Global Lack of Access to Clean Water: Factors and Solutions

Abstract

Lack of access to clean water is a global issue affecting billions of people. Through a literature review, this paper explores the various factors that may explain the context of lack of access to clean water. This paper will hypothesize solutions to improve lack of access to clean water. Through a statistical analysis, the literature review will be tested and the findings discussed. The findings show that the most common factors for lack of access to clean water include poor economic standing and poor infrastructure. The findings explore the various consequences of the issue in terms of society, politics, and economy. The paper poses nuance of political issues in the context of lack of access to clean water. The findings conclude that a broad, systemic approach funneled through various governmental agencies will need to improve infrastructure for lack of access to clean water to be solved.

Introduction

Across the world, many people lack access to basic necessities like food, water, and shelter. Two billion people live out of reach of a clean water source (NPR, 2023). These people and their needs are often forgotten. In addition, over 2.4 billion people are exposed to contaminated water regularly (World Wildlife Fund, n.d.). Water containing dangerous pathogens is one of the leading causes of deadly illnesses such as cholera and other water-borne diseases. Furthermore, according to the World Health Organization (2022), around 2 billion people drink water from a source that is contaminated with fecal matter. The resulting diarrheal infections when paired with insufficient hygiene kill about 829, 000 people every year (WHO, 2022).

There are many factors which lead to the scarcity of clean water. Most people with a lack of access to clean water live in poor countries where governments cannot afford adequate infrastructure. Factors such as climate change and political instability also factor into the global water crisis (UNICEF, n.d.). From the combination of several of these factors, many populations are left behind without the basic necessity of drinking water for themselves and their families.

What is Water Scarcity?

For the purposes of this paper, water scarcity must be defined. The term water scarcity can imply many things. For example, it can describe an area with polluted water sources. It can also refer to an area with extreme drought and lack of accessible water. Moreover, White (2014) notes that water scarcity is hard to define since water infrastructure is not measured by one standard method. Damkjaer and Taylor agree water scarcity can be defined by several different metrics, and claim that it can also be defined holistically (2017). They elaborate on how there are differences in economic and physical water scarcities.

Physical water scarcity is when a location lacks clean water because of a drought or other dry conditions which limits the total volume of available water in that area. However, this paper will focus on economic water scarcity. Economic water scarcity is present if there is a sufficient amount of potable water but a lack of infrastructure to make it accessible to the population (Damkjaer & Taylor, 2017).

With economic water scarcity often comes a lack of access to clean water. Clean water is defined as being water unfit for drinking. A lack of access to clean water can either mean people are consciously drinking from a contaminated source or that they believe the water source they use is not contaminated, while in reality, it is. Both mean that people are not able to drink from a safe source of fresh water.

Where is Lack of Access to Clean Water Most Prevalent?

Lack of access to clean water is mostly related to economic water scarcity, in which infrastructural shortcomings are the biggest factor in the issue (Damkjaer and Taylor, 2017). Because of this broad factor, the two billion people who lack access to clean water around the world hail from many different countries (NPR, 2023).

Though climate change and political instability can play a part in limiting access to clean water, a lack of government spending and poor infrastructure are the main causes of limited access to clean water. As a result, poorer nations have the least access to clean water.

Sub-Saharan Africa is shown through many statistics to be in lack of drinking water because of socioeconomic factors (Abba, Ibrahim, Ntouda & Sikodf, 2013). In fact, only 30% percent of people have access to a safely managed drinking water source in Sub-Saharan Africa (Ritchie & Roser, 2019). In the article, a safely managed drinking water source is defined as a water source that is on-site, available when in demand, and safe from microbial threats.

Though Sub-Saharan Africa is the region most recognized in issues of lack of access to clean water, other impoverished regions in the world suffer from the same dilemma. Around 38% of people in Central and Southern Asia do not have access to a safely managed water source, and only 29% of people in this region have access to a basic water source—which is defined as an improved water source that can take up to 30 minutes round-trip to access (Ritchie & Roser, 2019). In Latin America and the Caribbean, 25% of people still do not have access to safely managed drinking water (Ritchie & Roser, 2019).

In conclusion, while there are people without access to clean water in almost every country, the overarching risk factor for an individual country's susceptibility is based on its economic status.

Water Pollution

The effects of lack of access to clean water are manifested through water-borne diseases. When people drink water from a contaminated source, they are exposed to pathogens which can lead to many illnesses including cholera, dysentery, and Hepatitis A (Ritchie, Roser, 2019). Combined, all deaths related to unsafe water sources killed 1.23 million people in 2019 (Ritchie, Roser 2019). In developing countries, contaminated water can spread pathogens like bacteria, viruses, and parasites to vulnerable populations, leading to deadly diseases (Abdullah, et. al., 2022).

Children are impacted heavily by water-borne illnesses. One in nine children under the age of five dies from diarrhea, and 88% of diarrheal infections stem from contaminated water (Ly 2022). In fact, the third-leading cause of death in children under the age of five is diarrheal infections (Water.org, n.d.)

The major factor leading to water contamination with harmful pathogens is poor sanitation. In 2020, only half of the world's population had access to a safely managed sanitation facility and over 6% of the world practiced open defecation (Ritchie & Roser, 2019). Twenty-two percent of people did not have access to a basic sanitation facility in 2020 , defined as a private facility that prevents human contact with waste (Ritchie, Roser, 2019 B). This means around 1.7 billion people had to share their daily sanitation facilities with people from other households– this level of contact makes the spread of pathogens easier.

The pollution that contaminates drinking water and limits access to clean water stems from a lack of access to sanitation facilities, and when waste is not treated properly, it contaminates drinking water sources and can lead to mortality.

Statistical Methodology Introduction

This paper will explore possible causation factors for lack of access to clean water as well as possible solutions to increase access to clean water. Statistical analysis will be used to test correlation between proposed factors and regions with high prevalence of lack of access to clean water. Statistical analysis will be used to test correlation between proposed solutions and regions which have increased access to clean water. Data will be collected from the World Bank Open Data Sets, MacroTrends, and the Global Economy.com. Factors and solutions will be tested for correlation.

