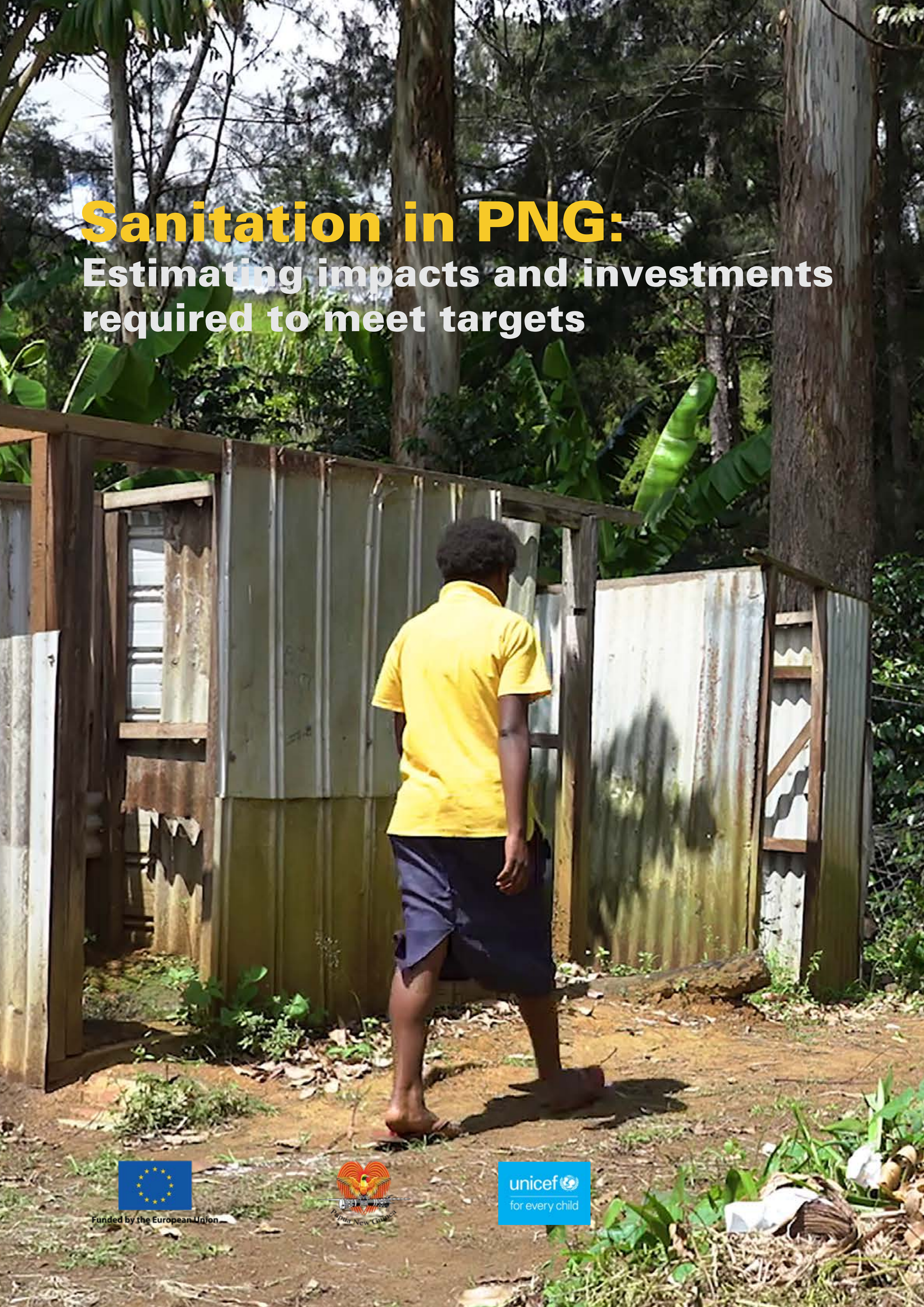
Sanitation in PNG:
Estimating impacts and investments required to meet targets



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Papua New Guinea

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Estimating impacts and investments required to meet targets

Final Report

August 2022

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BACKGROUND INFORMATION

ITEM	VALUE
Population (million persons, 2020) [a]	8.9
Average household size (no. of persons, 2012) [b]	5.0
Currency	Kina (PGK)
Exchange rate (PGK/USD, 2020) [c]	3.5
GDP per capita (PGK, 2020) [a]	9,540.0
Year in which physical data is generally presented in this study	2020
Year in which cost data is presented in the study	2020

Notes: [a] World Bank (2022); [b] NSO and ICF (2019); [c] ADB (2021)

EXECUTIVE SUMMARY

Low sanitation coverage is a serious concern in Papua New Guinea (PNG). This assertion is supported by the following information from the Joint Monitoring Programme (JMP, 2021a) of the World Health Organization (WHO) and United Nations Children's Fund (UNICEF). First, less than a quarter of the population of PNG in 2020 had access to improved sanitation. Second, access to improved sanitation has hardly changed since 2005. Third, partially explaining the previous point is the decline in the proportion of the urban population that had access to improved facilities. Fourth, access rates in urban areas for 2020 were nearly three times as much as in rural areas. Finally, the practice of open defecation has increased in the past 15 years.

Recognizing the low access rates and lack of significant progress in the sector, this study attempted to (a) generate evidence on the economic impacts of poor sanitation and (b) estimate the investment requirements in order to increase access to improved facilities. The estimation of economic impacts is termed a damage cost analysis that calculates the losses associated with current conditions and consequences of inaction. The estimation of investment requirements is a cost-target analysis that computes the expenditures necessary to achieve time-bound targets. The expectation is that the results of this study will provide government and other concerned stakeholders with valuable information that can help mobilize resources and inspire action in the sanitation sector.

The key findings of the sanitation impacts component of this study are as follows. First, the estimated overall losses from poor sanitation in PNG are in excess of PGK 2.5 billion/year (USD 734 million/year). This amount is equivalent to about 3% of the gross domestic product (GDP) of the country for 2020 or approximately PGK 284 person/year (USD 82 person/year). Second, the majority of the losses (87%) are incurred in rural areas and are mostly due to health-related impacts, especially premature deaths (see Figure A). Third, despite accounting for a relatively small proportion of the population, children under the age of 5 years suffer the largest share (68%) of the losses (see Figure B). Fourth, malnutrition-related diseases explain the bulk of the health-related and overall losses from poor sanitation (see Figure C). Fifth, depending on the interventions implemented, the estimated benefits from improved sanitation and hygiene practices range from about PGK 780 million/year to nearly PGK 1.4 billion/year. These gains are equivalent to PGK 87 to PGK 153 person/year. Sixth, the values provided here underestimate the impacts of sanitation in the country. The effects on water access and quality, the environment, tourism and social dimensions are also important but difficult to quantify in monetary units.

Investment requirements were estimated for the 2030 sanitation targets stated in the PNG Wash Policy and Medium-Term Development Plan (ADB, 2020; DNPM, 2018). Given the available information and assumptions in the study, achieving these objectives will require 579,000 people/year to gain access to improved facilities from 2020. This translates to about PGK 818 million/year (USD 236 million/year) or an annual amount equivalent to nearly 1% of 2020 GDP. The majority of the investments are needed for rural areas and have to be allocated for the construction of new facilities (see Figure D).

Following these findings, the main recommendation of the study is to implement investments in the sector immediately. Where funds are scarce, investments may be targeted to groups (e.g., rural regions and children under the age of 5 years) that experience the majority of the losses. This study also recommends re-evaluating existing sanitation targets because, apart from the seemingly heavy pressure it imposes on finances in the next few years, current trends in the sector suggest that these might be too optimistic.

Further research may also be undertaken in order to enhance the chances of success in investment undertakings. Two examples in this regard are studies on software expenditures and the economic performance of sanitation options. The final set of recommendations focuses on research and efforts to improve the information base of sanitation in PNG and strengthen the evidence for demonstrating the impact of poor sanitation on health and economic outcomes.

Figure A. **Disaggregated impacts of sanitation, million PGK/year**

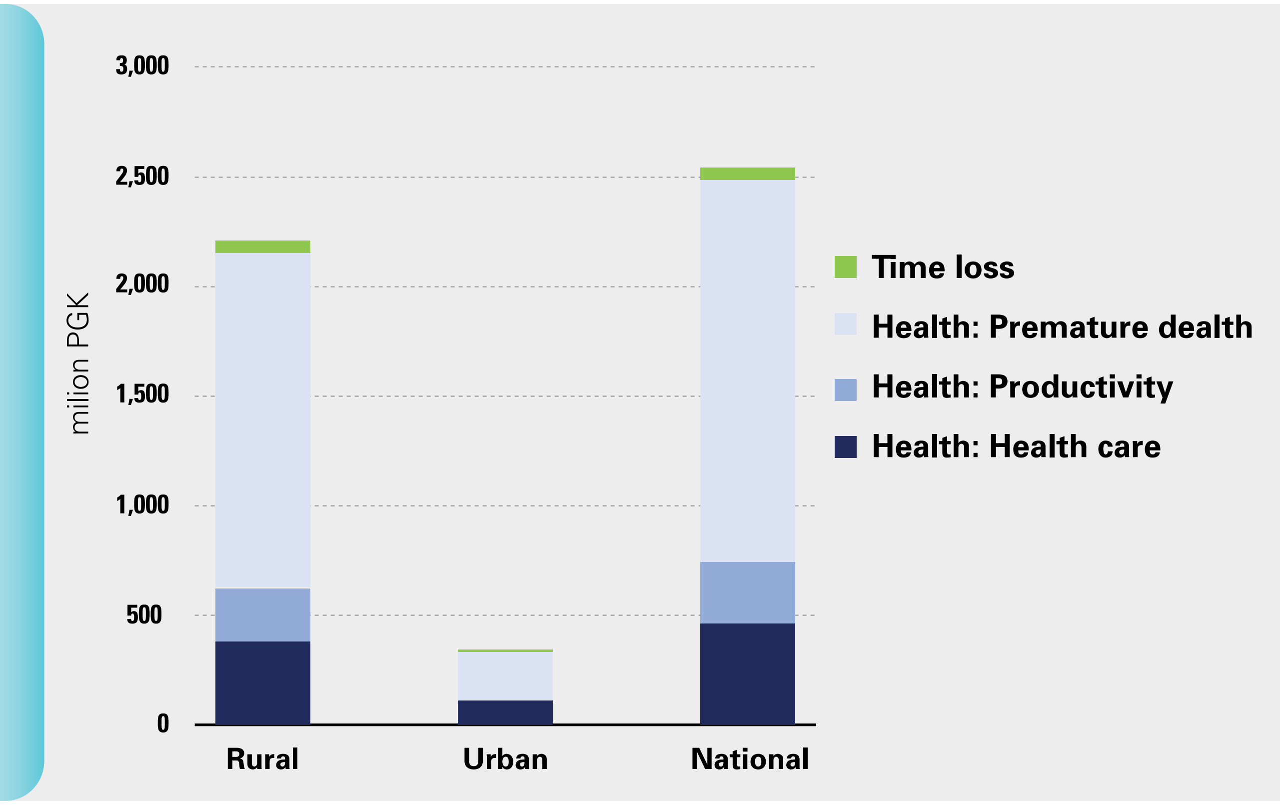


Figure B. Impacts of poor sanitation on different age groups, % of overall losses

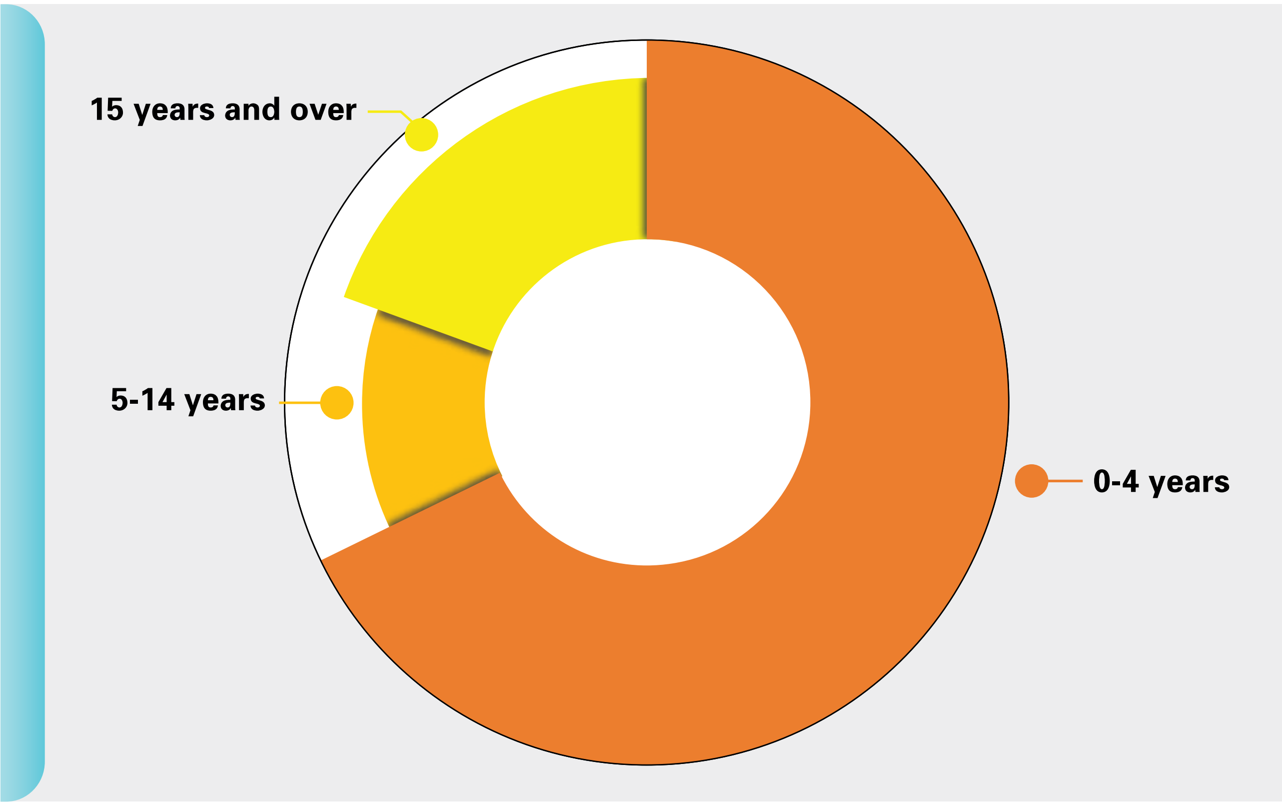


Figure C. Contribution of different diseases to health-related impacts, %

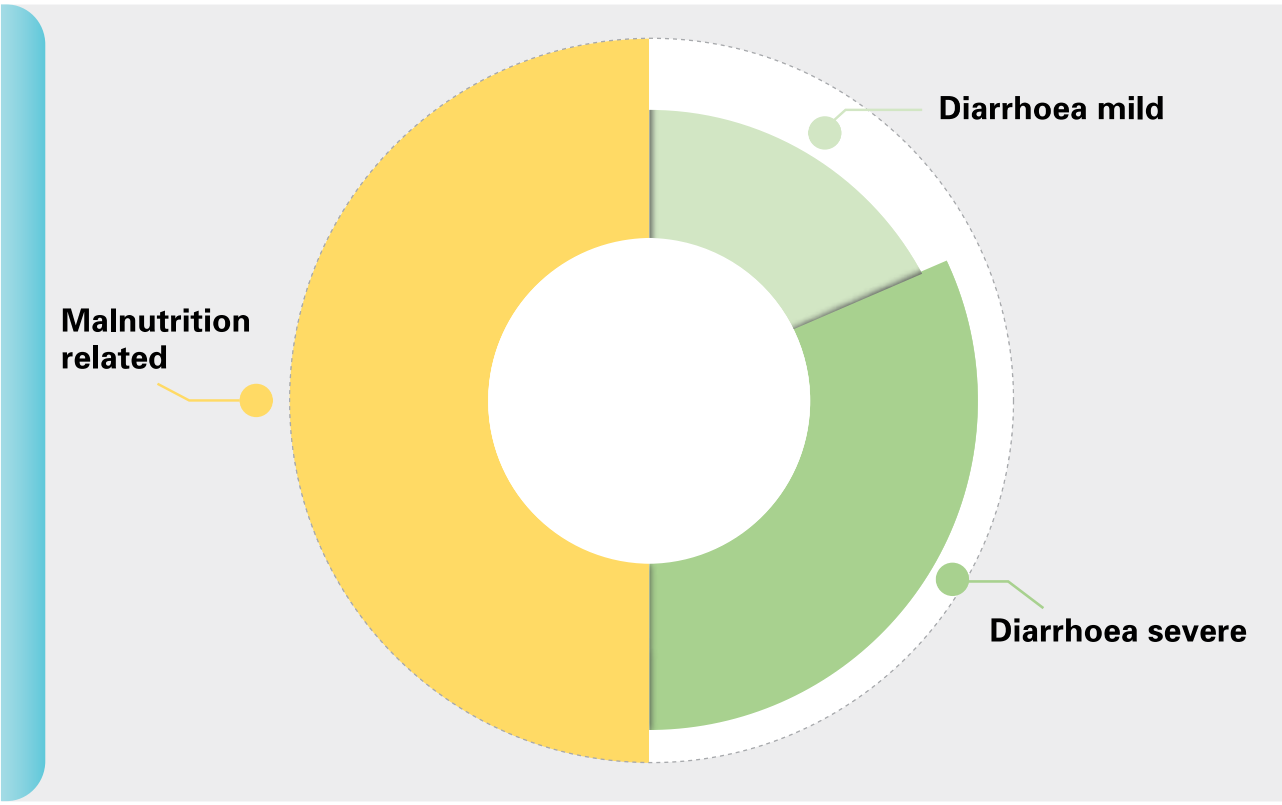
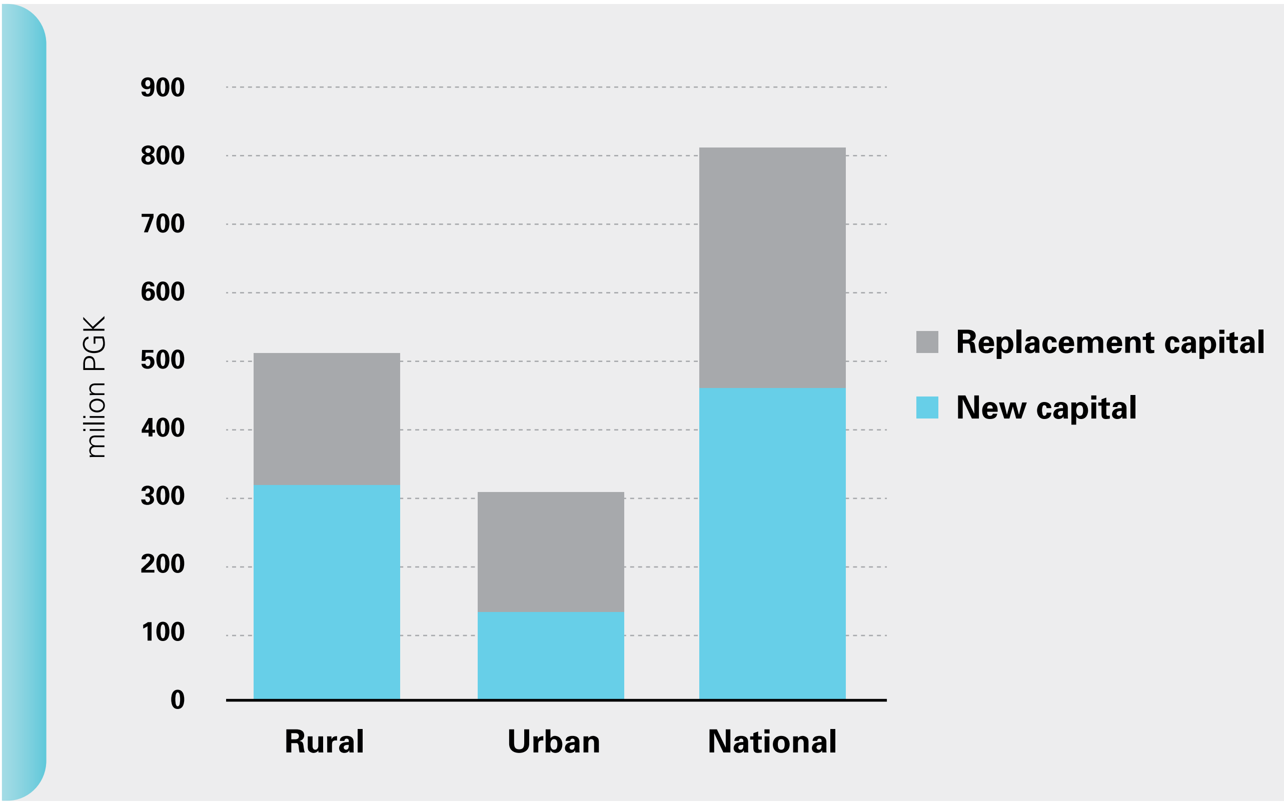


Figure D. **Disaggregated presentation of investment requirements, million PGK/year**



ACKNOWLEDGEMENTS

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The research team is grateful for the comments and questions of stakeholders who attended the presentation of the results at the Lamana Hotel on 22 July 2022. In addition, it also wishes to thank Edkarl Galing of the Asian Development Bank (ADB) for providing inputs on the sanitation sector in PNG.

