	*15.00%*	31,396	16,287	4,465	18,483	12,270	8,283	23,426	30,053	144,663
	15+	*10.00%*	20,931	10,858	2,977	12,322	8,180	5,522	15,617	20,035	96,442
	Total		209,308	108,583	29,769	123,221	81,797	55,217	156,175	200,351	*964,420*
Helminths	*0-4*	*70.00%*	3,729	1,934	530	2,195	1,457	984	2,782	3,569	17,182
	5-14	*20.00%*	1,065	553	152	627	416	281	795	1,020	4,909
	15+	*10.00%*	533	276	76	314	208	141	397	510	2,455
	Total		5,327	2,764	758	3,136	2,082	1,405	3,975	5,099	*24,545*
Trachoma	*0-4*	*85.00%*	95,705	176,093	63,474	291,960	48,968	5,364	29,479	124,225	835,267
	5-14	*10.00%*	11,259	20,717	7,467	34,348	5,761	631	3,468	14,615	98,267
	15+	*5.00%*	5,630	10,358	3,734	17,174	2,880	316	1,734	7,307	49,133
	Total		112,595	207,168	74,675	343,483	57,609	6,311	34,681	146,147	*982,667*
Scabies	*0-4*	*75.00%*	33,553	17,407	4,772	19,753	13,113	8,852	25,036	32,118	154,603
	5-14	*15.00%*	6,711	3,481	954	3,951	2,623	1,770	5,007	6,424	30,921
	15+	*10.00%*	4,474	2,321	636	2,634	1,748	1,180	3,338	4,282	20,614
	Total		44,738	23,209	6,363	26,338	17,484	11,802	33,381	42,824	*206,137*
Hepatitis A	*0-4*	*70.00%*	1,190	617	169	701	465	314	888	1,139	5,484
	5-14	*20.00%*	340	176	48	200	133	90	254	325	1,567
	15+	*10.00%*	170	88	24	100	66	45	127	163	783
	Total		1,700	882	242	1,001	664	449	1,269	1,627	*7,834*
Malnutrition	*0-4*	*90.00%*	306,048	211,691	62,124	253,765	145,433	130,772	202,627	324,585	1,637,045
	5-14	*10.00%*	34,005	23,521	6,903	28,196	16,159	14,530	22,514	36,065	181,894
	15+	*0.00%*	-	-	-	-	-	-	-	-	-
	Total		340,053	235,212	69,026	281,961	161,592	145,302	225,141	360,650	1,818,939
ALRI	*0-4*	*70.00%*	42,224	36,042	9,288	27,790	20,467	23,891	122,243	60,081	342,027
	5-14	*20.00%*	12,064	10,298	2,654	7,940	5,848	6,826	34,927	17,166	97,722
	15+	*10.00%*	6,032	5,149	1,327	3,970	2,924	3,413	17,463	8,583	48,861
	Total		60,320	51,489	13,269	39,701	29,238	34,130	174,633	85,830	*488,610*
Measles	*0-4*	*85.00%*	1,505	781	214	886	588	397	1,123	1,441	6,936
	5-14	*10.00%*	177	92	25	104	69	47	132	170	816
	15+	*5.00%*	89	46	13	52	35	23	66	85	408
	Total		1,771	919	252	1,043	692	467	1,321	1,695	8,160
Malaria	*0-4*	*60.00%*	5,060	10,866	6,469	9,136	7,792	11,806	4,960	3,477	59,566
	5-14	*25.00%*	2,108	4,528	2,695	3,807	3,247	4,919	2,067	1,449	24,819
	15+	*15.00%*	1,265	2,717	1,617	2,284	1,948	2,952	1,240	869	14,891
	Total		8,433	18,110	10,781	15,227	12,986	19,677	8,267	5,795	*99,276*
Total	*0-4*		645,996	536,868		698,602	299,630	223,792	506,270	700,899	3,781,424
	5-14		99,126	79,653	25,364	97,657	46,525	37,377	92,590	107,286	585,577
	15+		39,123	31,813	10,403	38,850	17,989	13,591	39,983	41,835	233,587
	Total		784,245	648,334		835,109	364,145	274,760	638,843	850,019	4,600,589