Literary Review

Global Water Scarcity: Its causes, Its Effects, and What it Needs in the Future

Consequences

The global lack of access to clean water affects two billion around the world (NPR 2023), but beyond just concerns of water-borne diseases there are other serious implications. The impacts of lack of access to clean water are high on the economy, gender roles, and educational opportunities.

Alvi and Nawaz found that lack of access to clean water has a negative impact on the productivity of a country (p. 81, 2017). In their research, Alvi and Nawaz (2017) ran an experiment to test indications on whether malnutrition and lack of access to clean water affected a country's Total Factor Productivity, an indicator of a country's economic productivity. They found that lack of access to clean water and malnutrition both negatively impact Total Factor Productivity–lack of access to clean water impacted it more– because these two situations lower the human capital of a country, which can hurt its capacity in its labor force and subsequently the money the country can make. As a result, this means many people in countries where lack of access to clean water is prevalent may be trapped in their situation because their country lacks the sufficient resources to improve.

Another aspect of lack of access to clean water is the division of gender roles it brings. In many regions around the world, including Sub-Saharan Africa, women are expected to acquire clean water for their households, but they often have to walk far and for long hours, facing threats of harassment, sexual assault, and infection from contaminated water (Assefa et. al, 2021). This paints the reality that lack of access to clean water creates social problems. It creates an inequality between men and women and disadvantages the latter. The roles women are forced into can limit their access to education, proper hygiene and sanitation resources, and economic freedom (Assefa et. al. 2021). Even though they are the primary water collectors and bear most of the risks associated, Sub-Saharan African women are still largely excluded by men from water management decisions (Assefa et. al. 2021). Moving forward, increasing access to clean water in regions like Sub-Saharan Africa can limit the struggles women face. Increased water access can prevent thousands of assaults, illnesses, injuries, and more.

Lack of access to clean water also affects education. According to Choudhuri and Desai (2021), educational metrics for young children in rural India are lower for households where water is collected from free sources outside the housing unit. When mothers spend more time collecting water and fuel for their households in unpaid labor, the children are most affected, especially young boys– receiving less time from their mothers, their educational outcomes are impacted negatively (Choudhuri and Desai, 2021). This means the secondary repercussions of women's role in the clean water crisis affects the younger generations, and if such processes continue, the cycle may repeat.

Children also face hardships in attending school due to disease; over 75% of student absenteeism is related to illness (Adhikari & Shankar 2022). Increasing access to clean water and reducing the impact of water-borne illnesses can decrease student absenteeism. In fact, according to O'Reilly (et. al, 2008), in a study from Western Kenya it was found that providing clean water, hygiene education, and handwashing facilities led to a 35% decrease in student

absenteeism (Adhikari & Shankar 2022). Absenteeism in students is a concerning symptom of lack of access to clean water. If students do not participate in school and miss out on their education, it can keep them trapped in poverty.

Children, especially girls, also struggle with attending school because of the time they are forced to spend acquiring water for their families (Dhital et. al 2021). According to their research, Dhital et. al found that completion rates of primary and lower-secondary school for girls in Nepal is around 15% lower than for boys, even though enrollment rates are similar (2021). Especially in hilly areas where accessing water is difficult, this means that girls often miss time in school because of domestic chores such as water fetching. Much of this is true around the developing world, where young girls who work in these chores continue as they get older and eventually remain trapped in these roles, not progressing in their education and repeating the cycle with their children. This is concerning because it means if access to clean water is not increased in places like the hilly parts of Nepal, improvements in education will not be met.

Factors

There are two main factors which lead to lack of access of clean water: lack of infrastructure and population stress. In most countries suffering from economic water scarcity (Damkjaer and Taylor, 2017) the current infrastructural systems are not able to produce clean drinking water for the population. In many places, there is enough rainfall to provide an adequate amount of freshwater for drinking, but not enough infrastructure to make the water clean. Such infrastructure is often stressed through population burdens. Over the past 50 years, the global population has increased by billions, and water sources have become pushed to the limits in underdeveloped countries to the point where many people now drink unsafe water.

Something to look at is how water becomes contaminated in the first place; this prompts discussion of sanitation. Over 2.4 billion people in the world lack access to sanitation, and as populations rise, pollution will only become worse (Rosa, Boretti, 2019). Lack of sanitation facilities is a large part of the infrastructural problem and is the source of the contamination of drinking water; if sanitation is improved, more people will be drinking safe water as less pathogens are spread into water sources.

Beard et al., (2022) noted that research and information regarding sanitation can be unreliable and does not paint the whole story; classifications of whether or not a facility is improved or unimproved are often incorrect and are not helpful for decisions regarding waste and sanitation from local governments. Urban areas throughout the developing world struggle with sanitation, and in many cities existing sewer systems do not connect to all residents, are not regulated by public health officials, and are not emptied properly, leading to the spread of fecal matter into surface water (Beard et. al 2022).

Especially in cities, dense populations when paired with insufficient sanitation methods mean that water sources will get contaminated. For example, in their research, Beard et. al. found that in Mumbai, a city with a population density of over 27,000 people per square mile and a population of around 12 million, around 10% of people openly defecate, equating to roughly 1.2 million people openly defecating on a regular basis in Mumbai. With such a high level of exposure of pathogens to the ground water, disease can spread easily. As urbanization expands to developing countries in the future, this means current problems will be exacerbated unless

the root of the sanitation crisis is solved. Improving current infrastructure will only become harder with a higher population.

The reasons for which infrastructure in underdeveloped countries are inadequate are mostly tied into the financial ability of local governments and local population densities. Poor governments cannot afford to pay for infrastructure systems, especially large-scale ones connecting to residents in all parts of cities–including informal settlements. In rural areas, governments largely cannot afford to pay for infrastructural systems, including water infrastructure. Even when built, systems may not be updated or managed well, leading to deteriorating quality. Additionally, dense populations can overload the capacities of existing infrastructure to a point where they become ineffective. Ineffective infrastructure is something that can arise in all countries; as systems become less taken care of and overworked, they will not be efficient and will become inadequate.