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ACRONYMS

ADB	Asian Development Bank
ALRI	Acute lower respiratory infection
CPI	Consumer Price Index
DHS	Demographic and Health Survey
DNPM	Department of National Planning and Monitoring
DOH	Department of Health
ESI	Economics of Sanitation Initiative
EU	European Union
GDB	Global Burden of Diseases, Injuries and Risk Factors Study
GDP	Gross domestic product
GOPNG	Government of PNG
HIES	Household Income and Expenditure Survey
JMP	Joint Monitoring Programme
PGK	Kina
NRI	National Research Institute
NSO	National Statistics Office
OP	Outpatient
PNG	Papua New Guinea
SDA	Service Delivery Assessment
SDG	Sustainable Development Goal
UN	United Nations
UNICEF	United Nations Children’s Fund
USD	United States dollar
VIP	Ventilated improved pit latrine
VSOL	Value of statistical life
WASH	Water, Sanitation and Hygiene
WHO	World Health Organization
WSP	Water and Sanitation Program

1.

INTRODUCTION

The lack of access to improved sanitation facilities is a serious concern for PNG. Data from the Joint Monitoring Programme (JMP) of the World Health Organization (WHO) and United Nations Children's Fund (UNICEF) shows that less than 24% of the population of the country in 2020 had access to improved sanitation facilities (JMP, 2021a). Removing the people who share facilities, this estimate falls to only about 19% of the population. These proportions are below the average for Oceania, where JMP estimates indicate that over 39% of the population had access to improved sanitation facilities in 2020 (JMP, 2021b).

Figure 1 reveals some disturbing trends for the sanitation sector of PNG. First, the increase in coverage rates has been slow. Between 2005 and 2020, access to improved sanitation rose by only about two percentage points. While these are actually better than the average for Oceania, it pales in comparison to the global average where access rates rose by about 18 percentage points over the period.[1] Second, there is evidence that open defecation has become a more common practice in PNG. From an estimated 13% of the population in 2005, open defecation rose to 16% of the population in 2020. This trend goes against one of the targets of the Sustainable Development Goal (SDG) for clean water and sanitation that calls for an end to open defecation by the year 2030 (United Nations, 2015). Third, the proportion of the population who have access to improved sanitation in urban areas also fell from about 65% in 2005 to 58% in 2020. Fourth, there is a wide disparity in access rates between rural and urban regions in PNG. In 2020, only about 18% of the rural population had access to improved facilities.[2] This is less than a third of the access rate estimated for urban areas.

As JMP data indicates that the number of people who practice open defecation in rural areas is about 18%, then more than 3 in 5 people in these regions have access to unimproved facilities. This point is supported by UNICEF-led studies in selected rural regions in the country. In developing a plan from 2018-2023 for the Goroka District of the Eastern Highlands Province, (UNICEF et al., 2018) found that at least three out of four households it visited had access to toilet facilities.

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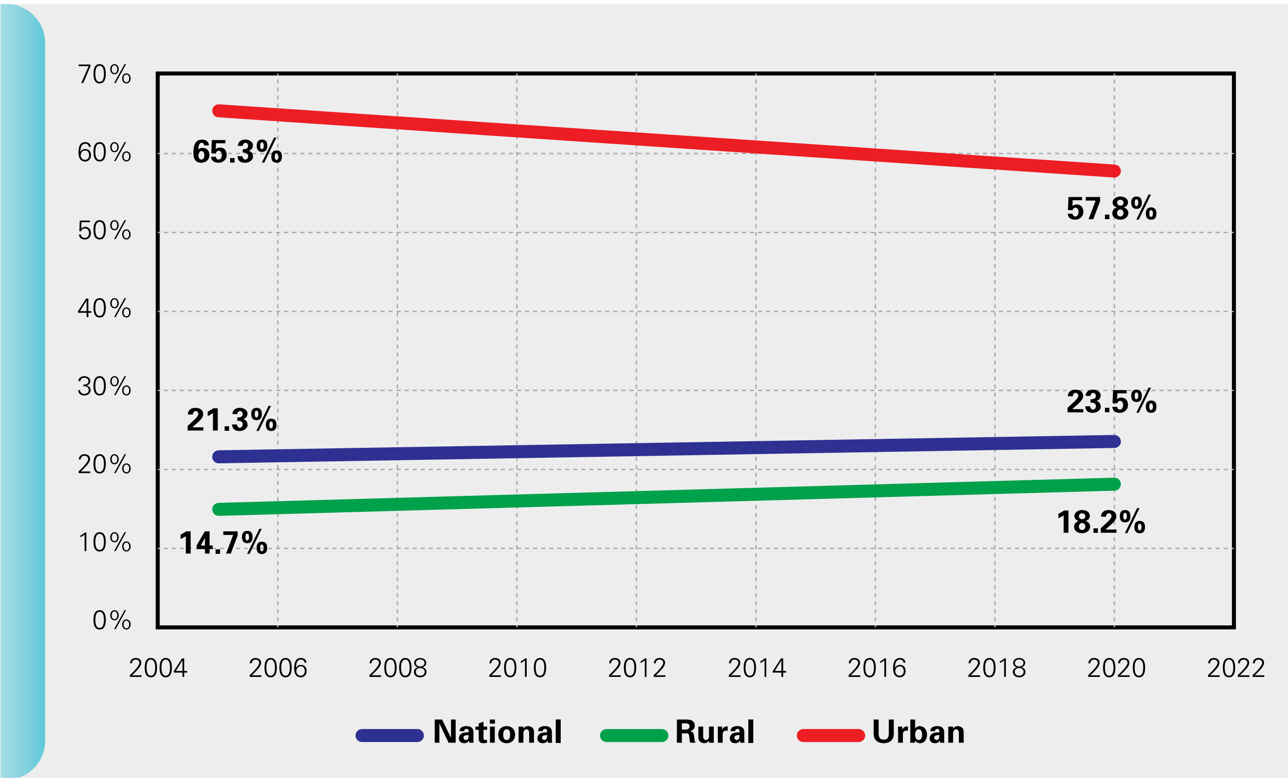
1 JMP (2021b) indicates that average access to improved sanitation in Oceania rose from 38.7% in 2005 to 39.5% in 2020. At the global level, access rates went up from 67.6% in 2005 to 85.8% in 2020.

2 This estimate includes people who have private and shared access to improved sanitation facilities.

However, these toilets did not have "lids over the drop-holes" (p. 13) and are therefore not qualified as improved facilities. A similar undertaking in the Nawaeb District of Morobe Province found that close to nine out of ten households that had access to sanitation were using uncovered pit latrines (UNICEF et al., 2018).

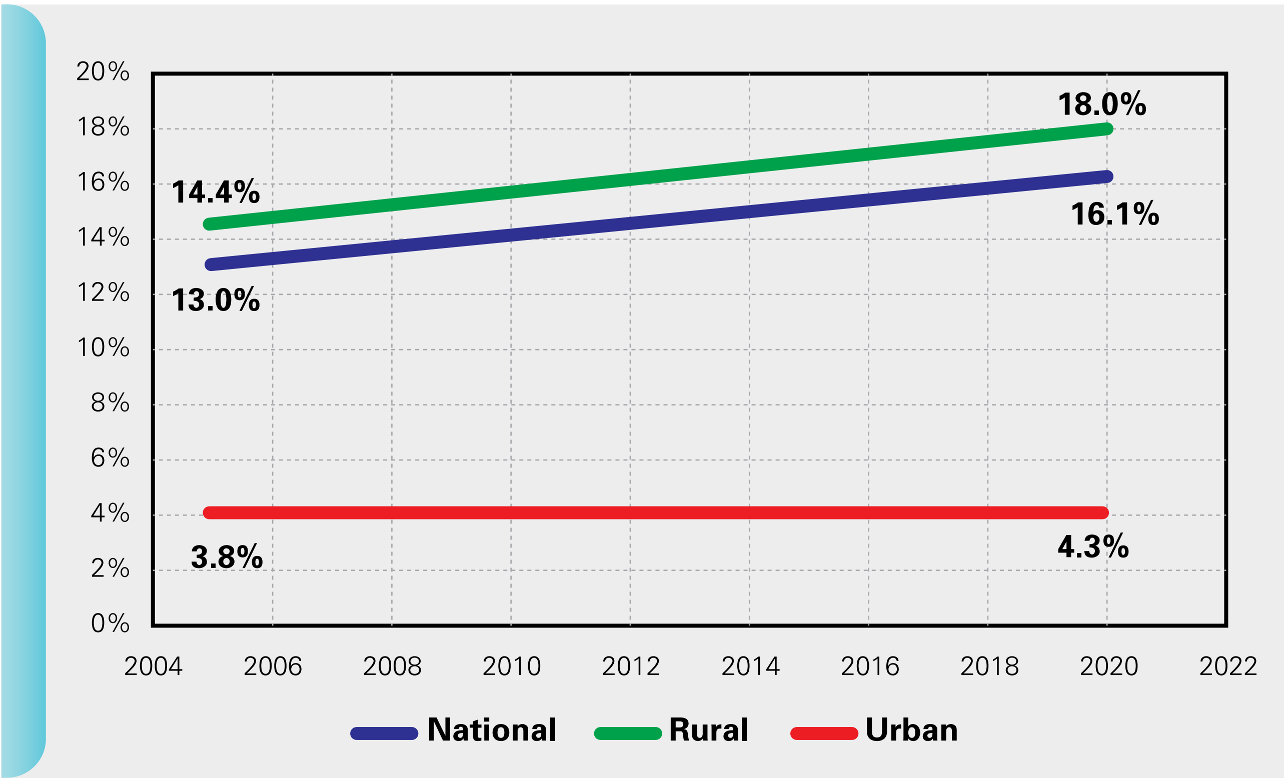
Disappointing as the reported access rates may be, studies also suggest other issues with respect to the disposal of waste in PNG. For example, the Asian Development Bank (ADB, 2019) estimated that only 14% of the population of Port Moresby had access to "safely managed" sanitation.[3] The World Bank (2014), in a survey of eight informal settlements in Port Moresby and Wewak, also found that (a) dry pit latrines tend to overflow during the wet season, and (b) "pits fill quickly and are not emptied" (p. 15).

Figure 1. Selected data on sanitation for PNG, 2005-2020, % of the population



(A) Access to improved sanitation facilities

3 The study uses the SDG definition of "safely managed sanitation service as the use of an improved facility that is not shared with the: wastewater treated offsite, or excreta is transported and treated offsite, or excreta treated and disposed of in-situ" (p. 6).



(B) Open defecation

Source: JMP (2021a).
Note: Improved sanitation combines shared and private facilities.

The cleanliness of toilets, presence of handwashing facilities, and the number of people sharing facilities are concerns as well. Recent information from the Demographic and Health Survey (DHS) for 2016-2018 (NSO and ICF, 2019) indicates that only 33% of the respondents had a basic handwashing facility.[4] It adds that another 34% of the respondents had a limited handwashing facility or a facility located on the premises but does not have soap and/or water. Less comprehensive surveys reveal that the presence of handwashing facilities was not as good as the averages reported in the DHS. A World Bank (2017) study in selected rural communities observed that only about 1 in 20 households had handwashing facilities in toilets. In the case of urban areas, the ADB (2018) found similar results from a survey conducted in the Tete settlement in Port Moresby. In this study, four out of five of the toilets inspected did not have handwashing facilities. A recent study led by the European Union (EU et al., 2019) in four districts of PNG asserted that more than half of the toilets were not clean. A World Bank (2014) study of urban informal settlements in Port Moresby and Wewak also uncovered evidence that shared toilets were overused. It also noted that, in some situations, more than 60 people shared a facility.

4 The NSO and ICF (2019) define this as a facility in the premises that has soap and water. The survey had 16,021 respondents and was implemented from October 2016 to December 2018.

Exposure to poor sanitation affects the lives of people and imposes economic costs. Hutton et al. (2008) and Hutton and Haller (2004) for example note the impacts of poor sanitation on disease incidence, water quality and access, time in accessing private toilets, tourism and other impacts. Disease incidence in this case translates to losses associated with treatment, the inability to perform usual activities and even death.

An example of a toilet in a health facility in Western Highlands Province.

This study attempts to generate evidence on the economic impacts of poor sanitation and estimate investment requirements in order to increase access to improved sanitation facilities in PNG. The estimation of economic impacts is a damage cost analysis that is designed to calculate the losses associated with current conditions and the consequences of inaction. The other task is a cost-target analysis that seeks to compute the expenditures necessary to achieve time-bound targets. In the end, the study hopes to provide government and other stakeholders with valuable information that can help mobilize resources and inspire action in the sanitation sector.

While this study is unaware of research that quantified the economic impacts of sanitation in PNG, there have been previous attempts to do so in other countries. As part of a cost-benefit analysis, Hutton and Haller (2004) estimated the benefits from increased access to improved sanitation at the global level. Hutton et al. (2008) estimated the economic impacts of poor sanitation in the Philippines, Indonesia, Cambodia and Viet Nam. Implemented under the Economics of Sanitation Initiative (ESI) of the World Bank, the study found economic losses of about USD 9 billion/year or about 2% of the combined gross domestic product (GDP) of the four countries.[5]

There is evidence to support that idea that investing in sanitation makes good economic sense. Hutton and Haller (2004) for example estimated a return of USD 5 to USD 28 per USD 1 invested on sanitation interventions in developing regions. A more recent study of 47 field sites in six Asian countries (Hutton et al., 2015) provides further support for the notion that it is worth investing in sanitation. While the current study does not evaluate the net gains from different sanitation options, these results justify the task of calculating investment requirements in this report.

5 *ESI estimates are measured at 2005 prices. Interested readers may also consult ESI studies in South Asia, Africa and Latin America at the website <www.wsp.org> of the Water and Sanitation Program (WSP) of the World Bank.*

There have been several attempts to estimate investment requirements for meeting sanitation targets in different countries. For example, Hutton and Varughese (2016) calculated the funds needed for complying with the SDGs at the global and regional levels. Another study, known as the Service Delivery Assessment (SDA), computed investment requirements for seven countries in the Asia-Pacific region (World Bank, 2015).[6] Among its outputs was the estimate that PNG needs to invest USD 70 million/year in order to achieve sanitation targets for 2030 (World Bank, 2015; DNPM et al., 2013). Given the availability of the SDA, it is possible to view the current study as an attempt to generate updated estimates.

The remainder of this report is organized as follows. Section 2 briefly discusses the methodology for the components of this study. Section 3 presents the estimates and a brief discussion of the findings on the impacts of sanitation. Section 4 provides a similar discussion for the investment requirements associated with meeting sanitation targets. Section 5 concludes by enumerating some recommendations.

6 The SDA was implemented under the guidance of the Water and Sanitation Program (WSP) of the World Bank and its partners.

2. METHODOLOGY

The estimation of the impacts is a valuation exercise. In contrast, the calculation of investment requirements is a costing exercise. As the methods and approaches that will be used for these components are different from each other, these are presented as separately in this section.

2.1 Scope of the analysis

Sanitation is a broad subject. In the ground-breaking study from Southeast Asia on the economics of sanitation, Hutton et al. (2008) notes that sanitation encompasses (a) human and animal excreta management, (b) grey water management, (c) solid waste management, (d) drainage and general flood control, (e) industrial, trade, village and medical waste, (f) vector control, (g) food safety, (h) other agricultural waste, and (i) broader environmental sanitation. It is important to note that the estimates in this study will be limited to human excreta management only.

This study will also follow the JMP definition for improved and unimproved sanitation. That is, improved sanitation facilities are those designed to prevent human contact with human excreta (WHO et al., 2006).[7] This includes facilities such as (a) pour/flush toilets connected to a piped sewer system, septic tank or pit latrine; (b) ventilated improved pit latrine; (c) pit latrine with slab; and (d) composting toilet. Facilities excluded from the list above are considered as unimproved sanitation by the JMP. In the context of the SDG for clean water and sanitation, improved facilities are further divided into safely managed, basic and limited sanitation services. The JMP website defines basic and safely managed sanitation services as improved facilities that are not shared by other households. The difference between these two types of services rests on the treatment and disposal of human excreta. Improved facilities that are shared by different households are considered as limited services.[8]

7 WHO et al. (2006) also provides a list of improved and unimproved facilities.

8 More details are provided in <https://washdata.org/monitoring/sanitation>.

Estimates will be generated for the rural and urban regions of PNG. In the case of the sanitation impacts, the study will also generate estimates for different age groups. All results presented at the national level will be sums or weighted averages of region-specific and/or age-group-specific outcomes.

Access to safe sanitation facilities and clean water can contribute to a 36% reduction in health-related costs.

2.2 Impacts of poor sanitation

A useful approach for this component of the study was developed under the ESI of the World Bank (Hutton et al., 2008). The methodology calculates the economic costs associated with the lack of access to improved sanitation facilities. Being an economic analysis, estimates go beyond financial or out-of-pocket costs, and focus more on the losses to society. The process begins by identifying the impacts of poor sanitation in physical units and then converts these estimates into monetary units. This section briefly describes the key concepts, assumptions and techniques behind the methodology. The interested reader may consult chapter 2 and Appendix A of Hutton et al. (2008) for more details.