Annex Table D7: Breakdown Diseases by Region

Diseases	Region	Red River Delta	North East	North West	North Central Coast	South Central Coast	Central Highlands	South East	Mekong River Delta	Total
Diarrheal	*Urban*	52,030	20,512	4,146	16,887	24,629	15,508	85,025	41,379	260,116
	Rural	157,278	88,070	25,623	106,334	57,169	39,709	71,150	158,972	704,304
	Total	209,308	108,583	29,769	123,221	81,797	55,217	156,175	200,351	**964,420**
Helminths	*Urban*	1,324	522	106	430	627	395	2,164	1,053	6,620
	Rural	4,003	2,241	652	2,706	1,455	1,011	1,811	4,046	17,925
	Total	5,327	2,764	758	3,136	2,082	1,405	3,975	5,099	**24,545**
Trachoma	*Urban*	27,989	39,136	10,400	47,072	17,346	1,772	18,881	30,184	192,780
	Rural	84,606	168,032	64,275	296,411	40,264	4,538	15,800	115,962	789,887
	Total	112,595	207,168	74,675	343,483	57,609	6,311	34,681	146,147	**982,667**
Scabies	*Urban*	11,121	4,384	886	3,609	5,264	3,315	18,174	8,845	55,598
	Rural	33,617	18,824	5,477	22,728	12,219	8,487	15,208	33,979	150,540
	Total	44,738	23,209	6,363	26,338	17,484	11,802	33,381	42,824	**206,137**
Hepatitis A	*Urban*	423	167	34	137	200	126	691	336	2,113
	Rural	1,278	715	208	864	464	323	578	1,291	5,721
	Total	1,700	882	242	1,001	664	449	1,269	1,627	**7,834**
Malnutrition	*Urban*	84,531	44,434	9,613	38,641	48,654	40,810	122,572	74,487	463,742
	Rural	255,523	190,779	59,413	243,320	112,938	104,492	102,569	286,164	1,355,197
	Total	340,053	235,212	69,026	281,961	161,592	145,302	225,141	360,650	**1,818,939**
ALRI	*Urban*	14,994	9,727	1,848	5,441	8,803	9,586	95,075	17,727	163,201
	Rural	45,326	41,762	11,421	34,260	20,435	24,544	79,559	68,103	325,410
	Total	60,320	51,489	13,269	39,701	29,238	34,130	174,633	85,830	**488,610**
Measles	*Urban*	440	174	35	143	208	131	719	350	2,201
	Rural	1,331	745	217	900	484	336	602	1,345	5,959
	Total	1,771	919	252	1,043	692	467	1,321	1,695	**8,160**
Malaria	*Urban*	2,096	3,421	1,501	2,087	3,910	5,527	4,501	1,197	24,240
	Rural	6,337	14,689	9,280	13,140	9,076	14,150	3,766	4,598	75,036
	Total	8,433	18,110	10,781	15,227	12,986	19,677	8,267	5,795	**99,276**
Total	*Urban*	194,948	122,477	28,569	114,446	109,642	77,169	347,801	175,558	1,170,610
	Rural	589,297	525,858	176,565	720,663	254,503	197,590	291,042	674,461	3,429,979
	Total	784,245	648,334	205,134	835,109	364,145	274,760	638,843	850,019	**4,600,589**