In underdeveloped countries, poor water infrastructure is becoming more and more normal, as implementing large-scale water facilities will take a long time, while meanwhile the population is growing and increasing pressure on existing infrastructure. Something to consider is corruption; in many developing countries, governmental corruption results in money that could be spent in public infrastructure–including drinking water facilities and services–being extracted by governmental officials (Breen & Gillanders, 2021). For example, in 1995, Thailand's government approved a wastewater management plant for the greater Bangkok region, but the project remained incomplete after the discovery of governmental corruption aimed at increasing the cost of the land up to ten times the original amount (Breen & Gillanders, 2021). Corruption cases like these illustrate how even when governments in developing countries manage to afford water infrastructure projects, the benefits do not reach the general population.

Overall, factors such as poor water infrastructure, lack of sanitation facilities, and population strain all contribute to the global lack of access to clean water; these factors are all intertwined by their prevalence in poor nations.

Politics

The global political landscape is shifting to increasingly reflect the climate situation facing the world. Countries are increasingly working together for sustainable development, and much of this work has been to increase access to clean water. Many countries have collaborated for climate resilient development, which has proven to be less successful when not politicized (Grashow, Calow, Casey, et. al, 2021). Unified efforts in development can lead to improvements in water infrastructure and may bring closer the achievement of the United Nations Sustainable Development Goal (SDG) 6, aimed to bring universal clean water and sanitation access to all by 2030 (Grashow, Calow, Casey, et. al 2021.)

The United Nations SDGs were set in 2015 after being adopted by all UN members. They are composed of 17 main goals focused on human development, environmental sustainability, and other areas of human improvement. The adoption of these goals displays the nature of modern politics when it comes to humanitarian crises. SDG 6 concerns an issue disproportionately affecting poor nations, but is something all 193 nations in the United Nations have vowed to help solve. International cooperation for sustainable development is a key part of new–age global politics and an important part of the solution to increase access to clean water.

However, much of the support expressed on the global stage does not enact change. According to an assessment based on a meta-analysis conducted by Beisheim (et. al, 2022), there is no strong evidence to support that the UN SDGs have led to differences in policies and actions from member nations to fulfill the goals; observed changes that have led to fulfilling these goals were often found to not be strongly correlated with the adoption of the SDGs but rather coming into place before the goals were made.

This being said international collaboration leads to optimism about issues such as the global lack of access to clean water. Such collaboration also takes place through the role of non-governmental organizations (NGOs). NGOs are crucial in helping to translate the SDGs into local governmental policies; NGOs in this stance can be both international and local (Demailly & Hege 2018). NGO involvement across countries may vary, but they mostly work with governments to bring about development (Demailly & Hege 2018). However, some NGOs work to take action themselves–hundreds of NGOs around the world are directly contributing to SDG 6 to fight for clean water access and sanitation rights–, and these are known as operational NGOs (Abiddin, et. al). Direct action is a positive thing that can lead to efficiency, but it is not reasonable for all NGOs, especially as many may lack the funds or capabilities to take charge without the help of governments (Abiddin et. al. 2022). However, many NGOs are still able to make a meaningful impact by themselves.

Many non-profits and external organizations are involved in the water crisis, especially in African countries. Many NGOs and charities fund infrastructure projects as well as direct aid through service (Cochrane et. al, 2019). In fact, according to a survey from Afrobarometer, over 50% of Africans believe local governments are doing a poor job of managing access to clean water and Sanitation (Han, Howard, 2020). Additionally, 20% of Africans attempting to get utility services from the government said they had to bribe officials, surveying reported (Han, Howard, 2020). In such instances, local governments are not the best option for the general improvement of infrastructure, and non-governmental organizations can take over as the chief drivers of progress. However, though non-governmental organizations contribute to saving many lives, they do not always have the same ability to help as local governments because they are often funded by foreign countries or by investors which are not present in the countries which they are aiding, leading to a contrast in what is thought to be needed in aid and what is needed (Smock, 1996).

Overall, it is not the responsibility of non-governmental organizations to help people in other countries; the problem ultimately needs to be addressed by local governments who should not rely on external aid any more than they have to. Around the world, lack of access to clean water in underdeveloped countries is mainly seen as a national issue, especially when examined by human rights organizations and the global perspective (Abraham, et. al, 2020). In fact, most metrics and statistics regarding lack of access to clean water are made by country rather than locality. Additionally, the responsibility to fulfill the UN Sustainable Development Goals for 2023 lies with national governments (Brimont & Hege, 2018). Because of this, it can be said that the local needs of a country and its clean water access is first a priority of its national government; the country has a duty to its citizens to grant them their universal human rights, but they can use the help of local governments to distribute their help as well as better understand the situation.

But for progress to be made, focus in increasing access to clean water should be shifted towards local governments and their role in increasing access to clean water (Abraham, et. al. 2020). Nation-wide or even district-wide infrastructural solutions take time to implement, as opposed to smaller-scale local solutions which are more efficient. Municipalities can understand and take care of the needs of citizens better than large-scale governments (Reddy 2016). However, city governments often lack the funds and the power to implement useful sanitation and drinking water systems (Brown et. al. 2020). Even though city governments have a closer perspective on local clean water access, their lack of money means that national governments should also have a role in solving the clean water crisis. With a larger tax base and more authority, national governments are key in underpriviledged countries.

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The politics of clean water access are not only relevant through the lens of what types of government provide aid but rather through conflicts. As clean water becomes less scarce, conflicts over international water sources as well as conflicts between rural and urban areas over accessibility to clean water sources are growing more and more common.

Equal sharing of water resources becomes difficult between countries sharing water resources along their boundaries (Alexandrova & Dhaliwal, 2010). Though more closely related to physical water scarcity (Damkjaer & Taylor, 2017), water conflicts are still a concerning symptom of lack of access to clean water. In many hot war zones in underdeveloped countries, water becomes an unnecessary wrinkle that only leads to more violence and bloodshed (Alexnadrova & Dhaliwal, 2010). This means that countries where people are already struggling with a lack of access to clean water may have to worry about conflicts in their region, only making their situation worse.