Impacts quantified in the study

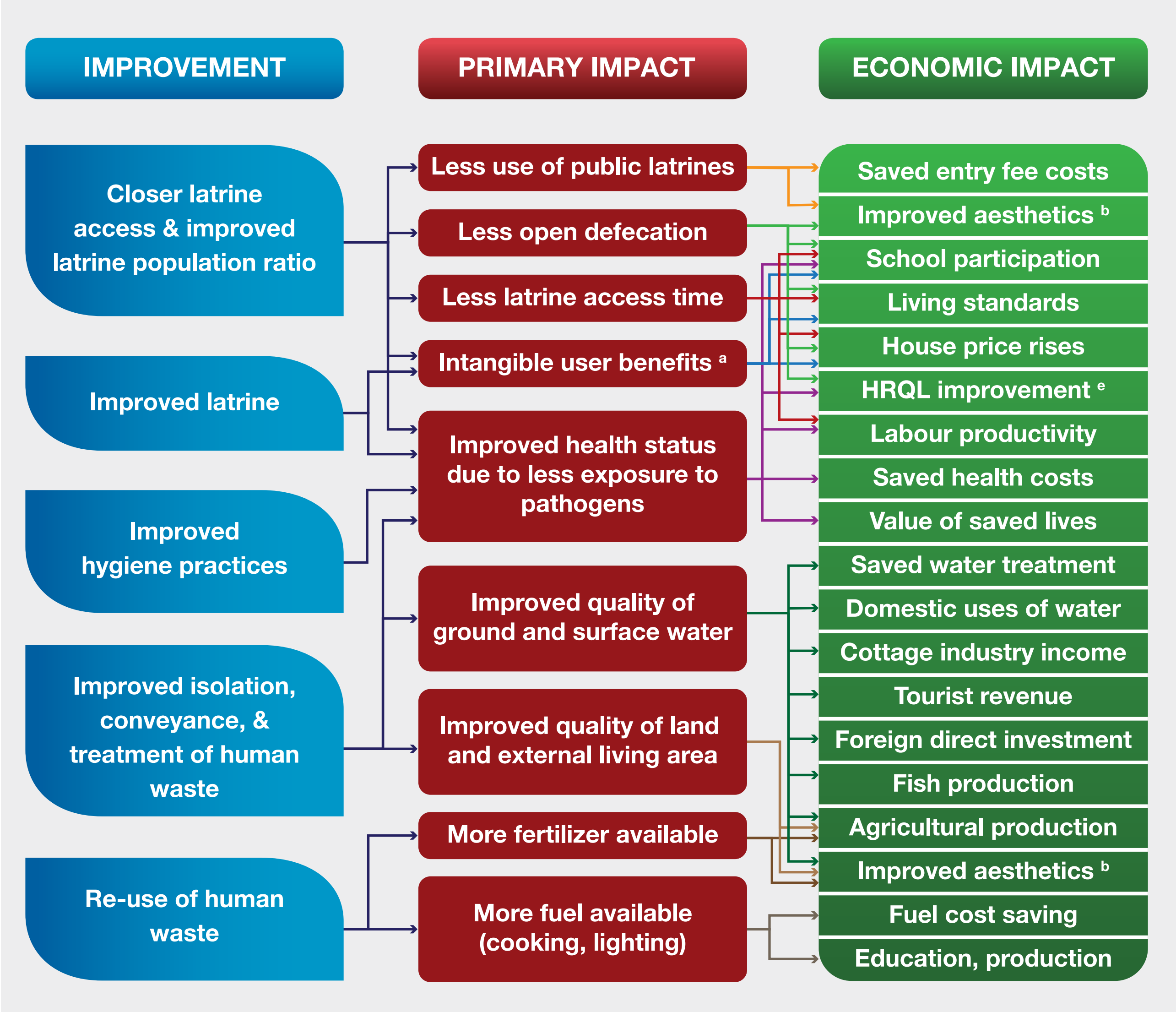
Figure 2, taken from Hutton et al. (2008), illustrates the primary and economic benefits of the different dimensions associated with improved sanitation. Representing the avoided costs associated with the lack of access to improved facilities, it suggests that each dimension tends to have multiple effects on the population.

The focus of this study is on improving fecal waste management and puts emphasis on the box in Figure 2 that is labelled "improved isolation, conveyance, and treatment of human excreta". The gains associated with this dimension are on (a) health due to less exposure to pathogens, (b) the quality of ground and surface water, and (c) quality of land and surface area.[9] These translate to economic benefits such as greater school participation, health-related quality of life, labor productivity, lower health care cost and saved lives. As a segment of the PNG population practiced either open defecation or used shared facilities, the study will also include the boxes on (a) closer latrine access, (b) improved latrine system, and (c) improved hygiene practices.

The scarcity of data and related research makes it very difficult to quantify all the physical and economic impacts presented in Figure 2. Table 1 shows that only the health-related and time loss impacts will be calculated in this study. This implies that the results in this report underestimate the full impacts of poor sanitation in PNG.

9 As noted later in this section, only the health-related gains arising from less exposure to pathogens are captured in this study.

Figure 2. **Primary and economic impacts associated with improved sanitation**



Source: Hutton et al. (2008).

Notes: [a] Comfort, convenience, security and privacy; [b] visual effects and smells; [c] HRQL refers to health-related quality of life.

Table 1. Impacts quantified in the study

Impact	Sub-impacts	Costs due to
Health	Health care costs	treatment of disease
	Productivity costs	time away from work/regular activities as a result of disease
	Premature death	premature death due to disease
Time loss		time loss searching/waiting for a toilet to become available

Techniques and key inputs

This section briefly describes the key techniques and inputs used in estimating health-related and time loss impacts.[10] To reduce clutter in the text, a discussion of the data and assumptions that are used in the computations will be relegated to Annexes A and B.

Health-rated impacts. Poor sanitation contributes to higher incidence of disease. These diseases in turn lead to costs associated with health care, productivity and premature death. Health care costs are expenses for the treatment of diseases such as the fees of medical practitioners, payments for medical procedures, expenditures for medicines, and other incidental expenses. Where appropriate, fees for rooms in health centers are also included to account for inpatient care. Productivity losses recognize that sick people are unable to perform their usual tasks. Especially in the case of children, this also includes household members or friends who care for the sick. Premature death recognizes that diseases associated with sanitation can lead to the termination of life prior to the expected lifetime of the people.

There are many diseases associated with poor sanitation.[11] The ESI studies for Southeast Asia (Hutton et al., 2008), for example, included diarrhoea diseases, helminths, scabies, trachoma, hepatitis A, hepatitis E, acute lower respiratory infections (ALRI), malaria, and other diseases associated with malnutrition. The selection of diseases was guided by their relative importance and availability of data in the countries.

The focus in this study will be on diarrhoeal diseases and diseases associated with malnutrition such as measles, malaria and ALRI. The calculation of the physical impacts starts by estimating the number of people who get sick or die from the above diseases because of poor sanitation. This involves collecting information on incidence and mortality rates, and attribution factors. The information of attribution factors allows the study to confine the estimates to people who get sick and/or die because of poor sanitation.

In order to calculate health care costs, information is also collected on (a) treatment seeking behavior, (b) costs of medication, (c) outpatient (OP) visit rates, (d) rate of inpatient admission and length of inpatient stay, and (e) unit costs of OP and inpatient care. The data is used to compute OP and inpatient costs for the people who get sick.

Productivity costs are determined by also collecting information on (a) the average number of days in which people are taken away from their regular activities because of illness, and (b) the value of time. As in previous ESI studies, the time of children is also given value. However, the value of their time is assumed to be a fraction of the adults.

Following the technique used in previous ESI studies, the current effort uses the human capital approach for estimating the costs of premature death. This method monetizes the life of a person by taking the net present value of their stream of lost future income because of premature death.[12] Incomes were assumed equal to per capita GDP.

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10 Interested readers may refer to Hutton et al. (2008) for the techniques used in calculating the impacts that are not quantified in this study.

11 Table A4 of Hutton et al. (2008) enumerates the diseases linked to sanitation.

12 An alternative method is the value of statistical life (VSOL) approach, which is briefly discussed in Annex B.

Time loss impacts. Time loss impacts exist because there are segments of the population who do not have access to private facilities. People who practice open defecation waste time looking for a private place to defecate. People who share facilities or use a public toilet also consume time travelling to the facilities. They may also lose time waiting or queuing before being able to use the toilets. This component of costs recognizes that the time people spend for the aforementioned activities has value. In estimating these losses, key inputs are (a) the number of people that do not have private toilets, (b) their average travel and waiting time, and (c) monetary value for time. As discussed in Annex B, the unit value of time is based on GDP per capita.

Improved sanitation and mitigating impacts

Avoided losses represent the benefits from improved sanitation. These gains vary by the impacts being evaluated. A person who gains access to a private toilet will no longer experience time loss impacts. However, the proportion of avoided losses are smaller for health-related impacts. The benefits are also sensitive to the type of improvement adopted. Hutton et al. (2015) reviewed the literature on the reductions in relative risks for health-related losses associated with improved facilities and practices. Using carefully selected values from the literature, the study then applied the reductions to compute the benefits from improved sanitation.

Improved facilities like this are contributing positively to the overall productivity, health and well-being of people.

Following Hutton et al. (2015), the study assumes that people gaining access to improved basic sanitation facilities will avoid 36% of the health-related costs.[13] By improved basic sanitation, the study refers to improved pit latrines, toilets with open-bottom septic tanks or toilets with sewage that is not properly disposed or treated. People who gain access to improved basic sanitation and implement better hygiene practices are assumed to have gains of 50%. In other words, improved hygiene practices constitute an additional 14 percentage points (50% - 36%) of gains. Finally, adding proper emptying of septic tanks or sewerage with full wastewater treatment to the above leads to a gain of 65%. In calculating the benefits, the percentage gains discussed above will be applied to the proportion of the population who do not have access to improved sanitation facilities.

13 Hutton et al. (2015) recognizes that benefits will vary by disease. However, it uses the same proportions for the diseases included in this study.

Limitations and sources of uncertainty

This study has several limitations. First, it is confined to health-related and time loss impacts of sanitation in households. The possible effects on water access and quality, the environment, tourism and other dimensions of human welfare were not quantified. Second, health-related impacts were limited to diarrhoeal and malnutrition-related diseases only. Third, the analysis also ignores the impacts of the lack of access to improved facilities in schools, hospitals and other public places. All these limitations suggest that the study underestimates the full impacts of sanitation in PNG.

Exposure to poor sanitation affects the lives of people and imposes economic costs.

Compiling information for quantifying impacts was a very challenging task. Relying mostly on secondary data, there were many instances in which the required information was missing or not specific to the rural and urban regions of PNG, the year of analysis (2020) or both. This means that completing the dataset required borrowing inputs that were constructed or generated for other countries or regions. There were also cases in which multiple values were available for one variable. If there is a lack of information on which of the alternative values was more reliable, the approach adopted in the study was to select the value that produces conservative estimates of the impacts. These challenges suggest uncertainty in the magnitudes of the estimated losses and, consequently, the benefits associated with improved sanitation.

Recognizing the uncertainty in the estimates, this study will implement a sensitivity analysis. The intent is to check the extent to which the calculated impacts are likely to change under alternative assumptions. Two sets of sensitivity analysis will be conducted. One set implements a 10% increase in the values of selected inputs. The objective of this task is to get a better sense of the assumptions that have the strongest impacts on the results. The second set of experiments examines how estimates will change using plausible alternative assumptions for the inputs. Rather than working with arbitrary changes in the inputs, the coefficients selected here represent values that are available from the literature.

2.3 Investment requirements to meet targets

The cost-target analysis seeks to generate costings for achieving time-bound targets. The outcome of the process is a calculation of the investments necessary to attain the said targets. Like the impacts component of the study, estimates will be generated for both rural and urban regions of PNG. What follows is a brief discussion of the tool that will be used for the task as well as the necessary inputs.

Estimation technique and key inputs

A useful methodology for this component is the approach developed for the SDA project of the World Bank. The project was a collaborative effort that involved estimating investment requirements for the WASH sector of PNG and six other countries in the Asia-Pacific region (World Bank et al., 2015; DNPM et al., 2013).

The SDA uses a MS Excel-based costing tool to generate estimates of the annual investments necessary to achieve targets. Its key inputs are data on (a) existing and projected population, (b) existing sanitation coverage rates, (c) target coverage rates, (d) desired composition of facilities (technology mix) in the target year, (e) unit costs of facilities, and (f) expected life of facilities.

Information on projected population and coverage rates will determine the number of people who will need to be provided with facilities over the period of analysis. The existing and desired composition of facilities will detail the type of facilities that will be received by each individual that gains access. The sets of information above generates the number of people that will be provided specific facilities over the period of analysis. For example, it will compute the number of people who will need to gain access to toilets that dispose of waste in septic tanks. Multiplied by the unit cost/person/facility, this generates an estimate of the expenditures on new capital. Over the period of analysis, some facilities will become unusable because of depreciation. Information on the expected life of facilities assists in estimating the replacement costs of worn-out capital.

Estimates provided in DNPM et al. (2013) used secondary data for its inputs. It also relied heavily on consultations with experts and key stakeholders in order to fill-in information gaps and validate assumptions. The current exercise also adopts the same approach. With the details presented in Annex C, data on existing facilities were drawn from the JMP (2021a) and DHS (NSO and ICS, 2018). Overall and detailed sanitation targets and information on facilities were obtained from existing studies and a consultation with selected experts. To reduce clutter in the text, specific inputs to this component of the study are presented in Annexes A and C.

Limitations and sources of uncertainty

The focus of the current study is on the cost of constructing new and replacing worn-out facilities. It ignores software expenditures which the World Bank et al. (2015, p. 17) specifies as interventions to "elicit household self-investment (such as for social mobilization, behavior change, and facilitating private sector engagement)". As with the impacts component of this study, the analysis is also limited to households only. It ignores investments in schools, hospitals and other public places. The obvious implication of these limitations is that estimates in this report are likely to be conservative.

There are a number of inherent sources of uncertainty in the current study.[14] These deal mainly with information on costs and expected life of facilities. For one, the materials used for constructing a facility (e.g., toilets that have access to septic tanks) are likely to differ from one household to the next. This means that the unit cost and expected life of a facility may be different across households. Hence, useful summary estimates may have to be obtained from surveys. However, resources for such an activity are available for this study. In order to confront the uncertainty caused by the reliance on the literature and consultations, this study will implement a sensitivity analysis on the costs and expected life of facilities. To be more specific, the task will examine how 10% changes in these variables will affect the overall costs.

14 These uncertainties are also present in the SDA estimates.

3.

RESULTS: IMPACTS OF SANITATION

3.1 Estimated impacts

Overall losses and benefits

Table 2 summarizes the overall economic impacts of sanitation in PNG. It indicates losses of slightly over PGK 2.5 billion/year or approximately 3% of the 2020 GDP of the country. The majority of the losses (about PGK 1.7 billion or 69% of the total) are explained by premature deaths. A far second are costs for treating diseases or health care losses. Time-related losses, which are either due to lost productivity arising from illness or time searching for a place to defecate, account for the smallest proportion of the impacts.

Table 2. Overall impacts of poor sanitation

Item	Health-related costs				Time access costs	Overall Losses
	Health care	Productivity	Premature Death	Total		
Total costs per year						
million PGK	464.5	275.9	1,748.0	2,489.9	51.8	2,540.2
million USD	134.3	79.7	505.2	719.6	15.0	734.2
% of GDP	0.5	0.3	2.0	2.9	0.1	3.0
% of overall costs	18.3	10.9	68.8	98.0	2.0	100.0
Costs per capita per year						
PGK	51.9	30.8	195.4	278.3	5.8	283.9
USD	15.0	8.9	56.5	80.4	1.7	82.1

Source: Annex D.

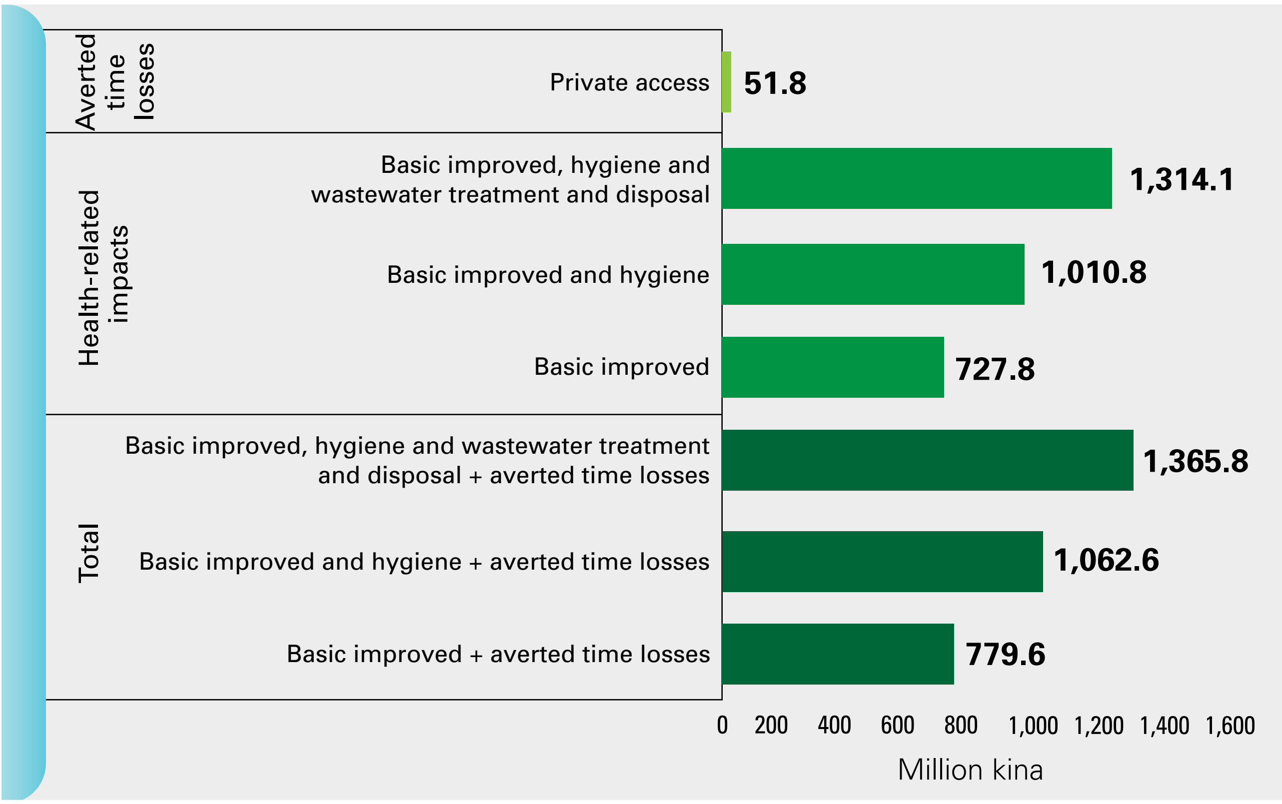
As noted earlier, benefits from access to improved sanitation facilities represent avoided losses. In the case of health-related gains, these are also sensitive to the type of intervention implemented. Figure 3 presents the estimated benefits. It indicates that majority of the potential gains are attributable to avoided health-related losses. Depending on the nature of interventions introduced, the benefits range from PGK 779.6 million/year to nearly PGK 1.4 billion/year. It is important to note that the estimated gains may be larger than what is presented in this report. The reason is that the values in Figure 3 represent providing access to segments of the population that currently use unimproved facilities or have no facilities at all. It ignores potential benefits from providing "better" facilities to people who already have access to improved facilities. An example would be a household who currently uses an improved pit latrine but gains access to toilets that flush to sewer facilities.

Table 3 presents a more detailed account of the impacts. It indicates that majority of the losses are incurred in rural areas. The estimated overall cost in these regions, which is over PGK 2.2 billion/year, is more than six times as much as in urban areas (PGK 333.2 million/year). The dominance of the losses in rural areas is also reflected in each of the components. However, the disproportionate impact on rural areas is most apparent in the case of time access costs. Despite being the smallest of the four components, the estimated time losses of nearly PGK 49.9 million/year in rural areas is almost 27 times as large as in urban areas (PGK 1.9 million/year). The finding that most of the losses are incurred in rural areas is not surprising because the majority of the population live there and access to improved sanitation is much lower than in urban communities.