Annex Table D8: Sources of drinking water for households, 2004

	Source of water (%)									
	Private tap	Public standpipe	Buying water	Deep drill well with pump	Hand dug well,	Filtered Spring water	Other well	Rain water	River, lake, spring, pond	Others
WHOLE COUNTRY	**15.32**	**3.76**	**0.54**	**23.02**	**22.75**	**0.58**	**8.45**	**14.76**	**7.40**	**3.42**
By area										
Urban	49.82	7.14	1.10	18.90	10.94	0.16	4.17	4.67	2.06	1.04
Rural	3.71	2.63	0.34	24.40	26.72	0.72	9.90	18.16	9.20	4.22
By region										
Red River Delta	17.46	1.58	0.23	29.62	12.21	0.07	0.42	37.89	0.19	0.33
North East	9.78	2.26	0.07	7.75	47.88	0.85	13.92	2.49	3.43	11.57
North West	7.15	3.29	0.00	1.05	23.55	6.10	13.98	2.04	5.41	37.43
North Central Coast	9.36	1.35	0.10	19.96	50.07	0.72	7.97	6.11	0.77	3.59
South Central Coast	12.96	2.91	0.41	23.81	48.85	0.28	7.62	0.00	1.32	1.84
Central Highland	10.04	1.75	0.13	2.38	22.33	1.49	52.06	1.10	3.62	5.10
South East	30.01	5.62	2.23	34.51	10.57	0.41	13.47	0.98	1.15	1.05
Mekong River Delta	12.10	8.31	0.40	24.65	1.29	0.27	0.70	21.13	31.05	0.10

Source: Vietnam Household Living Standard Survey 2004

Annex Table D9: Water quality – Fresh-water quality guidelines for protection of aquatic life Standard Detail Information (TCVN 6774:2000)

Standard Code:	TCVN 6774:2000
Standard Name:	Water quality – Fresh-water quality guidelines for protection of aquatic life
Year of Issuance:	2000
Category:	Water quality
Type:	Fresh-water quality for protection of aquatic life
Content:	Water quality standard

Maximum value

No.	Name	Formula	Unit	A	B	C	D
1	2,4,5T	-	mg/l	<=0.16			
2	2,4D	-	mg/l	<=0.45			
3	Aldrin/Dielrin	-	ug/l (microgam)	<0.008			
4	Amoniac	NH3	mg/l	<=2.2	<=1.33	<=1.49	<=0.93
5	Asen	As	mg/l	<=0.02			
6	B.H.C	-	ug/l (microgam)	<0.13			
7	Cacbondioxit	CO2	mg/l	<12			
8	Cadimi	Cd	ug/l (microgam)	0.8-1.8			
9		-	mg/l	<=05			
10		TDS	mg/l	<=1000			
11	Suspended solid	SS	mg/l	<100			
12	Lead	Pb	mg/l	0.002-0.007			
13	Clordan	-	ug/l (microgam)	0.02			
14	Crom	Cr	mg/l	<=0.02			
15	Grease	-	-	not observable			
16	DDT	DDT	ug/l (microgam)	0.004			
17	Copper	Cu	mg/l	0.002-0.004			
18	Endosulfan	-	ug/l (microgam)	0.01			
19	Endrin	-	ug/l (microgam)	<0.014			
20	Heptaclo	-	ug/l (microgam)	0.06			
21	Lindan	-	ug/l (microgam)	0.38			
22	Malation	-	ug/l (microgam)	<=0.32			
23	Temperature	to	oC	Natural temperature			
24	Biological Oxygennn Demand	BOD5	mg/l	<10			
25	Dissolved Oxygen	DO	mg/l	5			
26	Paraquat	-	mg/l	<=1.80			
27	Paration	-	ug/l (microgam)	<=0.40			
28	pH	pH	-	6.5-8.5			
29	Phenol	-	mg/l	<=0.02			
30	Selen	Se	mg/l	<=0.001			
31	Mercury	Hg	ug/l (microgam)	<=0.1			
32	Cyanide	CN-	mg/l	<=0.005			

Annex Table D10. Fish production levels by region (in thousand tons)

Regions	Recorded Weight							Total volume
	Farming		Total farming	Catching			Total catching	
	Fish	Shrimps and others		Sea catch		Inland catch		
				Total	Fish			
Whole country	**933.50**	**503.90**	**1437.40**	**1809.70**	**1340.70**	**185.70**	**1,995.40**	**3432.80**
Red River Delta	163.60	51.72	215.32	84.13	62.33	24.39	108.53	323.85
North East	34.38	10.62	45.01	33.14	24.55	9.94	43.09	88.09
North West	5.80	0.10	5.90	0.00	0.00	1.41	1.41	7.31
North Central Coast	40.97	20.14	61.12	176.07	130.44	2.73	178.80	239.91
South Central Coast	5.29	20.58	25.87	329.79	296.81	54.51	384.30	410.17
Central Highlands	10.29	0.22	10.51	0.00	0.00	3.68	3.68	14.19
South East	44.96	45.29	90.25	415.47	307.80	3.52	418.99	509.24
Mekong River Delta	628.19	355.20	983.38	700.28	518.80	156.34	856.62	1840.01