Logistical Challenges and Possible Solutions

The question of how to solve lack of access to clean water is nuanced. There are many factors which must be considered, but to answer it is necessary to go back to the causes. As stated, the main factors discussed leading to lack of access to clean water included population strain and inadequate infrastructure for both drinking water and sanitation. Addressing population strain ties back into improving infrastructural capabilities, as the only way to solve population strain is to increase total infrastructural capacity to include more people. Therefore, solutions would mostly be composed of increasing access to sanitation and improving infrastructure that brings people clean water. How to do this is where the path becomes less clear.

Improving infrastructure means the investment of money into public facilities. Implementing infrastructure requires the power of national governments, which have the financial capabilities that local governments do not (Brown et. al. 2020). However, the assessments of requirements by local governments give better insights into how to implement change (Reddy 2016). Both governments need to work together to improve infrastructure. This needs to be through both policy and investment at higher levels and implementation on lower levels.

Improving infrastructure means increasing both sanitation and drinking water facilities. An example of a successful improvement in sanitation was implemented by the government of India; from 2014-2019, over 100 million toilets across India were built, and the percentage of rural people who had access to toilets went from 40% to nearly 100% in this time (Bharat & Sarkar, 2021). India's aggressive policy towards achieving SDGs can also be seen with the *Jal Jeewan* Mission, which aims to grant universal clean water access within India (Bharat & Sarkar 2021). Attention to both of these issues, especially sanitation, helped to solve the other one and lead to change much faster; in the same way, SDGs are linked and solving one may help solve another. In the case of India, facilities were improved by the national government. In fact, the public sector is the driving force in most infrastructural development in poor countries (Gurara et. al, 2018). However, many governments face limitations preventing them from improving their own infrastructure capabilities.

Limitations to improving infrastructure include governmental corruption and low financial capabilities. Corruption is identified as a large challenge to solving the UN SDGs, and it is acknowledged as hard to measure because of its hidden nature (Mugellini & Villeneuve 2019). Corruption, especially in developing countries, can hold back development because it often results in money that could be spent on infrastructure being abused by officials in power. For example, in a case study of Nigeria, Idris and Salisu found that corruption was found to be negatively correlated with infrastructural development (2016). Corruption poses a strong limitation to how much infrastructure can truly progress. Corruption often includes bribes, but most corruption which affects development is tied to corrupt officials allocating funds to improper places. Corruption around the developing world can have adverse impacts on how much infrastructure can improve, which in turn perpetuates lack of access to clean water.

Because of the limitations with governments with their financial capacity and corruption, NGOs pose as viable solutions for clean water access. Their access to resources and money has a promising future that can save millions of lives.

Linking Global Water Scarcity with Statistics

Methodology

Based on the causes and solutions discussed, several factors were tested for correlation to determine the accuracy at which they can predict a country's lack of access to water situation. The factors in question are GNI per capita, sanitation access, female education, foreign aid received, and government expenditures.

For the data collection, the top and bottom 20 countries in terms of clean water access– based on the data from Macrotrends.net– with available data were used. The countries used do not all fit in the top or bottom 20 of the list; for certain variables, countries within these ranges lacked sufficient data. As such, countries directly outside the top and bottom 20 that had the sufficient data were selected. For the foreign aid received variable, only the bottom 40 countries in terms of clean water access were considered. The government expenditure variable lacked relevant data for many countries, resulting in 10 out of the top 20 countries being used and 10 of the bottom countries used.

All data was collected from the World Bank Open Data, Macrotrends.net, and Global Economy.com. The data was inputted into Google Sheets and checked for correlation with the control variable of clean water access by country. The R-Value for each variable was calculated using Google Sheets functions. The R-value for each variable will be interpreted in the discussions section.