Most of the losses in rural areas are attributable to premature death. The estimated losses of more than PGK 1.5 billion/year are about 69% of the total for the region. Within costs of premature death in rural areas, the largest component (PGK 1.2 billion/year) is among children under the age of 5 years.

An examination of the results by different age groups also shows that children under the age of 5 years suffer the brunt of the losses in the entire country. Its total costs of about PGK 1.7 billion/year is almost 68% of the total. As with the regional effects, the largest source of costs for children is premature death (PGK 1.4 billion/year).

Figure 3. **Benefits associated with access to improved sanitation, million PGK/year**



Source: Annex D.

Table 3. Impacts by rural/urban area and by age group, million PGK/year

Region / Age group	Health-related costs			Time Access	Total
	Health care	Productivity	Premature Death		
Rural					
0-4 years	175.2	104.0	1,197.2	5.0	1,481.5
5-15 years	68.6	49.3	160.3	10.1	288.4
15 years +	139.3	90.3	172.8	34.8	437.2
All ages	383.1	243.6	1,530.4	49.9	2,207.0
Urban					
0-4 years	53.2	20.2	167.1	0.2	240.7
5-15 years	7.8	3.5	21.0	0.3	32.7
15 years +	20.5	8.5	29.5	1.3	59.9
All ages	81.5	32.3	217.6	1.9	333.2
National					
0-4 years	228.5	124.2	1,364.4	5.1	1,722.2
5-15 years	76.3	52.9	181.3	10.5	321.0
15 years +	159.8	98.8	202.3	36.1	497.0
All ages	464.5	275.9	1,748.0	51.8	2,540.2

Source: Appendix D.

Health-related costs

To understand the health-related costs, it is useful to begin by examining the physical impacts. Table 4 details the estimated cases, deaths and lost productive time associated with poor sanitation. It indicates a disease incidence in excess of 9.3 million cases/year. Owing much to its population and a slightly larger proportion of children living in these regions, 8.1 million cases/year or nearly 87% of the total were estimated for rural areas. Most of the cases in the country, about 8.7 million/year, are explained by mild diarrhoea. This is due to its (a) relatively high incidence rate especially for children under the age of 5 years and (b) high attribution factor.[15] These assumptions also explain why children under the age of 5 years have the greatest number of cases. Despite only accounting for slightly less than 14% of the PNG population, close to 4 million cases/year or 43% of the total were estimated for this age group.[16] The second largest number of cases was calculated for people over the age of 15 years. However, given the lower incidence rates assumed for this age group, this finding was driven mostly by demographic factors.

The estimates show that about 4,485 deaths/year are associated with poor sanitation. Children under the age of 5 years account for most of the deaths. The reason for this is that majority of the deaths are attributable to malnutrition-related diseases such as ALRI, malaria and measles. Following the pattern observed for disease incidence, most of the deaths are in rural areas.

15 The attribution factor refers to the proportion of cases attributable to poor sanitation. The interested reader may refer to Annex Table B2 for the assumptions on the incidence rates and attribution factors used in the calculations.

16 Annex Table A1 presents the age group population of PNG.

Table 4. Estimated cases, deaths and productive time losses associated with poor sanitation by disease, region and age group

Item / Region / Age group	Mild diarrhoea	Severe diarrhoea	Malnutrition-related diseases [a]	All diseases
Number of cases per year (000)				
Rural				
0-4 years	3,023.9	206.2	15.6	3,245.7
5-15 years	1,488.6	101.5	nc	1,590.1
15 years +	3,024.4	206.2	nc	3,230.6
All ages	7,536.9	513.9	15.6	8,066.4
Urban				
0-4 years	709.8	40.6	1.6	752.0
5-15 years	127.1	7.3	nc	134.4
15 years +	335.9	19.2	nc	355.0
All ages	1,172.8	67.0	1.6	1,241.4
National				
0-4 years	3,733.7	246.7	17.2	3,997.7
5-15 years	1,615.7	108.8	nc	1,724.5
15 years +	3,360.2	225.4	nc	3,585.6
All ages	8,709.7	580.9	17.2	9,307.8
Number of deaths per year				
Rural				
0-4 years	-	277.9	2,512.3	2,790.2
5-15 years	-	371.9	nc	371.9
15 years +	-	755.7	nc	755.7
All ages	-	1,405.5	2,512.3	3,917.8
Urban				
0-4 years	-	38.8	350.7	389.5
5-15 years	-	48.8	nc	48.8
15 years +	-	128.9	nc	128.9
All ages	-	216.4	350.7	567.2
National				
0-4 years	-	316.7	2,863.0	3,179.7
5-15 years	-	420.7	nc	420.7
15 years +	-	884.5	nc	884.5

Item / Region / Age group	Mild diarrhoea	Severe diarrhoea	Malnutrition-related diseases [a]	All diseases
All ages	-	1,621.9	2,863.0	4,485.0
Lost productive time (000 days)				
Rural				
0-4 years	15,754.6	2,074.5	123.8	17,952.9
5-15 years	7,755.6	760.6	nc	8,516.2
15 years +	6,907.7	883.4	nc	7,791.1
All ages	30,417.9	3,718.5	123.8	34,260.2
Urban				
0-4 years	3,140.9	338.1	10.1	3,489.2
5-15 years	562.6	46.5	nc	609.0
15 years +	661.6	76.2	nc	737.8
All ages	4,365.2	460.7	10.1	4,836.0
National	-	-	-	-
0-4 years	18,895.5	2,412.6	123.8	21,431.9
5-15 years	8,318.2	807.1	nc	9,125.3
15 years +	7,569.3	959.6	nc	8,528.9
All ages	34,783.0	4,179.3	123.8	39,086.1

Source: Author's computations.

Note: [a] Malnutrition-related cases, which were only estimated for children under the age of 5 years, represent ALRI and malaria. Malnutrition-related deaths also includes measles.

Lost productive time refer to the number of days lost because of disease. This was estimated using assumptions on cases, treatment practices and days lost per case.[17] Table 4 indicates that around 39.1 million person-days/year are lost due to diseases associated with poor sanitation in PNG. Consistent with data on disease incidence, most of the lost time is in rural areas – about 34.3 million days/year or 88% of the total. Children under the age of 5 years account for more than half of the lost days. Despite the assumption that people who have mild diarrhoea do not suffer as long as those with severe diarrhoea and malnutrition-related diseases, the sheer volume of its cases explains the dominance of this disease in the estimates of lost productive time.

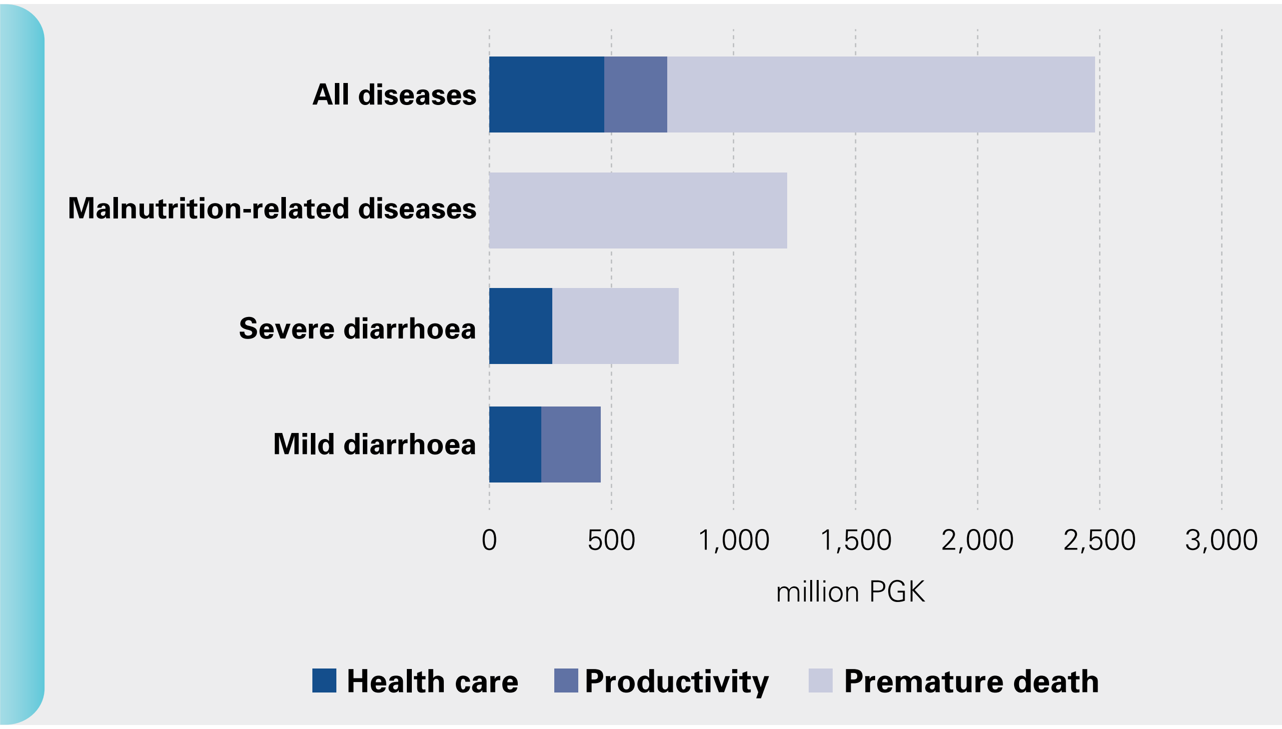
Figure 4 presents the estimated monetary impacts by disease. It indicates that malnutrition-related diseases account for nearly half (PGK 1.2 billion/year) of total health-related costs. Moreover, almost all of the costs for these diseases are due to premature death.[18] Figure 4 also shows that premature death is the dominant

17 Annex B provides details of the assumptions in this study.

18 The interested reader may refer to Annex D for the detailed estimates.

source of costs for severe diarrhoea. Estimated to be about PGK 519.5 million/year, this explains nearly 65% of total health-related costs attributable to the said disease. Despite accounting for the greatest number of cases, mild diarrhoea represents the smallest component of health-related costs. This is explained mostly by the assumption that no deaths are attributed to this disease. However, mild diarrhoea accounts for sizeable proportions of health care and productivity losses.

Figure 4. Estimated costs by disease, million PGK/year



Source: Annex D.

Note: Costs of malnutrition-related diseases were computed only for children under the age of 5 years. Costs for other diseases were computed for all age groups.

Time loss impacts

Table 5 provides insights on the time loss impacts. It indicates that the lack of access to private toilets causes more than 5.8 million lost days/year. About 96% (5.6 million days) of these losses are incurred in rural areas. This is due to the fact that the majority of the population of PNG lives in these areas and that access to private toilets is lower in these regions. More than half of the time losses, or over 3.2 million days/year, is attributable to shared toilets. This is because shared facilities in PNG are more common than open defecation.[19] Losses for adults or persons over the age of 15 years were estimated to be slightly over 3.1 million days/year. Accounting for about 54% of the total, this estimate broadly reflects demographic conditions in the country.[20]

19 Shared facilities refers to toilets or latrines that are both improved and unimproved. Information on the proportion of the population that have access to these facilities is provided in Annex Table A1.

20 In the estimates, adults accounted for about 58.5% of the total population of PNG.

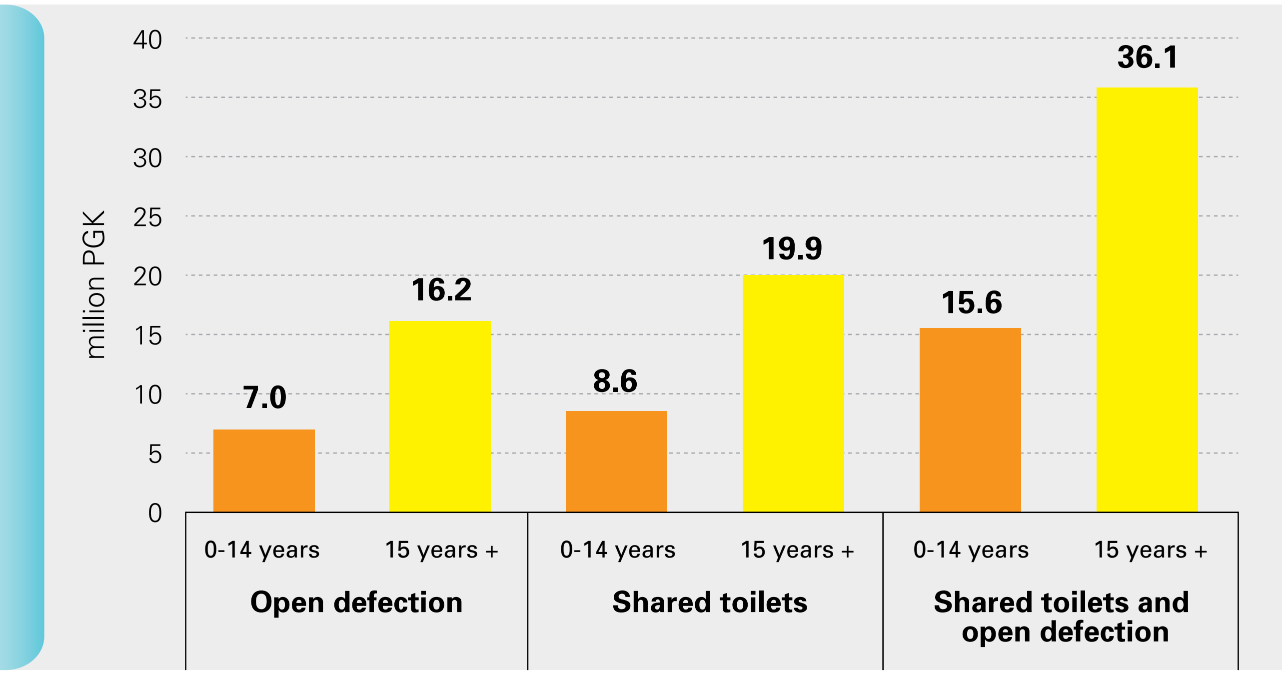
Figure 5 converts the physical losses in Table 5 into monetary units. Consistent with earlier findings, losses from shared toilets are larger than those for open defecation. Losses for adults are also much larger than for children. The second finding is due mostly to the (a) fact that adults account for a larger proportion of the population, and (b) assumption that adult time is valued two times as much as for children.

Table 5. Time lost due to open defecation and shared toilets, days per year

Facility / Age group	Rural	Urban	National
Open defecation			
0-14 years	1,197,032	17,988	1,215,020
15 years +	1,377,701	23,370	1,401,071
All ages	2,574,732	41,359	2,616,091
Shared toilets			
0-14 years	1,412,040	70,928	1,482,968
15 years +	1,625,161	92,148	1,717,309
All ages	3,037,201	163,076	3,200,277
Shared toilets and open defecation			
0-14 years	2,609,072	88,916	2,697,988
15 years +	3,002,861	115,518	3,118,380
All ages	5,611,933	204,435	5,816,368

Source: Author's computations.

Figure 5. **Value of time lost due to open defecation and shared toilets, million PGK/year**



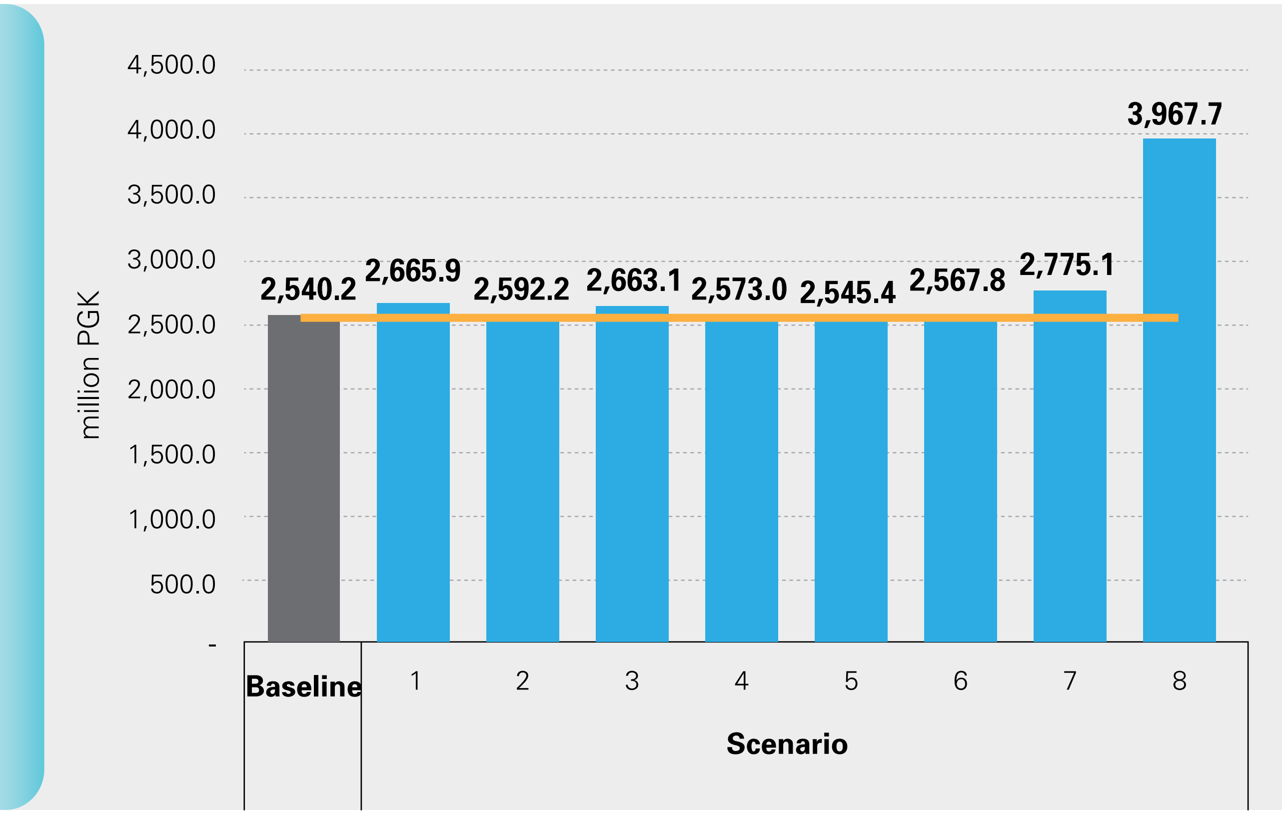
Source: Author's computations.

3.2 Sensitivity analysis

As explained earlier, the uncertainty in the estimates will be addressed by examining how the results respond to alternative assumptions. Two sets of experiments are presented in this section. The first set deals with a 10% increase in carefully selected variables. The second set uses alternative information available in the literature.

Figure 6 shows the estimated losses from alternative scenarios. The baseline scenario indicates the overall losses presented in Section 3.1. Scenarios 1 to 6 present the outcomes from 10% increases in selected assumptions. Figure 6 indicates that losses are quite sensitive to diarrhoeal incidence (Scenario 1) and mortality from malnutrition-related diseases (Scenario 3). To be more specific, the simulation results show that the annual losses will be higher by about PGK 125.7 million/year (approximately 5%) higher than the baseline in Scenario 1. In the case of higher mortality rates for malnutrition-related diseases (Scenario 3), annual losses are expected to rise by about PGK 122.8 million/year. The experiments also show that the estimates are not too sensitive to assumptions regarding travel time (Scenario 5) and days off productive activities (Scenario 6).