Source: Statistics Yearbook 2005 on Agriculture, Forestry and Fishing (GSO)

Annex Table D11. Share of household having toilet by type of toilet, area, and region (in percentage)

	Share of household having toilet	Type of toilet				
		Flush toilet with septic tank/ sewage pipes	Absorbing flush toilet	Double vault compost latrine	Toilet directly over the water	Others
WHOLE COUNTRY	**86.17**	**32.48**	**4.65**	**23.82**	**12.65**	**26.40**
By area						
Urban	94.17	73.73	7.07	8.77	3.20	7.22
Rural	83.48	16.82	3.73	29.53	16.23	33.68
By region						
Red River Delta	96.79	32.95	2.11	36.50	3.10	25.35
North East	90.70	15.90	2.21	39.83	3.06	39.00
North West	81.67	11.07	1.28	10.36	5.56	71.73
North Central Coast	89.33	17.07	2.84	43.94	2.27	33.86
South Central Coast	64.62	51.72	10.27	18.91	0.75	18.34
Central Highland	82.37	24.28	9.64	9.03	2.16	54.89
South East	90.48	64.19	9.88	4.84	1.97	19.13
Mekong River Delta	76.25	24.67	4.06	2.63	59.10	9.51

Source: Vietnam Household Living Standard Survey 2004

Annex Table D12. Percentage of household using latrines and types of latrines

Percentage of household using latrine by region (urban area)

Region	Separately using	Sharing	Did not have	Total
Red River Delta	84.18	15.37	0.44	100.00
Northeast	88.98	8.21	2.90	100.00
Northwest	91.84	6.95	1.21	100.00
North Central Coast	86.04	9.10	4.86	100.00
South Central Coast	79.08	6.04	14.88	100.00
Central Highlands	90.96	4.88	4.16	100.00
Southeast	89.16	7.92	2.92	100.00
Mekong Delta	61.81	35.25	2.95	100.00
Total	82.91	13.31	3.78	100.00

Percentage of households using latrine by regions (rural area)

Region	Separately using	Sharing	Did not have	Total
Red River Delta	84.9	14.0	1.2	100.00
Northeast	75.6	7.9	16.5	100.00
Northwest	69.0	4.9	26.1	100.00
North Central Coast	76.4	12.2	11.4	100.00
South Central Coast	40.4	6.1	53.5	100.00
Central Highlands	69.1	3.8	27.1	100.00
Southeast	74.0	10.4	15.7	100.00
Mekong Delta	52.2	40.0	7.8	100.00
Total	69.4	17.1	13.5	100.00