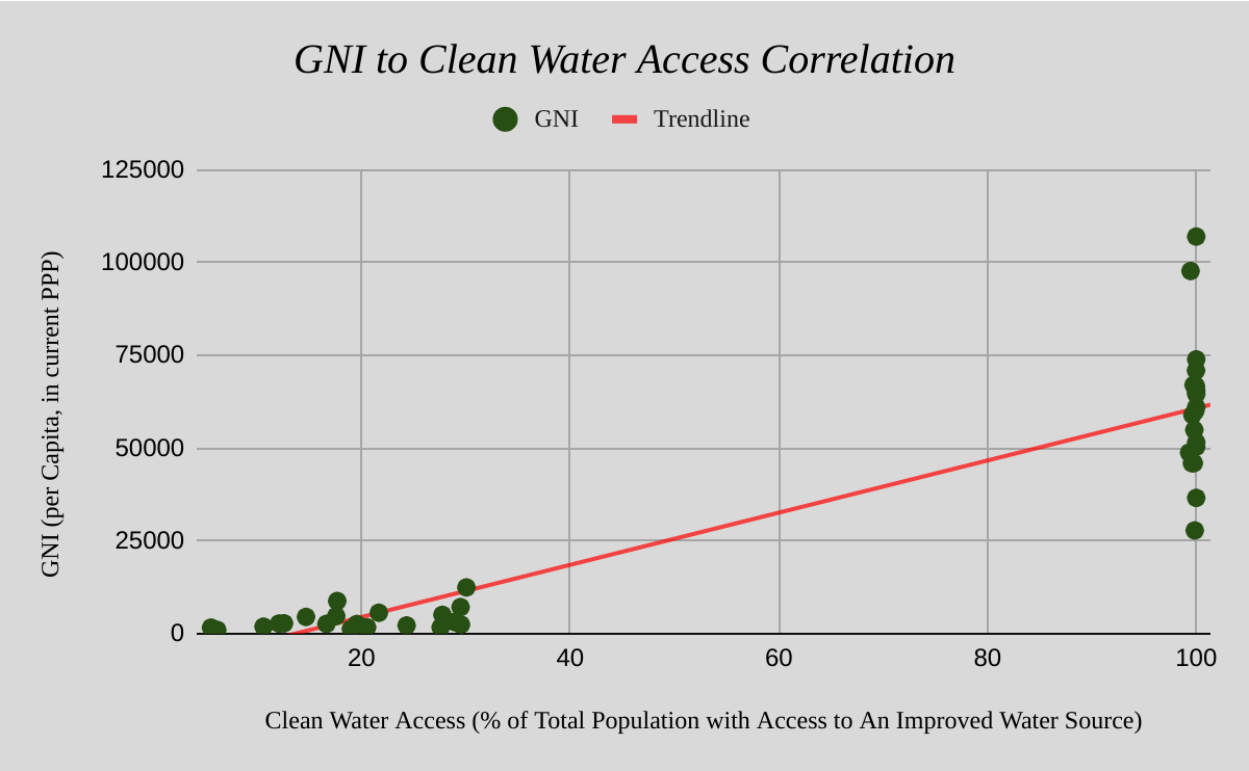
Factors/Variables Used

- % of Population with Access to an Improved Water Source, which was defined as a chemically safe source that is available on site through tap or other reliable collection method (Macrotrends.net) This variable was the constant in all correlation trials.
- GNI per capita, PPP (current international $)
- People using at least basic sanitation services (% of population)
- Persistence to last grade of primary, female (% of cohort)
- Net ODA received per capita (current US$)
- Government Expenditure, percent of GDP

Results

Correlation Between GNI per Capita (PPP) and Clean Water Access (% of total Population)

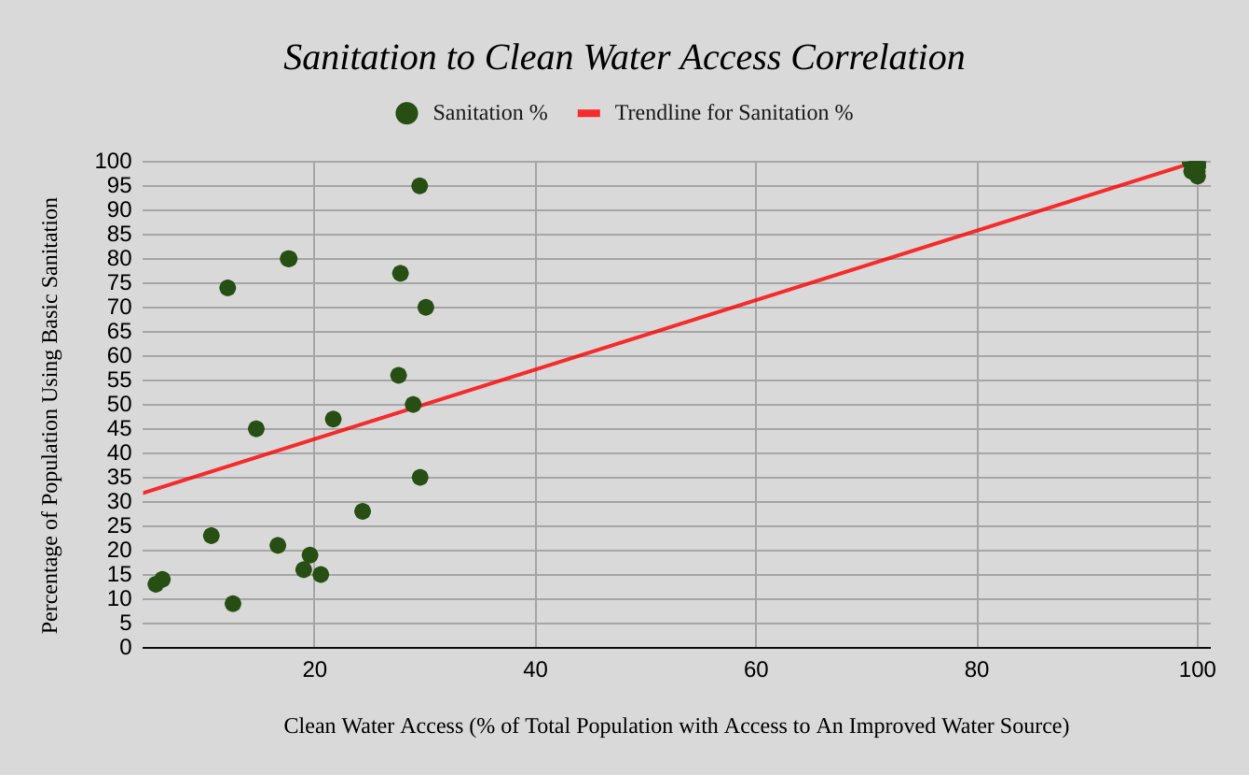
r=0.9084



The correlation between GNI Per Capita and Access to Clean Water was 0.9084, meaning that there is a strong positive correlation between the two factors. GNI Per Capita is a commonly used metric to determine the economic state of a country. A country with higher GNI is considered to be more developed, and vice versa. Therefore, the positive correlation indicates that more developed countries are likely to have higher rates of access to clean water. GNI per capita can be viewed as a major factor in how able countries are to manage their water infrastructure. As previously discussed, weaker infrastructure is a factor that can lead to lack of clean water access. Therefore, countries with lower GNI per capita–thus less developed– are more likely to face problems with clean water access.

Correlation Between Sanitation Access (% of population with access to basic facilities) and Clean Water Access (% of total Population)