Figure 6. Estimated losses from alternative scenarios, million PGK/year



Source: Author's computations.

Note: Scenario 1 = 10% increase in incidence rates for all diarrhoeas; Scenario 2 = 10% increase in the mortality rate from diarrhoea; Scenario 3 = 10% increase in the mortality rate for malnutrition; Scenario 4 = 10% increase in the valuation of time (also similar to a 10% increase in income); Scenario 5 = 10% increase in the travel time of people who do not have access to private toilets; Scenario 6 = 10% increase in the days off productivity activities of people who are sick; Scenario 7 = proportion of mild in total diarrhoeal cases is similar to Cambodia; Scenario 8 = mortality rates from diarrhoea equal to values set in WHO (undated).

Scenarios 7 and 8 are based on alternative sets of assumptions drawn from the literature. As explained in Annex B, this study assumes that only about 5% (urban) to 6% (rural) of diarrhoeal cases are severe. Scenario 7 raises the proportion of severe cases to 12%. This is equivalent to the assumption for Cambodia in earlier ESI studies (Hutton et al., 2008).[21] It is also important to note that deaths associated with diarrhoea were not adjusted in this experiment because the assumptions in the current study are based on deaths per 1,000 persons rather than on case fatality rates. Hence, the changes here were only applied to health care and productivity losses. Scenario 8 assumes a higher mortality rate for diarrhoea among children under the age of 5 years. The current estimates assume about 29.3 deaths per 100,000 persons.[22] The coefficient was taken from Troeger et al. (2018) and is very conservative compared to estimates presented in the WHO (Global Health Observatory) which indicate about 337.1 deaths per 100,000 persons. The alternative scenario uses the high estimate from the WHO.

Figure 6 shows that the higher proportion of severe diarrhoeal cases in Scenario 7 causes estimated losses to rise by about PGK 234.9 million/year or 9% of the baseline value. This is due to higher treatment costs and longer days lost associated with severe diarrhoeal cases. In the case of Scenario 8, the higher mortality rates for diarrhoea results in estimated losses that are higher by about 56% or PGK 1.4 billion/year.

3.3 Discussion

This study found that the overall losses from poor sanitation in PNG are in excess of PGK 2.5 billion/year. The major source of these costs are health-related losses, especially premature deaths. Rural areas and children under the age of 5 years account for most of the losses. The study also attempted to estimate the benefits from providing access to improved facilities to the segment of the population that currently uses unimproved facilities or practice open defecation. Depending on the interventions, the calculated benefits range from about PGK 779.6 million/year to slightly less than PGK 1.4 billion/year.

These estimates are significant. The annual per capita losses, which are about PGK 283.9, are roughly equivalent to 7 days' worth of lost productivity per year.[23] The losses take greater significance when one notes the positive association between access to improved facilities and wealth (see Figure 7). This means that the poor are the ones who lack access to improved facilities and are likely to be more exposed to its impacts. The extent to which these groups are least able to finance the costs of treating sanitation-related illnesses suggests a larger strain on the public health care system.

Table 6 shows the estimated impacts for four countries in Southeast Asia. It indicates that the overall losses range from about 1.3% of GDP in Viet Nam to 7.2% in Cambodia. The estimated

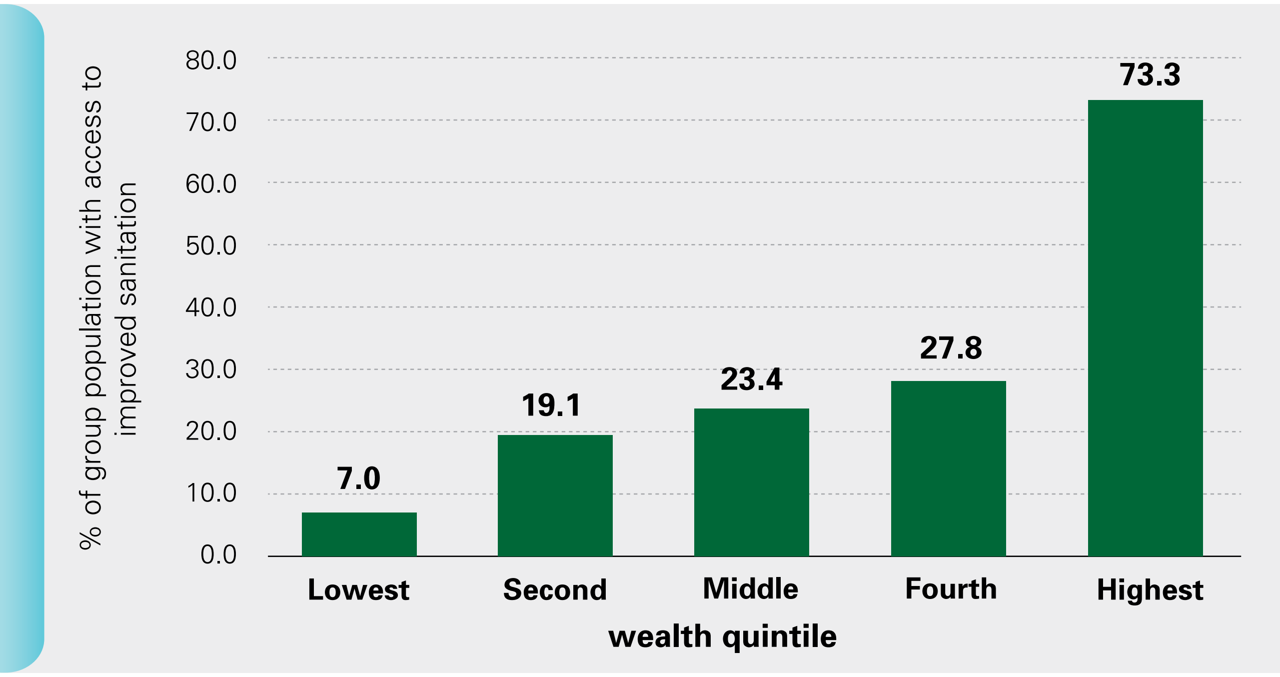
21 *A study by Lamberti (2012) states that about 65% of diarrhoeal cases are mild, with the remaining cases being classified as either moderate or severe. Apart from the undue complication of introducing moderate cases of diarrhoea in the study, the decision to use information for Cambodia was deemed sufficient to examine the implications of using different incidence rates for mild and severe diarrhoea.*

22 *This is the estimate prior to the application of the attribution factor.*

23 *This was calculated by dividing the estimated losses/person/year (= PGK 283.9) by GDP per capita/working day for 2020, which is estimated to about PGK 38.6. Annex B describes the estimation of GDP per capita/ working day.*

loss for PNG, which is approximately 3% of GDP, is higher than the average for the four countries (2%). However, when one notes that the estimates here are confined to health-related and time loss impacts only, then it becomes clear the impacts in PNG are even more significant. In fact, focusing solely on health-related and other welfare impacts suggests that the estimated losses in PNG are much closer to Cambodia (3.6%) than what it seemed originally.

Figure 7. **Wealth and access to improved sanitation**



Source: NSO and ICF (2018).

Table 6. Selected results for ESI studies in Southeast Asia

Country	Loss (% of GDP)		Share of health and other welfare losses in total losses (%)	Total losses / health and other welfare losses
	Total	Health and other welfare losses [a]		
Cambodia	7.2	3.6	50.6	2.0
Indonesia	2.3	1.7	72.0	1.4
Philippines	1.5	1.1	73.8	1.4
Viet Nam	1.3	0.5	38.7	2.6
Average [b]	2.0	1.2	60.8	1.6

Source: Hutton et al. (2008).

Note: a Travel time is one component of other welfare losses. In the Philippines and Viet Nam, other welfare losses included a valuation of the absences of women from work and girls from school. For these countries, the values in the table accounts incorporate more impacts than what was calculated for PNG. b The share of overall losses in GDP for the four countries is a weighted average. All other summary statistics are simple averages.

The challenges associated with the availability of useful information explains the omission of the other impacts of sanitation. While the magnitude of such impacts may not be known until better data becomes available, it is possible to make a rough estimate as to the extent of the omitted losses by exploiting the results for Southeast Asia. Table 6 shows that the ratio of overall losses to the sum of health-related and other welfare losses range from 1.4 in the Philippines to 2.6 in Viet Nam. Applying these factors to current estimates for PNG implies total costs that range from PGK 3.4 to PGK 6.6 billion/year. The higher end of these estimates suggests a loss of approximately 7.7% of PNG's GDP for the year 2020. The attempt to generate conservative estimates in this report means that the costs for PNG may even be higher.

4.

RESULTS: INVESTMENT REQUIREMENTS TO MEET TARGETS

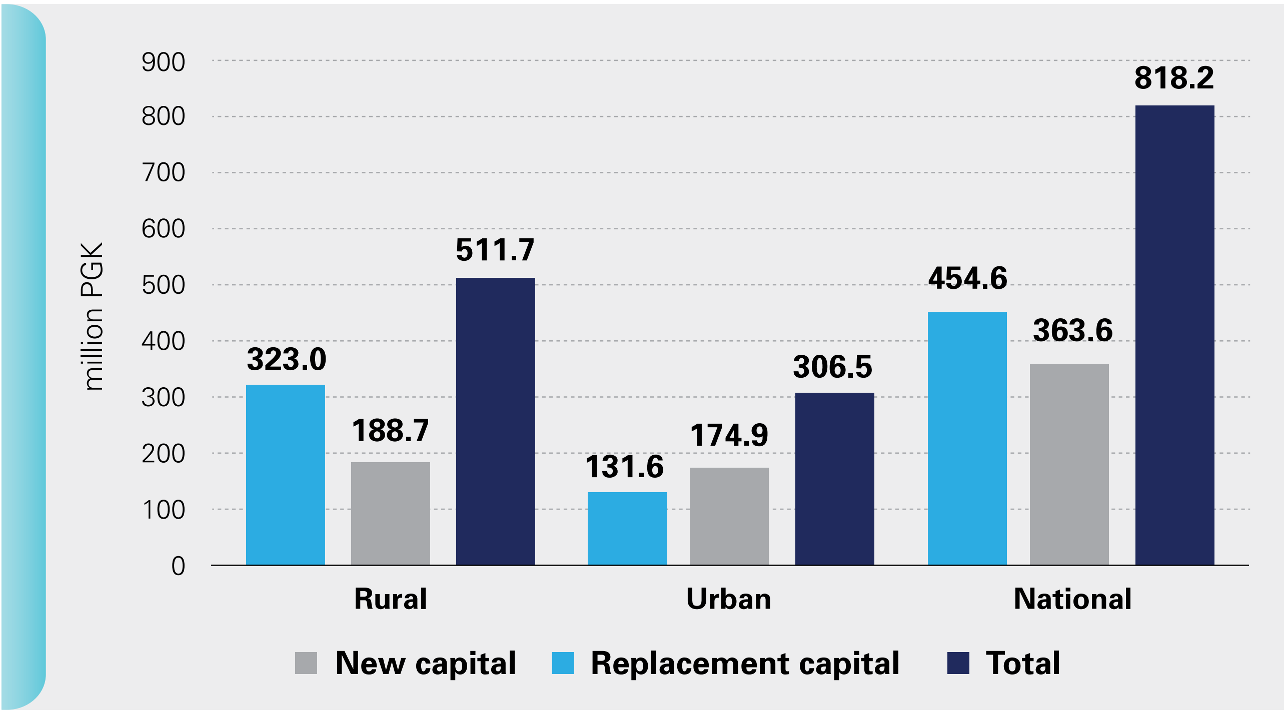
4.1 Estimated requirements

Investment requirements were calculated from 2020 to 2030. The target year was based on the PNG WASH Policy and the Medium-Term Development Plan 2011-2025 (ADB, 2020; DNPM, 2018). Following the targets stated in the aforementioned documents, this study assumed that access to improved sanitation facilities in PNG will rise to 70% and 85% in rural and urban areas, respectively. In the case of rural areas, this represents an increase of 52 percentage points over the access rates reported by the JMP (2021a) for 2020. The increase in urban areas is proportionately smaller because about 58% of the population already had access to improved facilities in 2020.

Based on the targets above and the other assumptions of this study, the country needs to invest about PGK 818.2 million/year from 2021 to 2030 (see Figure 8).[24] Nearly 63% of this amount (PGK 511.7 million/year) will be spent for providing access to the rural population. In addition, about 56% of the total investments or PGK 454.6 million/year will be allocated to new capital. The remainder (PGK 363.6 million/year) will be for replacing worn-out facilities.

24 Annex C presents the other assumptions of the study.

Figure 8. **Investment requirements to meet 2030 sanitation targets, million PGK/year**



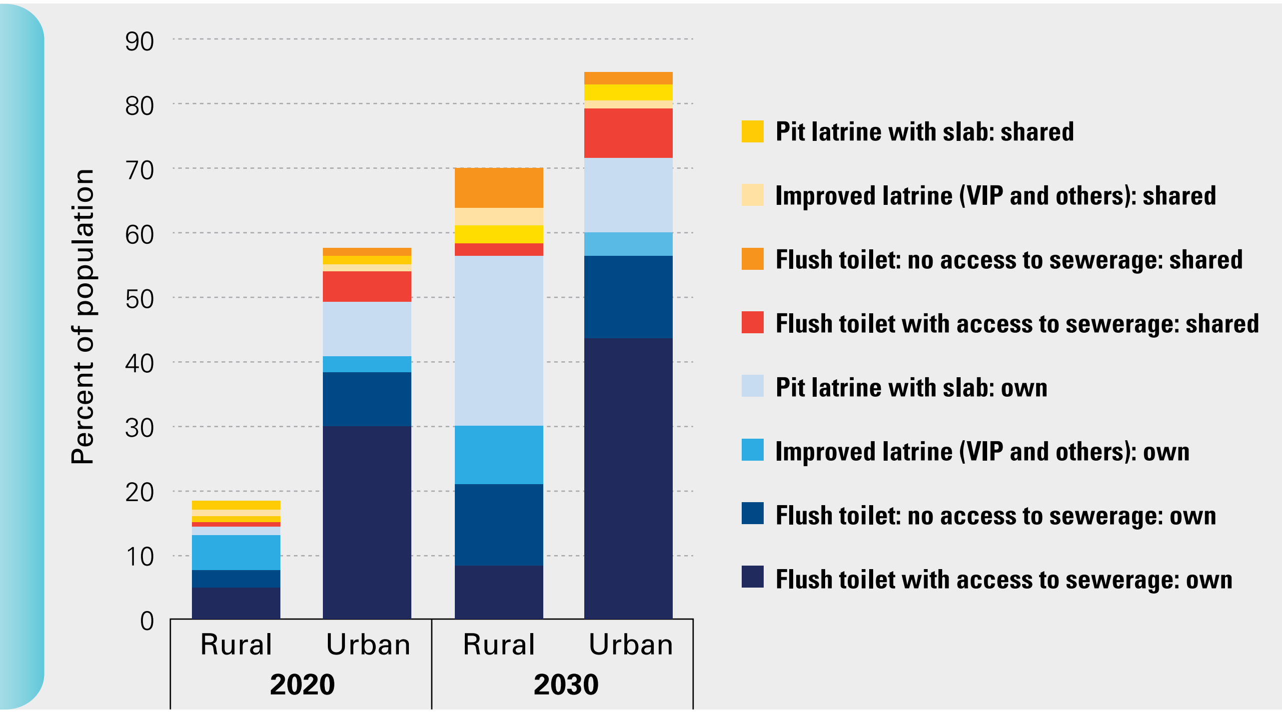
Source: Author's calculations.

In order to understand the costs, it is useful to examine how access to facilities are expected to change over time. Figure 9 shows access rates in 2020 and the target year. It indicates that, in the case of rural areas, the largest desired percentage increase is for private pit latrines with slab. Access rates for these facilities are assumed to increase from about 7% of the population in 2020 to 26% of the population in 2030. In contrast, the largest percentage gains in urban areas are assumed for private toilets with access to sewer facilities.

Figure 10 shows the calculated annual increases in the number of people who need to gain access to facilities. It indicates that about 579,000 people/year are required to gain access to improved facilities. The majority of these beneficiaries live in rural areas. Among the technologies, the largest increase is for pit latrines with slab in rural areas.

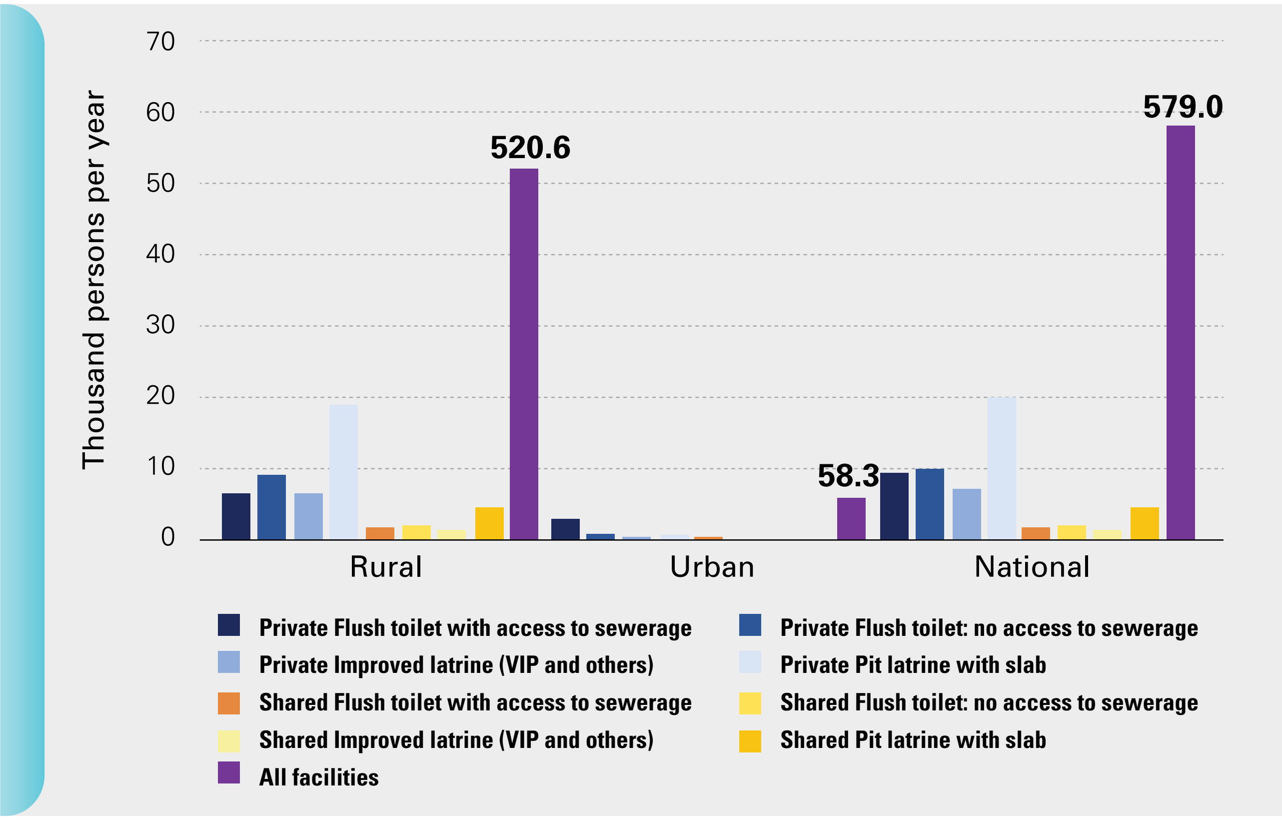
Table 7 presents estimates of investment requirements by technology. It indicates that close to 80% of the expenditures or PGK 654.1 million/year are for private toilets that have access to sewers. Combined with the information in Figure 8, this result highlights the assumption that such facilities are the most expensive of the options considered in the analysis. A far second are the expenditures on private pit latrines with slab, which is the least expensive option.