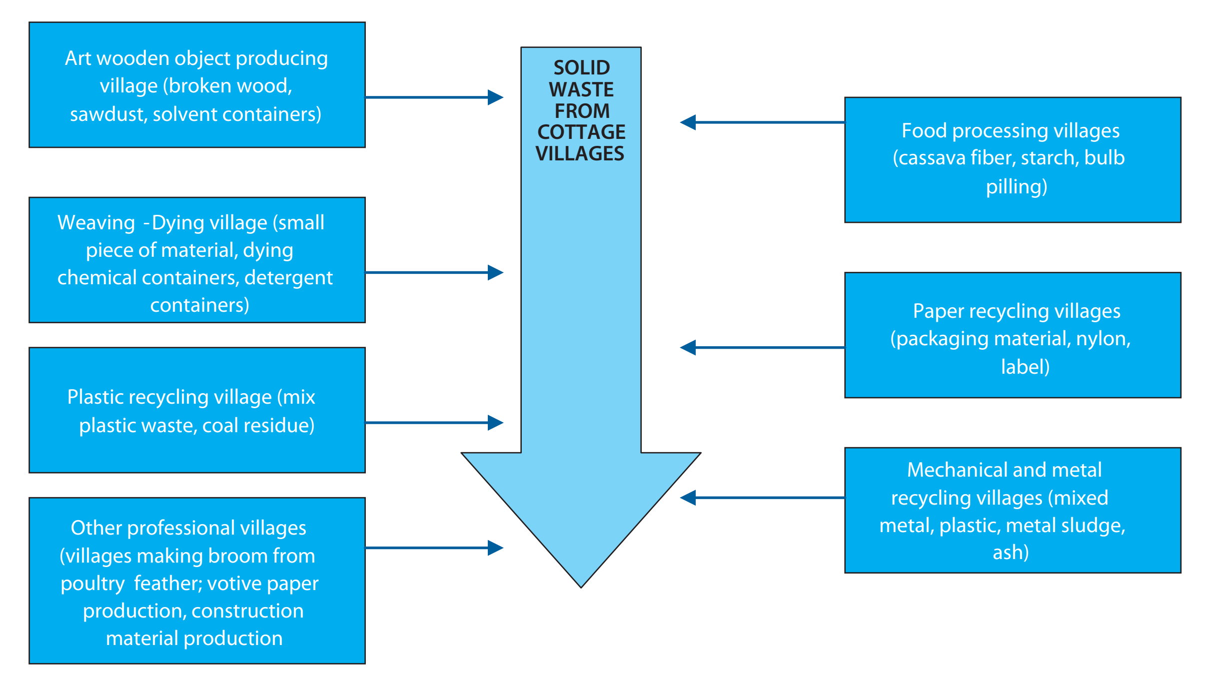
Source: National Health Survey 2001 – 2002

Annex Table D13. Cottage villages and their waste

Sector	Food	Recycled waste			Pottery, Porcelain and construction material	Textile, silk germination, leather	Fine arts and craft
Area		Paper recycling	Plastic recycling	Metal recycling			
The North	134	4	5	53	30	138	387
Central	42			23	23	24	103
The South	21		1	5	26	11	77
Total	197	4	6	81	79	173	567

Source: NEPA, MONRE 2003

Annex Box D1. Waste from cottage villages



Annex E: Results

Selected water quality measurements in rural area by region in 2006

Annex Table E1. Average pH by region and source of water

Region	Drilled well	Dug well	Rain water	Surface water	Tap water	General
Red River Delta	7.32	7.44	7.55	7.09	7.17	7.36
North East	7.38	6.63		7.39		6.91
North West	7.32	6.58	6.83	7.43	7.8	6.89
North Central Coast	6.76	6.79	6.99	7.54	7.14	6.79
South Central Coast	6.55	6.67	6.73	7.31		6.67
Central Highlands	7.4	6.07	6.89	7.39		6.22
South East	4.86	6.16	6.68		7.16	5.79
Mekong River Delta	7.02	7.38	7	7.73	7.18	7
Nationwide	**6.49**	**6.53**	**7.15**	**7.19**	**7.21**	**6.7**

Source: Report on Vietnam Rural Domestic Water Quality 2007.

Annex Table E2. Average Nitrite level by region and source of water (mg/l)

Region	Drilled well	Dug well	Rain water	Surface water	Tap water	General
Red River Delta	0.13	0.12	0	0.1	0.02	0.1
North East	0.06	0		0		0.01
North West	0.01	0.02	0	0	0.01	0.02
North Central Coast	0.04	0.02	0	0	0	0.03
South Central Coast	0.11	0.13	0.03	0.01		0.12
Central Highlands	0.01	0.02	0.1	0.04		0.02
South East	0	0.01	0.04		0	0
Mekong River Delta	0.02	0.04	0	0.03	0.01	0.01
Nationwide	**0.06**	**0.05**	**0.01**	**0.02**	**0.01**	**0.04**

Source: Report on Vietnam Rural Domestic Water Quality 2007.