r=0.8537

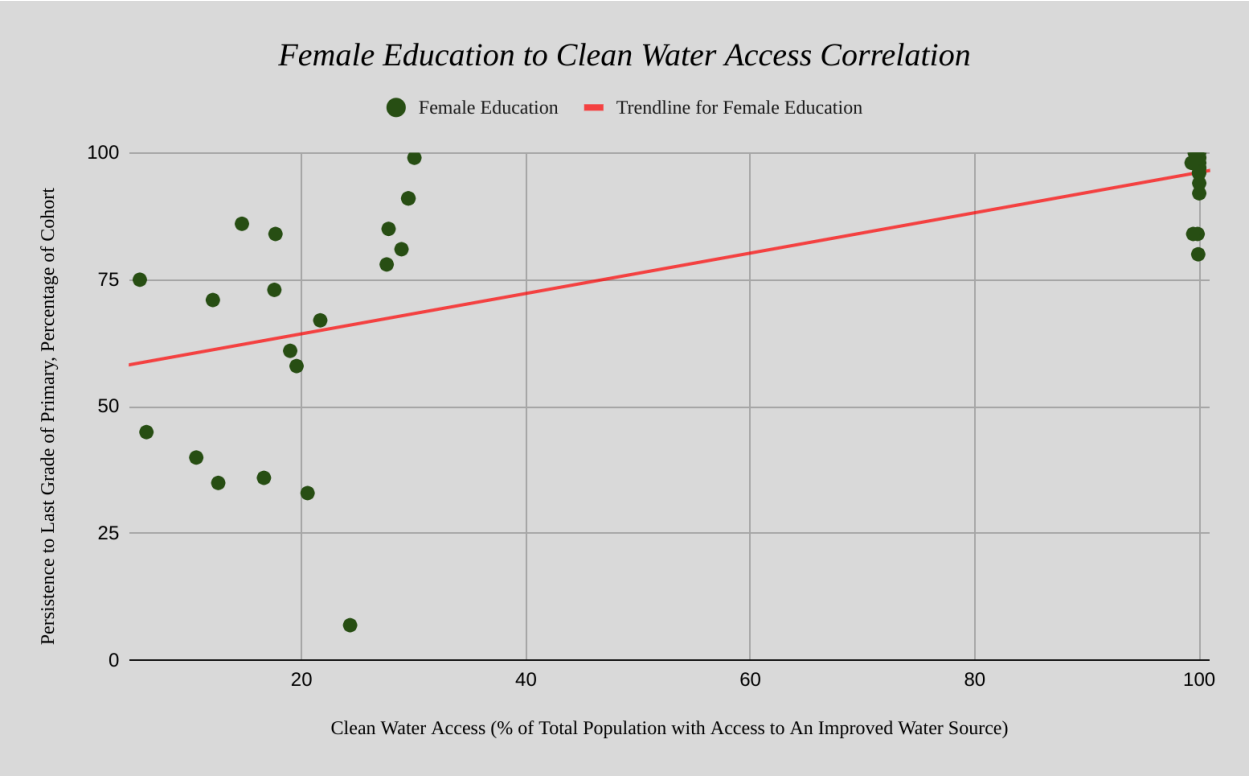


The correlation between clean water access and sanitation access was found to be 0.8537. This means that there is a strong positive correlation between the access to basic sanitation in a country and clean water access. Countries with high rates of basic sanitation usage have higher rates of clean water access. The opposite is also true. These results show the importance of sanitation as a factor for clean water access. Lack of sanitation around the world is a major causation factor of lack of access to clean water because improper sanitation leads to water sources being contaminated. In fact, 2.4 billion people live without sanitation and 90% of sewage is not treated at all in underdeveloped countries (Rosa, Boretti, 2019). With a high proportion of biological contaminants released into local water sources, there is already a higher risk of people drinking contaminated water. Additionally, when combined with inadequate water filtration infrastructure this means that the water will not be cleaned properly and there will be more risk.

Correlation Between Persistence to last Grade of Primary, Female, and Clean Water Access (% of Total Population)

r=0.687

This correlation coefficient indicates that there is a moderately strong positive correlation between the two variables.



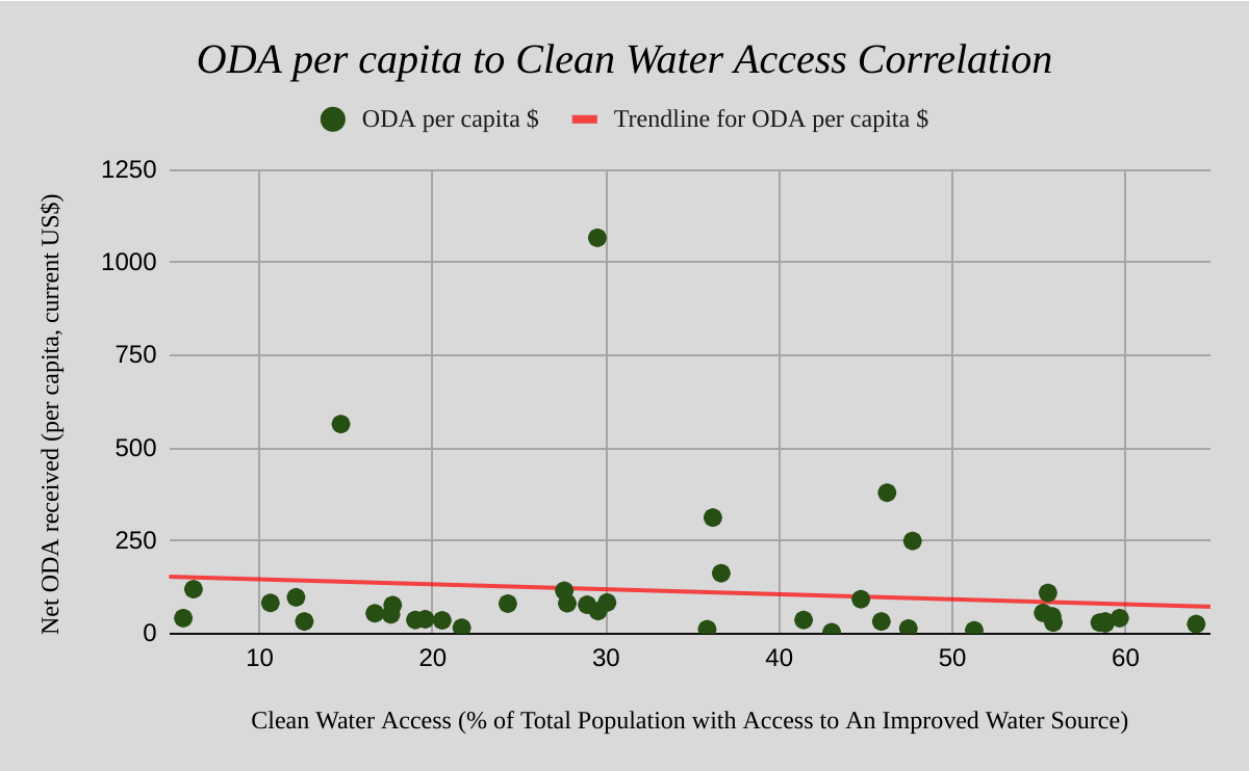
The correlation between Persistence to Last Grade of Primary (% of Cohort), Female and clean water access was found to be 0.687. This means that there is a moderate positive correlation between the two variables. As one variable increases, the other one will gradually increase over time as well. Thus, the higher the rate at which females finish primary, the higher the rates of clean water access in that country.