Figure 9. Access to facilities 2020 and 2030, % of the population



Source: Annex C.

Figure 10. Annual change in the number of people covered by technology, thousand persons



Source: Author's estimates.

Table 7. Investment requirements by technology, million PGK/year

Facility	Rural	Urban	National
Private			
Flush toilet with access to sewerage	379.6	274.5	654.1
Flush toilet: no access to sewerage	26.1	3.9	30.0
Improved latrine (ventilated improved pit latrines or VIPs and others)	20.9	1.5	22.4
Pit latrine with slab	34.2	2.6	36.9
Shared			
Flush toilet with access to sewerage	40.9	23.3	64.2
Flush toilet: no access to sewerage	2.8	0.3	3.1
Improved latrine (VIP and others)	2.7	0.1	2.8
Pit latrine with slab	4.4	0.3	4.7
All facilities	511.7	306.5	818.2

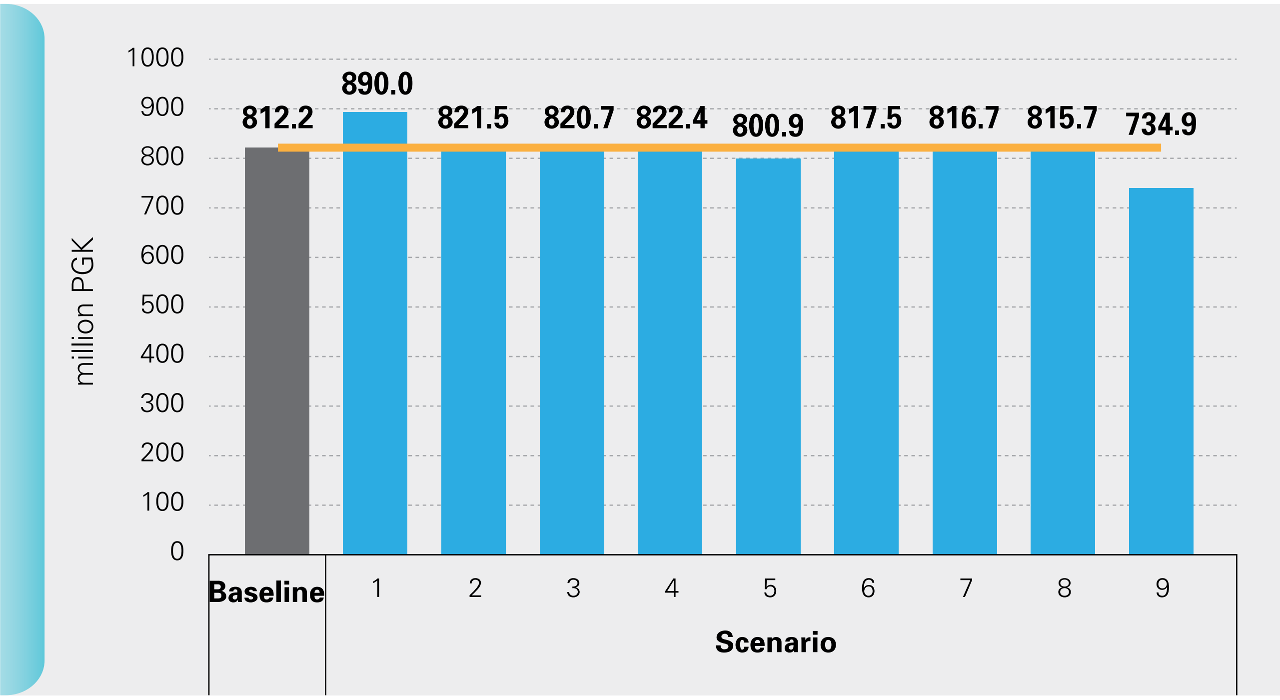
Source: Author's estimates.

4.2 Sensitivity analysis

This section presents the impacts on investment requirements of alternate assumptions on the unit costs and expected life of facilities, and population growth. The first set of experiments will help identify the assumptions likely to have the strongest effects on the estimates. In contrast, the experiment on population growth was included because of its relevance from a policy perspective.

Figure 11 shows the results from alternative scenarios. Scenarios 1 to 8 assume that prices and expected lives of different sanitation options are 10% higher than the values assumed in the baseline. Scenario 9 assumes that annual population growth in PNG is lower by one percentage point. The simulation results indicate that the estimates are most sensitive to changes in the assumptions for toilets that have access to sewers. Investment costs rise to about PGK 890.0 million/year, which is 9% higher than the baseline, when these facilities are 10% more expensive (Scenario 1). Investment requirements are expected to fall to about PGK 800.9 million/year if these facilities last 10% longer (Scenario 5). These outcomes are generally due to the earlier finding that toilets with access to sewers account for the largest proportion of investment requirements. The results for Scenario 9 also show that slower population growth can have a noticeable impact on investment costs. In the current analysis, a one-percentage point decline in the population growth reduces annual investment costs to about PGK 734.9 million/year. This amount is about 10% lower than the baseline estimate.

Figure 11. **Investment requirements under different scenarios, million PGK**



Source: Author's calculations.

Notes: Scenario 1 = unit cost of toilets that have access to sewers are 10% higher; Scenario 2 = unit cost of toilets that have access to septic tanks are 10% higher; Scenario 3 = unit cost of improved pit latrines are 10% higher; Scenario 4 = unit cost of pit latrines with slab are 10% higher; Scenario 5 = expected life of toilets that have access to sewers are 10% higher; Scenario 6 = expected life of toilets that have access to septic tanks are 10% higher; Scenario 7 = expected life of improved pit latrines are 10% higher; Scenario 8 = expected life of pit latrines with slab are 10% higher; Scenario 9 = population growth is one percentage point slower.

4.3 Discussion

This study estimated that the country needs to invest about PGK 818.2 million/year in order to meet its targets for 2030. While most of the costs will be for constructing new facilities, a significant proportion of the expenditures will be for replacing worn-out capital. Nearly two-thirds of the amount is for facilities in rural areas. This is explained by fact that access rates are relatively low, and a sizeable majority of the population live in these regions. However, the investment requirements for urban areas are disproportionately large especially when one accounts for its relatively small population and high access rates to improved facilities. The explanation for this result is that investments in this region are on a per unit basis higher than in rural areas. This is heavily influenced by a technology mix that has a bias towards more expensive options such as pour-flush toilets with access to sewer facilities.

The investment requirements are quite large, with annual costs amounting to close to 1% of GDP for 2020. Its magnitude may also be better appreciated by examining earlier estimates for PNG. The DNPM et al. (2013) study estimated investment requirements in the order of USD 70 million/year. This is roughly equivalent to PGK

219 million/year at 2020 prices.[25] It is less than two-fifths of 1% of the 2010 GDP of PNG.[26] While differences in assumptions make a direct comparison of the estimates difficult at best, it nonetheless highlights the high costs of meeting targets in this study.[27] In addition, data from the JMP (2021a) shows that access rates hardly changed for rural areas and even declined for urban areas.[28] This information along with population growth over the past decade implies that, all other variables remaining the same, annual investment costs to meet 2030 targets that are estimated from 2020 will be higher than costs estimated from 2010.

The magnitude of the investment requirements raises two additional concerns. The first deals with financing investments. This is associated with the sources of funds and identifying the groups that will eventually pay for the facilities. The second issue has to do with the earlier point on software expenditures and its importance in the success of investment projects.

Recent trends in the sanitation sector suggest that, unless sufficient funds are forthcoming, existing targets are quite optimistic. In fact, a simple linear extrapolation using data from 2005 suggests that the 2030 targets for rural and urban areas are likely to be missed (see Figure 12). This implies that existing targets may have to be re-evaluated.

While there are many possible targets for PNG, this study experiments with two alternative scenarios. The first scenario assumes moving the target year from 2030 to 2040. The other scenario focuses on reducing the 2030 targets. In the latter, the 2030 target is set to about half of the gap between existing access rates and the current targets. In the case of rural regions for example, the target will be reduced from 70% in 2030 to about 44%. This implies an increase of 26 percentage points from the existing access rate of 18% instead of the 52 percentage points that was implied by initial target. In the case of urban areas, the 2030 target will be reduced from 85% to 71%. Given existing population growth rates, these targets imply that access to improved sanitation for the entire country in 2030 will be 48% instead of what was originally estimated to be about 72%.

Before presenting the results, it must be noted that these scenarios should not be treated as strong recommendations for the decision makers. The reason is that there are many other considerations in the target setting process. Rather, these experiments should be interpreted as the possible consequences of altering the targets on investment requirements. At the very least, this exercise may be viewed as another illustration of how the SDA costing tool can be used to develop targets for PNG.

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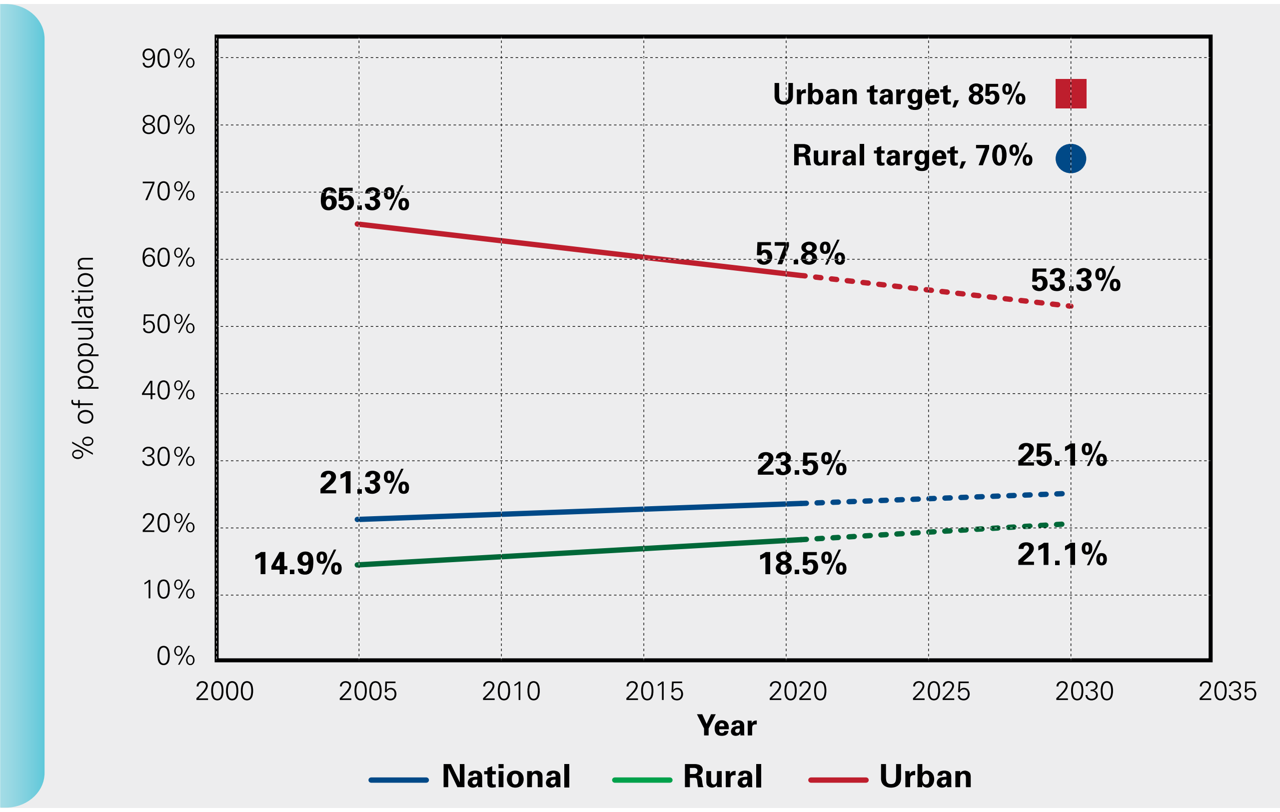
25 The DNPM et al. (2013) study estimate is measured at 2012 prices. It was converted to 2020 prices in two steps. The first step multiplies the amount by the exchange rate of PGK 2.1/USD in 2012 (ADB, 2021). The results were then multiplied by the ratio of the CPI for 2020 and 2012. The CPI data, which was 101.4 for 2012 and 151.0 in 2020, were obtained from ADB (2021).

26 The World Bank (2022) reports that the nominal GDP of PNG in 2010 was about PGK 38.8 billion.

27 Among the biggest differences between the current study and DNPM et al. (2013) is in the initial access rates. Using the information from the JMP (2012), DNPM et al. (2013) assumed access rates to improved sanitation of 71% and 41% for urban and rural populations, respectively. These are much higher than the assumptions in the current study, which are 18% for rural and 58% for urban populations in 2020. It is important to note that, as shown in Figure 1 of this report, JMP (2021a) access rates for 2010 are also much lower than the values presented in JMP (2012).

28 The interested reader may refer back to the introduction of this report for the details.

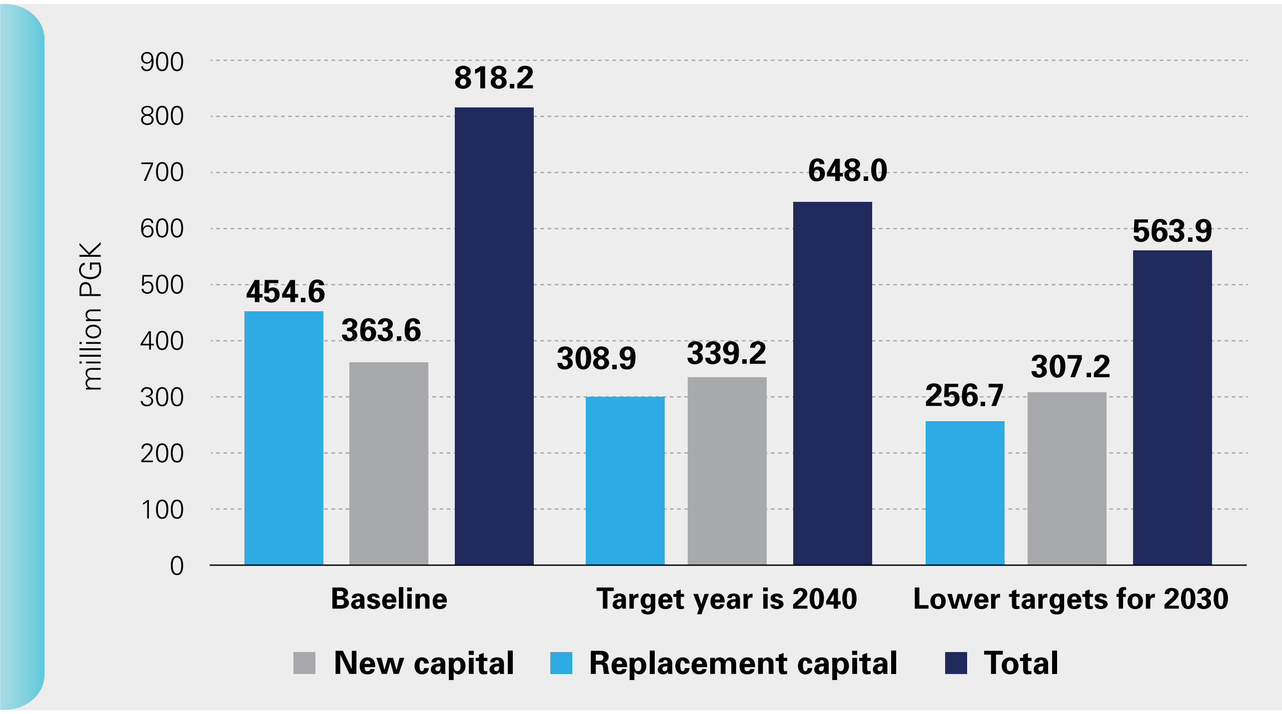
Figure 12. **Projected access rates and sanitation targets, 2030, % of the population**



Notes: Actual data was taken from the JMP (2021a). Projections were based on the author's computations.

Figure 13 presents the simulation results from the exercises. It shows that extending the target year to 2040 lowers total annual expenditures by 21% from PGK 818.2 million/year to PGK 648.0 million/year. In this scenario, costs do not fall as much as one would have initially anticipated because the rising population means that more people will have to gain access to facilities. Reducing the target access rates in 2030 reduces investment costs more significantly. Under this scenario, annual investment costs fall to about PGK 563.9 million/year. This is mostly due to the fall in new capital requirements.

Figure 13. **Investment requirements under alternative targets, million PGK/year**



Source: Author's calculations.

5. RECOMMENDATIONS

Recommendation 1: Investments in sanitation should be implemented urgently. This is motivated by the finding that the costs of sanitation in PNG are significant. Apart from causing deaths, the avoidable diseases associated with poor sanitation also put a strain on the public health care system. The inability of the sick and those caring for them to engage in their usual activities also has a negative impact on the productivity of the economy as a whole.

The call for more investments in the sector is also driven by the findings that access rates to improved facilities have not changed much, and have even declined in urban areas, in recent years. When considered along with the rising population of PNG, such a trend means that larger amounts of funds will be needed to achieve the sanitation targets if steps are not taken immediately.

Investments in sanitation should not be confined to toilets and treatment facilities only. The estimates presented in this report show that gains could be larger when investments in sanitation facilities are complemented by better hygiene practices. Information presented in the introduction of this report shows that there is scope for improving access to handwashing facilities in PNG.

Recommendation 2: Where funds are scarce, rural regions and areas with high concentrations of children should receive greater attention. Should scarcity of funds require concerned stakeholders to prioritize beneficiaries, then this study recommends allocating a larger proportion of the resources to rural regions and areas with high concentrations of children under the age of 5 years. The focus on rural areas is driven primarily by the finding that a large proportion of the impacts of poor sanitation is experienced by people living in these regions. The fact that access rates in rural regions are far lower than in urban regions may also mean larger net benefits from investments because the facilities that can be provided may not have to be as expensive on a per unit basis. While driven mostly by the assumptions on the desired technology mix, some evidence in this regard was provided in the estimation of investment requirements in this report.

The finding that children under the age of 5 years suffer disproportionately suggests that investments should be targeted to areas that have low access rates and high concentrations of this age group. Such an approach may, as in the case of investments in rural areas, lead to higher returns for every kina that is invested because of larger avoided losses.

Greater emphasis on rural regions does not translate to neglecting urban areas. In fact, attention to urban areas is necessary in order to at least arrest the decline in its access rates.

Recommendation 3: Re-evaluating sanitation targets for PNG. The analysis in Section 4 of this report shows that unless drastic changes take place in the next few years, current sanitation targets may not be achievable. Required annual investments are also quite large, amounting to about 1% of 2020 GDP. These findings suggest that current targets require re-evaluation and, perhaps, adjustment. Such revisions may also incorporate the SDGs, which includes the target of zero open defecation by 2030.

This report presented results from two alternative targets. However, it is worth reiterating that these should not be interpreted as specific policy recommendations. Rather, the counterfactual experiments should be viewed as an illustration of how the tool that was adopted in the study, which was borrowed from the SDA project, can be useful for target setting.