Annex Table E3. Average Nitrate level by region and source of water (mg/l)

Region	Drilled well	Dug well	Rain water	Surface water	Tap water	General
Red River Delta	4.28	5.61	1.89	1.71	2.53	4.07
North East	2.11	5.72		1.29		4.15
North West	3.9	4.38	2.41	1.66	2.3	3.51
North Central Coast	4.57	8.09	2.57	11.14	2.38	6.19
South Central Coast	7.04	22.01	8.73	0.54		17.2
Central Highlands	19.03	10.29	0.87	2.13		10.31
South East	3.36	20.59	2.28		0.83	6.84
Mekong River Delta	0.35	1.05	1.51	1.84	0.81	1.24
Nationwide	**4.68**	**10.76**	**1.85**	**1.61**	**1.02**	**6.68**

Source: Report on Vietnam Rural Domestic Water Quality 2007.

Annex Table E4. Average Amoni level by region and source of water (mg/l)

Region	Drilled well	Dug well	Rain water	Surface water	Tap water	General
Red River Delta	2.59	1.92	0.38	0.62	0.72	2
North East	0.52	0.49		0.43		0.48
North West	0.91	0.59	0.42	0.53	0.42	0.57
North Central Coast	0.53	0.46	0.4	0.49	0.25	0.49
South Central Coast	0.68	0.05	0.01	0.04		0.21
Central Highlands	0.02	0.01	0.52	0.1		0.2
South East	0.09	0.06	0.12		0.02	0.06
Mekong River Delta	0.84	0.56	0.11	0.33	0.06	0.2
Nationwide	**1.03**	**0.36**	**0.25**	**0.4**	**0.11**	**0.5**

Source: Report on Vietnam Rural Domestic Water Quality 2007.

Annex Table E5. Average dissolved oxygen level by region and source of water (mg/l)

Region	Drilled well	Dug well	Rain water	Surface water	Tap water	General
Red River Delta	6.85	7.8	1.08	7.76	4.34	6.17
North East	0.18	0.51		0.31		0.42
North West	0.23	0.78	0.32	0.34	0.1	0.61
North Central Coast	2.34	2.5	1.26	8.16	0.32	2.36
South Central Coast	1.7	1.16	0.2	1.01		1.29
Central Highlands	0.61	0.74	3.53	3.33		0.88
South East	0.14	0.44	0.73		0.22	0.24
Mekong River Delta	1.02	2.28	1.19	1.59	1.36	1.38
Nationwide	**2.81**	**1.38**	**1.17**	**1.15**	**1.09**	**1.67**

Source: Report on Vietnam Rural Domestic Water Quality 2007.

Annex Table E6. Average Clorua level by region and source of water (mg/l)

Region	Drilled well	Dug well	Rain water	Surface water	Tap water	General
Red River Delta	239.6	329.3	11.9	65.1	141.4	217.1
North East	17.5	29.3		10.9		23.2
North West	22	27.9	11.4	8.9	9.2	21.6
North Central Coast	84.7	81.3	14.2	56.8	19.9	78.2
South Central Coast	87.4	96.5	36.9	10.1		90.5
Central Highlands	26.6	13.1	0.6	3		13.3
South East	13.1	36.3	10.8		9.6	17.8
Mekong River Delta	277.3	147.3	3.7	9.5	63.1	48.4
Nationwide	**112.6**	**61.5**	**8.3**	**11.4**	**47.2**	**63.8**

Source: Report on Vietnam Rural Domestic Water Quality 2007.

Annex Table E7. Average Iron (Fe) level by region and source of water (mg/l)

Region	Drilled well	Dug well	Rain water	Surface water	Tap water	General
Red River Delta	1.02	1.08	0.04	0.46	0.06	0.83
North East	0.13	0.13		0.08		0.12
North West	0.03	0.16	0.04	0.09	0.03	0.13
North Central Coast	0.72	0.74	0.08	0.02	0.34	0.69
South Central Coast	0.39	0.04	0.01	0.04		0.13
Central Highlands	0.04	0.14	0.05	1.12		0.18
South East	0.1	0.04	0.01		0.01	0.06
Mekong River Delta	0.3	0.13	0.01	0.35	0.2	0.21
Nationwide	**0.54**	**0.25**	**0.03**	**0.23**	**0.12**	**0.29**

Source: Report on Vietnam Rural Domestic Water Quality 2007.

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