This specific variable was chosen because it gives insight into the idea that females spend more time in underdeveloped countries on household chores such as water-fetching than men (Assefa et. al, 2021). underdeveloped countries, often because of increased duties in the household and with water-fetching. It also gives insight into the idea that females may drop out of school because of increasing duties as they age. The findings show that a moderately positive correlation does exist between the two variables. Though not a causation factor as discussed, the gender disparity of clean water access can be a result of a country having low rates of clean water access. Thus, the findings solidify the idea that females may have increased household chores as they get older.

Correlation Between Net ODA Received Per Capita and Clean Water Access (% of Total Population)

r=-0.1232

This correlation coefficient indicates that there is little correlation between the two variables, but that it is slightly negative.



The correlation between the Net ODA received per capita and clean water access is -0.123. This means that the two variables are weakly negatively correlated. There is no statistically significant trend in the data that can be analyzed or used for inference.

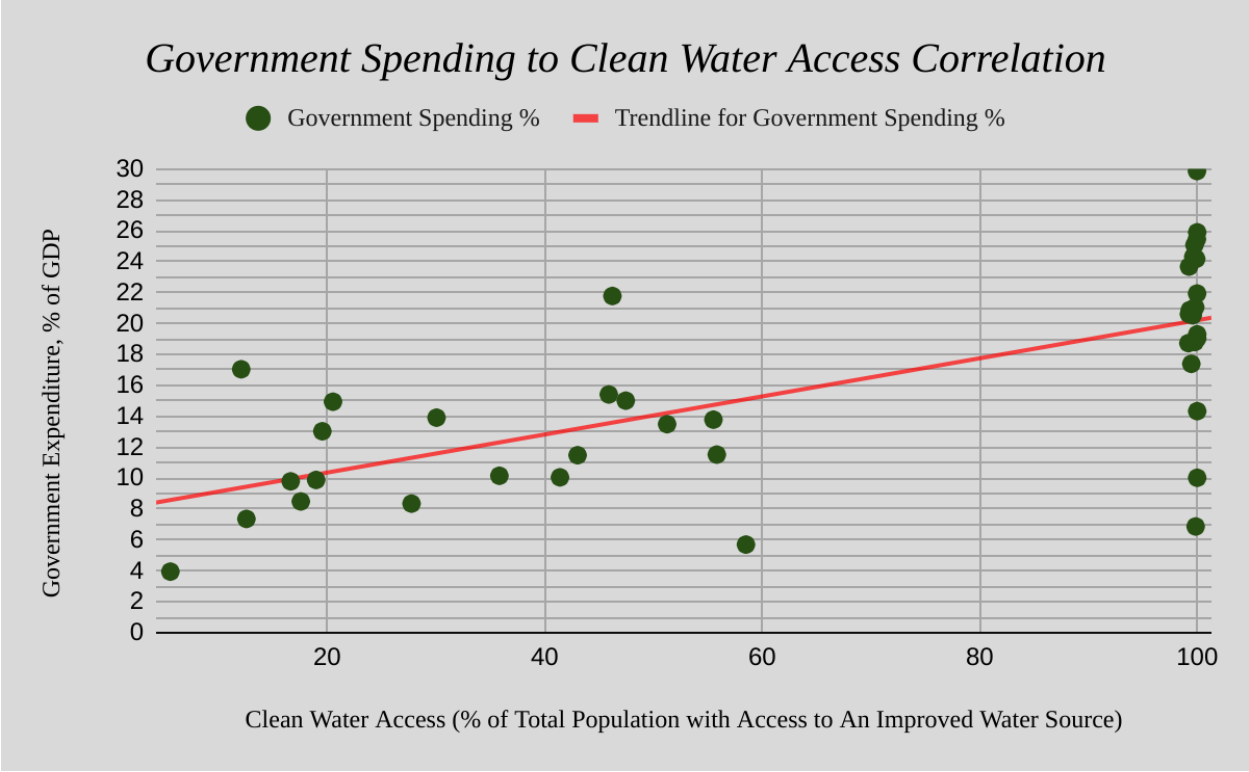
Mahembe and Ohdiambo (et. al, 2021) agree that aid must be channeled properly into a country for it to be effective, and the amount given plays a significant role. However, it would seem intuitive that more aid received would lead to a higher access of clean water. The counter to this may be that countries within the bottom 40 surveyed that were on the higher end received less aid because they were in less of a need. This could explain why the correlation was slightly negative. However, for the most part the data show that there is no valuable trend that can be extracted, meaning aid may be given arbitrarily or for other circumstances– ODA does not only factor in clean water access issues.

Overall, the results show that increased foreign aid does not directly increase clean water access for a country as compared to other undeveloped countries. This means that there must be other solutions on a global scale that could replace or enhance foreign aid.

Correlation Between Government Expenditures (% of GDP) and Clean Water Access (% of Population)

r=0.6808

This correlation coefficient indicates that there is a moderately strong positive correlation between the two variables.



Discussion

The implications of the correlation findings for GNI per Capita are that the global clean water crisis is an issue concerning the developing world. The findings confirm that the economy of a country is a major factor in relation to clean water access.

In terms of solutions, this can mean that developing the economy of a country may help with its clean water crisis. If a country's GNI per capita is higher, there will be a less chance–based on the findings– that there is a high prevalence of lack of access to clean water. The same could also be true for the opposite, as Alvi and Nawaz (2017) found that low access to clean water can negatively impact the productivity of a country. Improving clean water access can increase its productivity therefore, and based on the findings increasing a country's economy could also have the same effect on clean water access. Both metrics can help increase each other, leading to a continual growth period if solutions are created for either variable.