Recommendation 4: Improving the information base in PNG. Good quality information is essential to developing precise and credible estimates. While every effort was taken to use the best data available, this study recognizes these are not optimal and lead to uncertainty in the results. The natural recommendation that comes out of this is the need to strengthen the information base. Depending on available resources, this may involve surveys or targeted studies designed to provide inputs to the research. The objectives of such undertakings should be to generate (a) better quality data for the impacts of sanitation quantified in the current study, and (b) inputs that can be used to estimate the impacts that were omitted.

For all its shortcomings however, it should be noted that the outcomes of this report are still useful as a first step in evaluating the impacts of sanitation in PNG. Apart from identifying information that needs to be collected and/or improved, this study may also serve as a foundation for future research.

Recommendation 5: Evaluate the net benefits of different sanitation technologies. Especially when funds are limited, investments should be targeted on facilities that generate the highest net benefits. This requires identifying the menu of plausible technologies and evaluating the economic efficiency of each option. A good start here might be to follow the ESI Options study that was conducted for different countries in Asia a few years ago (Hutton et al., 2015). The analysis in that study implemented, among others, a cost-benefit analysis of different sanitation options in different contexts. Apart from showing that benefits from sanitation investments generally outweigh the costs, one of its key results was that the economic performance of similar technologies might vary under different contexts. This result is very important because it means the technologies that may perform well in one country may perform differently, even for a similar region, in PNG.

Recommendation 6: Evaluate financing dimension of sanitation investments. It is well known that funding for constructing facilities such as sewerage systems cannot be sourced directly from households. While toilets in household premises can be expected to be financed by the users, it is not difficult to imagine that this might also be a challenge especially because, as noted earlier in this study, it is the poor that generally do not have access to improved facilities. These are examples of concerns that will require an evaluation of the means by which sanitation investments will be financed. To the extent that support for providing access to improved facilities will be extended to poor households, such an analysis should also consider the means by which the services will be delivered.

Recommendation 7. Research on the relationships between sanitation and its impacts. While not directly addressed in the current study, there are still gaps in relating poor sanitation to its impacts. In the first batch of ESI studies alone (Hutton et al., 2008), the estimation of the impacts on water, tourism and other dimensions would clearly benefit from rigorous supporting research. Rather than going into the details, this report simply reiterates the need for future studies in this area.

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ANNEXES

Annex A. Demographic and sanitation coverage

The calculation of sanitation impacts and investment expenditures requires demographic and sanitation coverage data. This annex presents the values used in the estimation process and outlines the sources of information.

Demographic data

The estimation of sanitation impacts exploits regional and age group population data for PNG. In the case of investment requirements, information on regional population and population growth is needed. Annex Table A1 shows the inputs used in the analysis as well as their sources.

Annex Table A 1. Demographic data, Papua New Guinea

Item	Rural	Urban	National
Population [a]			
millions of persons, 2020	7.8	1.2	8.9
annual growth rate (%, 2011-2020)	2.0	2.3	2.0
Population distribution (%) [b]			
0-4 years	13.9	12.6	13.7
5-14 years	28.4	24.0	27.8
15 years +	57.7	63.4	58.5
Average household size (number of persons) [b]	4.9	6.0	5.0

Sources: a World Bank (2022); b NSO and ICF (2019).

Sanitation coverage

The components of the report on sanitation impacts and investments require different levels of disaggregation on sanitation coverage. For the estimation of impacts, information on access to private and shared facilities that are improved and unimproved is sufficient to implement the analysis. In contrast, detailed information on the types of facilities used by the population is necessary for the computation of investment requirements. While different in terms of detail, aggregate access rates for both components of the study must be consistent with each other. As much as possible, it should also use the most recent information available.

The most recently available data on access rates is provided by the JMP (2021a) for the year 2020. The disaggregation needed for both components of this study requires combining JMP estimates with survey data from the DHS (NSO and ICF, 2019).[29] The process of combining the two sets of data also exploited information on the rural and urban populations that were presented earlier.

29 The worksheets of JMP (2021a) also provides the DHS 2016-2018 data.

Annex Table A2 shows the information used in the impacts component of the study. The explicit treatment of shared in both improved and unimproved facilities was necessary for implementing the estimation of time loss impacts. Annex Table A3 presents the information used in the investment requirements component of study.

Annex Table A 2. Access to sanitation facilities used in the impacts component of the study, 2020, % of the population

Facility	Rural	Urban	National
Improved sanitation	18.2	57.8	23.5
Private	14.7	48.8	19.2
Shared	3.6	9.0	4.3
Unimproved sanitation	63.8	38.2	60.4
Private	46.1	31.1	44.1
Shared	17.7	7.0	16.3
Open defecation	18.0	4.1	16.1
Total	100.0	100.0	100.0

Sources of basic data: JMP (2021), NSO and ICF (2019).

Annex Table A 3. Access to sanitation facilities used in the investment requirements component of the study, 2020, % of the population

Facility	Rural	Urban
Improved sanitation		
Private		
Own-flush toilet with access to sewerage	2.3	29.6
Own flush toilet: no access to sewerage	3.2	8.6
Improved latrine (VIP and others)	2.4	2.6
Pit latrine with slab	6.8	8.0
Shared		
Own-flush toilet with access to sewerage	0.5	5.5
Own flush toilet: no access to sewerage	0.8	1.6
Improved latrine (VIP and others)	0.6	0.5
Pit latrine with slab	1.6	1.5
Unimproved and open defecation	81.8	42.2
Total	100.0	100.0

Sources of basic data: JMP (2021), NSO and ICF (2019).

Annex B. Data and assumptions for the impacts of poor sanitation

This annex documents the data and assumptions used in calculating the impacts of poor sanitation. In assembling the data set, priority was given to reliable information from secondary sources in PNG. If not available, this study drew information from other sources.

Heath impacts

The calculation of health-related impacts requires information on incidence/prevalence and deaths from diarrhoeal and malnutrition-related diseases attributable to poor sanitation. Annex Table B1 shows the assumptions used in this study. Combined with age group population data, these generate estimates of the number of people who get sick or die because of poor sanitation. For example, Annex Table B1 indicates that (a) 3.19 cases/person/year of mild diarrhoea for children under the age of 5 years in rural areas and (b) 0.88 of diarrhoeal diseases are attributable to sanitation. The product of these values (2.81 = 3.19 x 0.88) provides an estimate of the cases/person/year of mild diarrhoea for children under the age of 5 years in rural areas that are associated with poor sanitation. Further multiplying the outcome by age- and region-specific population generates the results presented in Table 4 of text.[30]

Annex Table B1 shows that there is no single source of information for the required variables. In cases where region-specific, disease-specific and age group-specific data are not available, the same value is used for all groups. An example of this is for the attribution factors. In situations where PNG-specific data is not available or not directly usable, the study borrowed information from other countries and regions. One example of this is the diarrhoeal incidence rate for persons over the age of 5 years which represents data for the Oceania region. Another instance is the attribution factor for malnutrition-related diseases, which is an estimate for Cambodia.

Not reflected in Table B1 is the fact that raw data had to be processed into forms that are applicable for the analysis. Where multiple options exist, values were also carefully selected to suit the objectives of the study. Some of the key adjustments and decisions made in the process are as follows. First, the DHS (NSO and ICF, 2019; NSO, 2009) reports disease incidence for the 2 weeks at the time of survey. Following the approach in Hutton et al. (2008), values were multiplied by 26 in order to generate annual estimates.[31] Second, data on incidence rates for diarrhoea do not disaggregate between mild and severe cases. In order to make a distinction, this study exploited data in the DHS 2006 (NSO, 2009) which provided the proportion of children that were reported to have blood in their stool. It was assumed in the computations that this represents the proportion of diarrhoeal cases that are severe. It is important to note that this assumption most likely generates a conservative estimate because the severity of diarrhoeal cases is not only manifested in the presence of blood in stool. In an ESI study for the Philippines for example, Rodriguez et al. (2007) treated people with acute watery diarrhoea, acute bloody diarrhoea, cholera and typhoid as severe cases of the disease. Third, mortality rates for diarrhoea among children under the age of 5 years was obtained from the Global Burden of Diseases, Injuries and Risk Factors Study (GBD) 2016 (Troeger et al., 2018) and represents information for the Oceania region. Alternative mortality rates, which are specific to PNG, are available from the Global Health

30 Annex Table A1presents the assumptions for region- and age-specific population.

31 The DHS (NSO and ICF, 2019) reports that 13.1% and 21.8% of children under the age of 5 years had diarrhoea in the past 2 weeks in rural and urban areas, respectively. Multiplied by 26, these suggest 3.4 and 5.7 cases/person/year in rural and urban areas, respectively. This translates to a national average of about 3.7 cases/person/year. The national estimate does not seem too different from the 3.4 episodes/child/year that Walker et al. (2010) calculated for 1990. However, it is higher than 2.9 episodes/child/year estimated by same study for 2010. It is important to note that the estimates of Walker et al. (2010) are not specific to PNG.

Observatory (WHO, undated). However, the value in that document leads to diarrhoeal deaths among children that are more than 10 times as much as those provided by Troeger et al. (2018).[32] Finally, Hutton et al. (2008) reports different attribution factors for malnutrition-related diseases among four countries in Southeast Asia. In the case of ALRI incidence for example, the attribution factors range from 0.13 in Viet Nam to 0.19 in Cambodia. Attribution factors for Cambodia were selected in this study because access to improved sanitation for that country at the time of ESI studies was the closest to the current access rates in PNG.

Annex Table B 1. Incidence rates, mortality rates and attribution factors

Indicator / disease	Rural		Urban	
	0-4 years	5 years +	0-4 years	5 years +
Incidence/prevalence rate (cases/person/year) [a]				
Diarrhoea				
Mild	3.19	0.77	5.36	0.50
Severe [b]	0.22	0.05	0.31	0.03
Malnutrition-related				
ALRI [c]	0.73	nc	0.73	nc
Malaria [d]	0.16	nc	0.12	nc
Morality rate (deaths/1000)				
Diarrhoea [e]				
Mild	-	-	-	-
Severe	0.29	0.21	0.29	0.21
Malnutrition-related [f]				
Measles	6.73	nc	6.73	nc
ALRI	5.84	nc	5.84	nc
Malaria	0.38	nc	0.38	nc
Attribution to poor sanitation and/or malnutrition				
diarrhoeal diseases [g]	0.88	0.88	0.88	0.88
Malnutrition-related: Incidence [h]				
ALRI	0.19	nc	0.19	nc
Malaria	0.08	nc	0.08	nc
Malnutrition-related: Mortality [h]	0.18	nc	0.18	nc

Notes: [a] Incidence rates for diarrhoea among children under the age of 5 years were calculated using data from the DHS 2016-2018 (NSO and IFC, 2019). Incidence rates for the other age groups, which represent information for the Oceania region, were obtained from Troeger, et al. (2018). [b] Severe cases represent the proportion of children with blood in stool. The data was obtained from the NSO (2009) and applied to all age groups. [c] Based on information from NSO and ICF (2018). [d] Based on information from NSO (2009). [e] All diarrhoeal deaths were attributed to severe cases only. [f] Based on information from WHO (undated). [g] Based on Hutton et al. (2015). [h] Based on Hutton et al. (2008).

32 The WHO (undated) reports a mortality rate of 337 deaths per 100,000 live births.

Health-related impacts: Treatment costs

The calculation of treatment costs requires combining previously presented information on disease incidence with treatment practices and unit costs of treatment. Annex Table B2 shows assumptions for treatment practices used in the computations. When multiplied by the number of cases, the proportion of cases seeking care assists in estimating the number of sick people who sought formal and traditional care. The average number of OP visits/cases then determines the number of times these services were sought. Multiplied by inpatient admission rates, this provides an estimate of the number of people who were confined in health centers.

Annex Table B 2. Treatment practices

Item	Rural	Urban
Cases seeking care per facility (%) [a]		
Diarrhoeal diseases		
Formal care (OP)	35.5	51.0
Informal/traditional care	1.1	1.6
No treatment	64.2	48.5
Total	100.8	101.2
Malnutrition-related diseases [b]		
Formal care (OP)	49.2	69.2
Informal/traditional care	0.4	0.5
No treatment	51.0	31.1
Total	100.5	100.8
Average number of OP visits/per case: Formal care [c]		
Mild diarrhoea	1.0	1.0
Severe diarrhoea		
0-4 years	3.0	3.0
5-14 years	2.0	2.0
15 years +	2.0	2.0
Malnutrition-related diseases	1.5	1.5
Average number of OP visits/per case: Informal care [d]	1.0	1.0
Inpatient admission rates (% of OP visits)		
Mild diarrhoea [d]	-	-
Severe diarrhoea [e]	41.0	41.0
Malnutrition-related diseases [e]	13.0	13.0
Average length of inpatient stay in primary facility (days) [c]		
Severe diarrhoea	3.0	3.0
Malnutrition-related diseases	4.0	4.0

Notes: [a] Based on information from NSO and ICF (2018). [b] This represents the weighted average for ALRI and Malaria. [c] Based on interviews conducted by the NRI. [d] Author's assumption. [e] Based on Hutton et al. (2008). Malnutrition-related diseases are the weighted average of assumptions for ALRI and Malaria.

As with disease incidence and mortality rates, information on treatment practices was also drawn from multiple sources. These also had many instances in which PNG-, region-, disease-, and/or age-group specific data was not available. The following are some of the assumptions worth noting. First, information on malnutrition-related diseases is the weighted average of data for ALRI and malaria. The weights were based on the estimated number of cases of each disease in PNG. Second, where alternative options exist, the bias was to use values that will generate conservative estimates. For example, this was the approach for selecting the number of OP visits per case and inpatient admission rates for severe diahhrea. Third, following the earlier ESI studies, it was assumed that no mild cases of diarrhoea would be admitted in formal facilities. Finally, no useful information on the practice of self-treatment was found for PNG. As it will not be surprising that such practices do exist in the country, it is very likely that treatment costs will be underestimated.[33]

Annex Table B3 shows the unit costs associated with formal care, informal care and non-health-related expenses. All information presented in the table are based on consultations conducted by the NRI. Ideally, OP unit costs represent payments for doctors, medicines and medical procedures. Inpatient costs also includes room rates and additional medical procedures associated with such treatments. However, the study was unable to obtain information on the costs of medications and many medical procedures. Hence, the costs included in this report only represent expenditures for doctors, rooms, and selected medical procedures. Consistent with the bias of the study towards generating conservative estimates, costs of informal care represent the lowest value reported in the consultations conducted by the NRI.[34] There are non-medical expenditures incurred by patients and their companions in seeking care. These include payments for transport, meals and other incidental expenses. This study simply included the lowest transport costs (round trip) reported in the consultations made by the NRI.[35] The fact that other non-medical expenditures were ignored reinforces the point that the estimates are conservative. It is also important to note that the 2009-2010 HIES of PNG (NSO, undated) shows that majority of the population walk to health centers (Appendix Table B4). This suggests that a large proportion of the actual transport costs may be better represented by the value of the time lost walking to health facility.

33 The 2009-2010 Household Income and Expenditure Survey or HIES (NSO, undated) found that about 38% of the respondents mentioned treating illnesses at home as a reason for not seeking treatment. The information provided is not disease specific.

34 The values collected by NRI in its consultations ranged from PGK 3 to PGK 500 per visit.

35 The values collected by NRI in its consultations ranged from PGK 3 to PGK 300 per round trip.

Annex Table B 3. Unit costs of health care, PGK/year, 2020 prices

Disease	Formal: Outpatient (cost per visit)	Formal: Inpatient (cost per day)	Informal care (cost per visit)	Non-health related costs (cost per visit, roundtrip)
Diarrhoea mild	63.2	0.0	19.1	2.9
Diarrhoea severe	63.2	321.6	19.1	2.9
Malnutrition-related	91.7	350.1	19.1	2.9

Source: Consultation with experts and health professionals.

Annex Table B 4. Means of transport to a health facility, % of respondents

Mode of travel	Rural	Urban	National
Walking	74.0	43.6	70.4
Car	21.6	51.6	25.0
Boat or canoe	1.6	-	1.5
Other	2.9	4.8	3.1

Source: NSO (undated).

Health-related impacts: Productivity losses

The calculation of productivity costs requires information on (a) disease incidence, (b) average number of days in which people are taken away from their regular activities because illness, and (c) the value of time. As the inputs of the study for estimating disease incidence was discussed earlier, the focus here is on the last two sets of data.

Annex Table B5 presents the assumptions for lost days due to illness. These values were obtained from consultations conducted by NRI with selected health facilities. In general, the decision was to use the most conservative estimates for mild diseases that are treated. The highest values provided by the respondents were used as the days off productive activities for cases that are not treated. The underlying assumption behind this decision is that people who do not seek treatment are likely to suffer from the disease longer than those who consult health professionals. However, exceptions are on the number of days for treated cases of severe diarrhoea among adults (over 15 years) and malnutrition-related diseases. In these instances, days off productive activities were set equal to the number of days for inpatient care. The reason is that the original values obtained from the consultations were lower than the number of days assumed for inpatient care.

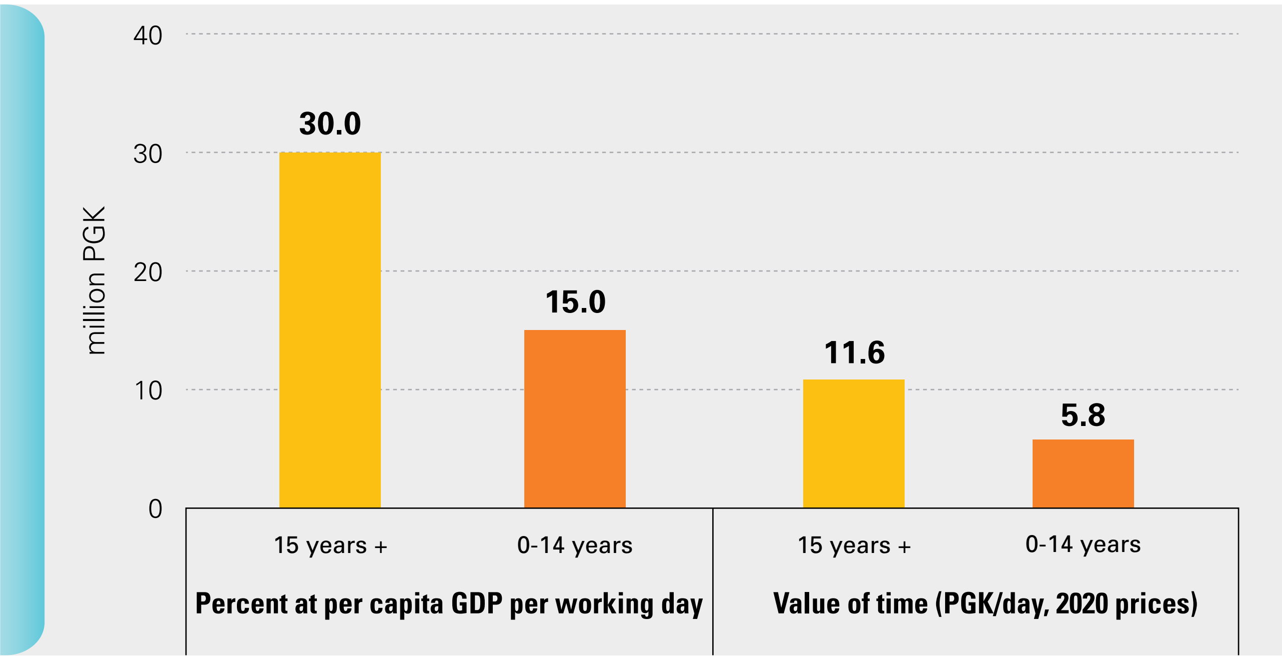
Annex Table B 5. Days of productive activities

Disease / Age group	Treated		Not treated	
	Mild	Severe	Mild	Severe
Diarrhoea				
0-4 years	2.0	3.0	7.0	14.0
5-14 years	2.0	3.0	7.0	10.0
15 years +	1.0	3.0	3.0	5.0
Malnutrition-related diseases	4.0	2.5	8.5	2.5

Source: Consultation with experts and health professionals.

Converting physical to monetary losses requires estimates of the value of time. The base for the latter in this study is GDP per capita per working day, which is about PGK 38.6.[36] Following ESI studies (Hutton et al., 2015), the economic cost of lost productive time for adults will be assumed equal to 30% of this value. In the case of children, the value is half of the adults. Annex Figure B1 summarizes the assumptions that are used in the study.

Annex Figure B 1. Unit values for lost time



Notes: Proportions are based on Hutton et al. (2008). GDP per day was calculated using annual estimates for 2020 provided by the World Bank (2022).

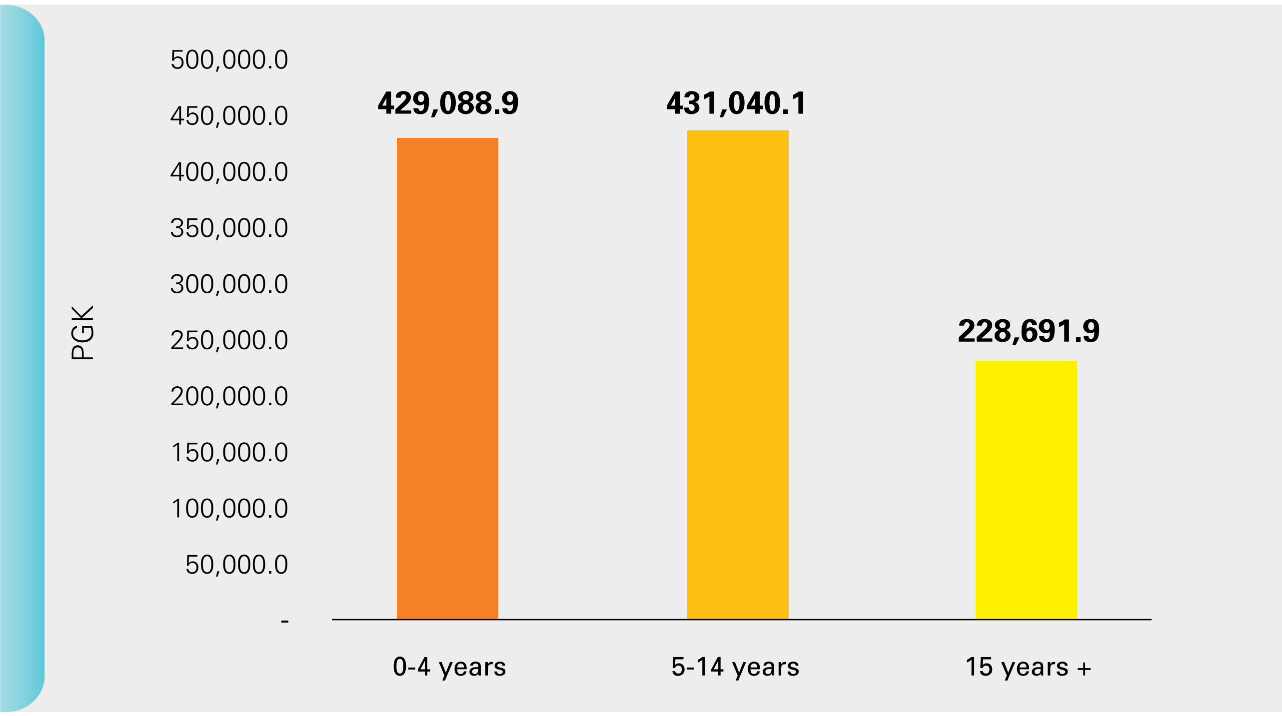
36 The value was derived by dividing GDP per capita for 2020 of PGK 9,540 (World Bank, 2022) by 247 working days. The latter was obtained by subtracting weekends and the 14 public holidays in PNG from the number of days in a year.

Health-related impacts: Premature death

Having presented the assumptions on premature death in Annex Table B1, all that remains is to discuss the inputs that specify a monetary value. There are two popular approaches for assigning a value to the costs of death. These are the value of statistical life (VSOL) and human capital approaches. Typically estimated with the aid of surveys, VSOL attempts to measure how much people are willing to spend in order to avoid death. In contrast, the human capital approach calculates the net present value of the lost income of an individual who dies prematurely. Owing to the absence of relevant VSOL studies in PNG, the human capital approach is used here.

Annex Figure B2 presents the values assigned to each premature death for the different age groups. These estimates were generated using the following assumptions. First, it uses the GDP per capita of PNG in 2020 as the measure of income. Second, following Hutton et al. (2008), persons work from the ages of 15 to 65 years. Third, per capita real GDP will growth at an average annual rate of 2.7%.[37] Fourth, the calculations also used the discount rate (3%) that was applied in the calculations for the ESI studies (Hutton et al., 2008).

Annex Figure B 2. Unit values for premature death, PGK/person



Source: Author's computations.

37 Using data from the World Bank (2022), this is the observed average annual growth of real GDP per capita from 2011 to 2019. Estimates for 2020 were excluded because the contraction for that year (= - 5.3%) unduly reduces the average from 2.7% to 1.9%.

Time loss assumptions

The calculation of time losses incurred by people who do not have access to private toilets requires information on the (a) number of people who share toilets or defecate in the open, (b) time needed to find a place to defecate, and (c) unit value of time. Annex A summarized the inputs that will determine the number of people who share toilets or practice open defecation. The estimate on productivity losses due to illness (see Annex Figure B1) will also be used to assign a monetary value to the time lost. Hence, all that remains here is a discussion of the assumptions for the time lost in accessing toilets.

A literature search found information on the location of toilets in PNG (see Annex Table B6). However, the data does not specify the time lost for accessing toilets. Hence, the decision adopted in this study is to use estimates from surveys conducted in ESI studies in Asia (Hutton et al., 2015). The level of detail presented in the ESI studies varies by country. In reports for the Cambodia, Indonesia and the Philippines for example, data was disaggregated by region, sex and age group. In contrast, reports for other countries provided less detail. In keeping with the intention of generating conservative estimates, this study used the values presented in Annex Table B7. The extent to which the assumptions may underestimate time loss impacts can be better appreciated by noting that the travel and waiting times used in the Philippines were at least 8 minutes and 18 minutes per trip for urban and rural areas, respectively (Rodriguez et al., 2011).

Annex Table B 6. Location of toilet facilities in PNG, % of households

Location	Rural	Urban	National
In own dwelling	46.4	10.2	14
In own yard/plot	45.1	74.2	71.1
Elsewhere	7.9	15	14.3
Missing	0.7	0.6	0.6
Total	100	100	100

Source: NSO and ICF (2019).

Annex Table B 7. Assumptions for estimating time loss impacts

Item	Rural	Urban
Time spent accessing toilets (minutes per round trip)		
0-14 years	4.0	4.0
15 years +	4.5	3.0
Number of trips per day		
0-14 years	2.0	1.0
15 years +	1.5	1.0

Notes: Travel times for rural and urban regions were borrowed from ESI studies in Indonesia (Winara et al., 2011) and Cambodia (Heng et al., 2012), respectively. Estimates for the number of trips were for Indonesia (Winara et al., 2011).

Annex C. Data and assumptions for the estimation of investment requirements

This annex describes the key inputs used in estimating the investment requirements. It begins by presenting the existing distribution of facilities and assumptions on the desired distribution in the target year. It then discusses the assumed unit costs and expected life of facilities.

Annex Table C1 presents the distribution of improved sanitation facilities as of 2020. Generated using information from the JMP (2021a) and DHS (NSO and ICF, 2019), it indicates that 18% and 58% of the population in rural and urban areas, respectively, had access to improved sanitation facilities. It also shows that the most common facility in urban areas, available to about 30% of its population, is a private flush toilet with access to sewerage facilities. In contrast, private pit latrines with slab (7%) are the most common facilities in rural areas.

The costing tool requires entries on the distribution of facilities as a proportion of total access to improved sanitation. This suggests taking the ratio of the access rates for each facility and the proportion of the population that have access to improved sanitation. Estimates are presented in the last two columns of Annex Table C1. In the case of urban areas, the values indicate that 51% (= 29.6 x 100 / 57.8) of the population that had improved sanitation own a flush toilet that has access to sewerage facilities.

Annex Table C 1. Distribution of improved sanitation facilities, 2020

Facility	% of population		% of the population that have access to improved sanitation	
	Rural	Urban	Rural	Urban
Private				
Flush toilet with access to sewerage: own	2.3	29.6	12.4	51.2
Flush toilet: no access to sewerage: own	3.2	8.6	17.7	14.9
Improved latrine (VIP and others): own	2.4	2.6	13.2	4.4
Pit latrine with slab: own	6.8	8.0	37.3	13.9
Shared				
Flush toilet with access to sewerage: shared	0.5	5.5	3.0	9.4
Flush toilet: no access to sewerage: shared	0.8	1.6	4.3	2.7
Improved latrine (VIP and others): shared	0.6	0.5	3.2	0.8
Pit latrine with slab: shared	1.6	1.5	9.0	2.6
Total	18.2	57.8	100	100

Source: JMP (2021a) and NSO and ICF (2019).

The costing tool also requires a detailed distribution of improved sanitation facilities in the target year. While aggregate targets exist for PNG, the study found no useable inputs for this data requirement.[38] Given this challenge, this study assumed that the shares of the specific facilities among the population that have access to improved sanitation in 2020 (last two columns of Annex Table C1) also apply in the target year (2030). The imposition of this assumption, given the aggregate targets for rural and urban areas, generates the distribution presented in Annex Table C2. This indicates, for example, that 44% of the urban population in the target year will have a flush toilet that has access to sewer facilities. This is higher than the 30% for 2020 that was mentioned earlier. In the case of rural areas, the assumption is that 26% of the population in 2030 will have access to private pit latrines with slab.

The estimation of the number of people who will have access to specific facilities requires combining information on the assumed access rates in Annex Table C2 and population growth. For the latter, the study assumed that the average annual growth of the rural and urban populations of PNG from 2011 to 2020, presented in Annex A, would remain the case from 2020 to the target year.

The study had difficulty in securing data on the unit costs of facilities and their expected lives. As a result, almost all of the basic information used here was obtained from the SDA report for PNG (DNPM et al., 2013). The only exception is the information on improved pit latrines provided by staff of UNICEF.[39]

Annex Table C 2. Distribution of improved sanitation facilities, target year

Facility	% of population			% of population with access to improved sanitation	
	Rural	Urban	National	Rural	Urban
Private					
Flush toilet with access to sewerage	8.7	43.5	13.4	12.4	51.2
Flush toilet: no access to sewerage	12.4	12.7	12.4	17.7	14.9
Improved latrine (VIP and others)	9.2	3.8	8.5	13.2	4.4
Pit latrine with slab	26.1	11.8	24.1	37.3	13.9
Shared					
Flush toilet with access to sewerage	2.1	8.0	2.9	3.0	9.4
Flush toilet: no access to sewerage	3.0	2.3	2.9	4.3	2.7
Improved latrine (VIP and others)	2.2	0.7	2.0	3.2	0.8
Pit latrine with slab	6.3	2.2	5.8	9.0	2.6
Total	70.0	85.0	72.1	100.0	100.0

Source: Author's assumptions.

38 A detailed distribution for the target year is actually available in the SDA document (DNPM et al., 2013). However, those targets are no longer relevant given the existing coverage statistics.

39 The unit cost provided by UNICEF staff was identical to the value assumed by Government of PNG et al. (undated) for VIP latrine that is combined with a low cost handwashing facility. Interested readers may also consult Hutton and Varughese (2016) for alternative unit costs of facilities for PNG.

Annex Table C3 lists the assumptions on unit costs and expected life of facilities. All costs are in per capita terms and expressed in 2020 prices. Costs per capita were generated by dividing the cost of facilities by the expected number of users. For private facilities, costs were divided by average household size. In the case of sewer facilities, which were drawn from the SDA report, construction costs were divided by the expected number of users. For shared facilities, per capita costs of private facilities were divided by 2.5. The basis for this assumption is a survey by the World Bank et al. (2014) in urban settlements of Port Moresby and Wewak that found that, among those who share facilities, about 2 to 3 families share a toilet.[40] All values were converted to 2020 prices using the CPI.

Expected life refers to the number of years before facilities require replacement. SDA assumptions in this case were based on consultations with experts. A similar approach was taken for the expected life of improved pit latrines that were drawn from UNICEF. This study also adopted the assumption in the SDA that shared facilities will have an expected life that is two-thirds as long as private facilities.

Annex Table C 3. Unit costs and expected life of facilities

Facility	Cost per capita (PGK/ year, 2020 prices)	Expected life (years)
Private		
Flush toilet with access to sewerage	4,021.8	25.0
Flush toilet: no access to sewerage	193.8	25.0
Improved latrine (VIP and others)	95.7	4.0
Pit latrine with slab	55.4	4.0
Shared		
Flush toilet with access to sewerage	1,608.7	16.7
Flush toilet: no access to sewerage	77.5	16.7
Improved latrine (VIP and others)	38.3	2.7
Pit latrine with slab	22.1	2.7

40 The reference cited that 2 to 3 families could mean 16 to 25 people sharing the one facility. It also recognized that there were instances in which up to 8 families (approximately 60 people) used a shared toilet.

Annex D. Detailed results of the impacts of sanitation

The table below provides detailed estimates on the impacts of sanitation. All outcomes are expressed in kina and valued at 2020 prices.

Location / Item	0-4 years	5-14 years	15 years +	All ages
Rural				
Health: Health care				
Diarrhoea mild	71,833,209	35,361,750	71,844,118	179,039,077
Diarrhoea severe	101,768,832	33,406,300	67,871,250	203,046,382
Malnutrition-related	2,147,207	nc	nc	2,147,207
Health: Productivity				
Diarrhoea mild	91,274,291	44,932,124	80,039,210	216,245,625
Diarrhoea severe	12,018,870	4,406,578	10,235,869	26,661,318
Malnutrition-related	717,100	nc	nc	717,100
Health: Premature death				
Diarrhoea mild	-	-	-	-
Diarrhoea severe	119,229,777	160,320,768	172,814,571	452,365,116
Malnutrition-related	1,078,008,835	nc	nc	1,078,008,835
Summary by disease				
Diarrhoea mild	163,107,500	80,293,874	151,883,328	395,284,702
Diarrhoea severe	233,017,479	198,133,646	250,921,691	682,072,816
Malnutrition-related	1,080,873,143	nc	nc	1,080,873,143
All diseases	1,476,998,122	278,427,520	402,805,019	2,158,230,660
Summary by impact type				
Health care	175,749,248	68,768,050	139,715,369	384,232,666
Productivity	104,010,261	49,338,702	90,275,079	243,624,042
Premature death	1,197,238,612	160,320,768	172,814,571	1,530,373,951
All impact types	1,476,998,122	278,427,520	402,805,019	2,158,230,660
Time loss				
Open defecation	2,278,880	4,656,129	15,963,432	22,898,441
Shared facilities	2,688,209	5,492,455	18,830,757	27,011,421
All components	4,967,089	10,148,584	34,794,189	49,909,862
Summary by type of loss				
Health related	1,476,998,122	278,427,520	402,805,019	2,158,230,660
Time loss	4,967,089	10,148,584	34,794,189	49,909,862

Location / Item	0-4 years	5-14 years	15 years +	All ages
All losses	1,481,965,210	288,576,104	437,599,208	2,208,140,523
Urban				
Health: Health care				
Diarrhoea mild	24,256,429	4,344,658	11,477,139	40,078,226
Diarrhoea severe	28,801,146	3,439,882	9,087,023	41,328,051
Malnutrition-related	312,996	nc	nc	312,996
Health: Productivity				
Diarrhoea mild	18,197,068	3,259,344	7,666,394	29,122,805
Diarrhoea severe	1,958,645	269,165	882,831	3,110,641
Malnutrition-related	58,779	nc	nc	58,779
Health: Premature death				
Diarrhoea mild	-	-	-	-
Diarrhoea severe	16,644,296	21,027,848	29,471,751	67,143,895
Malnutrition-related	150,488,397	nc	nc	150,488,397
Summary by disease				
Diarrhoea mild	42,453,497	7,604,002	19,143,532	69,201,031
Diarrhoea severe	47,404,086	24,736,896	39,441,604	111,582,586
Malnutrition-related	150,860,172	nc	nc	150,860,172
All diseases	240,717,756	32,340,897	58,585,137	331,643,790
Summary by impact type				
Health care	53,370,571	7,784,541	20,564,161	81,719,273
Productivity	20,214,492	3,528,509	8,549,224	32,292,225
Premature death	167,132,693	21,027,848	29,471,751	217,632,292
All impact types	240,717,756	32,340,897	58,585,137	331,643,790
Time loss				
Open defecation	35,878	68,339	270,792	375,008
Shared facilities	141,465	269,456	1,067,720	1,478,641
All components	177,342	337,795	1,338,512	1,853,650
Summary by type of loss				
Health related	240,717,756	32,340,897	58,585,137	331,643,790
Time loss	177,342	337,795	1,338,512	1,853,650
All losses	240,895,098	32,678,692	59,923,649	333,497,440
National				
Health: Health care				

Location / Item	0-4 years	5-14 years	15 years +	All ages
Diarrhoea mild	96,089,638	39,706,408	83,321,257	219,117,303
Diarrhoea severe	130,569,978	36,846,182	76,958,273	244,374,433
Malnutrition-related	2,460,204	nc	nc	2,460,204
Health: Productivity				
Diarrhoea mild	109,471,359	48,191,468	87,705,604	245,368,430
Diarrhoea severe	13,977,515	4,675,744	11,118,700	29,771,958
Malnutrition-related	775,879	nc	nc	775,879
Health: Premature death				
Diarrhoea mild	-	-	-	-
Diarrhoea severe	135,874,073	181,348,615	202,286,322	519,509,011
Malnutrition-related	1,228,497,232	nc	nc	1,228,497,232
Summary by disease				
Diarrhoea mild	205,560,997	87,897,876	171,026,861	464,485,733
Diarrhoea severe	280,421,566	222,870,541	290,363,295	793,655,402
Malnutrition-related	1,231,733,315	nc	nc	1,231,733,315
All diseases	1,717,715,877	310,768,417	461,390,156	2,489,874,450
Summary by impact type				
Health care	229,119,819	76,552,590	160,279,530	465,951,939
Productivity	124,224,753	52,867,211	98,824,304	275,916,268
Premature death	1,364,371,305	181,348,615	202,286,322	1,748,006,243
All impact types	1,717,715,877	310,768,417	461,390,156	2,489,874,450
Time loss				
Open defecation	2,314,758	4,724,468	16,234,224	23,273,450
Shared facilities	2,829,673	5,761,912	19,898,478	28,490,062
All components	5,144,431	10,486,379	36,132,702	51,763,512
Summary by type of loss				
Health related	1,717,715,877	310,768,417	461,390,156	2,489,874,450
Time loss	5,144,431	10,486,379	36,132,702	51,763,512
All losses	1,722,860,308	321,254,796	497,522,858	2,541,637,962

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