The findings fit with the general consensus of where clean water access is a prevalent issue. Ritchie and Roser (2021) state that death rates from unsafe water are much higher in lesser developed countries. Abba and Ibrahim (2012) state that a baby born in Sub-Saharan Africa is at over 500 times the risk of a baby from Europe dying from a diarrheal infection, one of the major impacts of the lack of access to clean water. The findings solidify these beliefs and show that to solve clean water access, the focus must be shifted to helping lesser developed countries. However, there are discrepancies on how to help lesser developed countries. Many countries receive foreign aid or aid from international non-governmental organizations under the guise of the Sustainable Development Goals (Beisheim et. al, 2022). The effectiveness of such aid varies in terms of how much money is actually given, and how much trickles down to the root of the issue–foreign aid is often ineffective and improperly used. (Anetor et. al, 2020)

Based on correlation alone, sanitation cannot be concluded as a direct cause of lack of access to clean water. However, based on previous discussions and the findings of this research, it can be implied that, as improper sanitation can contaminate clean water sources, lack of sanitation can be considered a causation of lack of access to clean water.

Therefore, possible solutions to the lack of access to clean water can include improving sanitation. Increased sanitation infrastructure and improved cultural attitudes to sanitation across less developed countries can help to decrease the lack of access to clean water. With fewer points of contamination into water sources, there will be a lesser risk for people to come into contact with contaminated water.

There are social and political implications from the findings of female education to clean water correlation. If females do have lower rates of primary completion in countries with low rates of access to clean water, this means that a lack of clean water access may be directly impacting their educational opportunities.

A gender-based disadvantage such as this, which is found across many countries, is something that may prompt concerns and increased focus to solving clean water access. If enough people consider this consequence of clean water access and it becomes recognized internationally, the issue could be classified under other Sustainable Development Goals and their solutions, which could lead to increased support and financial aid on the global stage (Beisheim et. al 2022). In turn, increasing female education completion may lead to higher rates

of growth in the economy and also more education about sanitation and how to access clean water (Chowdury et. al, 2023). Increasing female education has the possibility to be part of the clean water access solution, and these solutions in turn can further help to increase female education.

The correlation between the net ODA received and clean water access signifies that more foreign aid does not always lead to improved facilities for a population. ODA is defined as governmental money put towards developing countries for them to improve their situation. The findings show that there is very little statistical difference between countries of different levels of ODA in terms of clean water access. This means that increased aid doesn't directly solve lack of access to clean water; however, this number may be evened out because of how ODA is provided. It makes sense that ODA would be given to countries in need of clean water access improvements, so these countries could be helped until they were sufficiently equipped in their infrastructure. Then, the ODA would go to the next needy country. In a cycle like this, each country's ODA received will balance out and explain the results found above.

Overall, the results mean that foreign aid may not be the best method to solve global lack of access to clean water, or that current methods of channeling aid are ineffective.

The findings of the correlation between Government Expenditure and clean water access highlight the importance of solving infrastructural problems. Based on the data alone, it cannot be concluded that increased expenditures lead to higher clean water access rates. However, based on previous discussion, infrastructural shortcomings were identified as a factor for lack of access to clean water.

Improving infrastructure was also identified as the main way to solve lack of access to clean water. Though government expenditures and improvements in infrastructure are not the same, governments that expend more of their GDP are more likely to put money towards public infrastructure. Governments that spend lesser shares of their GDP may hold onto money more and prevent it from reaching public projects. Therefore, it can be concluded that if a government spends more money, there is a higher chance it can solve its lack of access to clean water issues. This establishes the previous idea that improving infrastructure is the main way to solve the lack of access to clean water.

Since improving infrastructure can be said to be the main solution to the lack of access to clean water, the focus on a global scale should be shifted there. If countries have better infrastructure as a whole and specifically for water, it will positively impact their population in terms of lack of access to clean water.

Conclusion

This paper has explored the global lack of access to clean water, an issue defined as affecting two billion people. The context of lack of access to clean water, governmental roles in clean water, and where it has the greatest impact were detailed.

Clean water access was explained in-depth through a literature review, where its unique consequences were introduced. It was made known that clean water access is something that affects people not only through water-borne diseases which kill nearly a million people per year but also more long-lasting impacts. Lack of access to clean water was found to harm a country's economic productivity and is correlated to GNI per capita, meaning that a poor clean water access percentage in a country can predict the same for GNI per capita in said country. Lack of access to clean water was found to harm educational outcomes– women who spent time fetching water were doing so during school time, which meant they completed schooling at lower rates. Male children who spent less time with their mothers if they were primary water fetchers also struggled with their educational outcomes.

As confirmed by the findings, there is a moderately positive correlation between both variables. This means that lack of access to clean water may be considered a social problem recognizable by the UN SDG 4, which aims to provide education for all children.

The meta-analysis hypothesized that the greatest factors for lack of access to clean water were lack of infrastructure, population burden, and improper sanitation. All three factors were considered to increase a country's population that lacked clean water. The results of the study also prove that GNI per capita and sanitation access are strongly correlated with clean water access, confirming the hypothesis provided in the literature review. This establishes the idea that to solve lack of access to clean water, improving sanitation and infrastructure are the most important methods. To do so, it will require the usage of NGOs, national governments, and local governments. All three bring forward unique perspectives and varying levels of ability, but all three are important for improving clean water access. If the proper amount of financial and political aid is given and distributed fairly, then the lack of access to clean water can improve.

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Appendix 1

Clean Water Access by Country

Country Name	2020
Liechtenstein	100.00%
Gibraltar	100.00%
Hong Kong	100.00%
Iceland	100.00%
New Zealand	100.00%
Kuwait	100.00%
Singapore	100.00%
Malta	100.00%
Greece	100.00%
San Marino	100.00%
Monaco	100.00%
Germany	99.99%
Macao	99.98%
Netherlands	99.97%
Belgium	99.91%
Puerto Rico	99.86%
United Kingdom	99.82%
Cyprus	99.77%
Sweden	99.75%
Finland	99.64%
Spain	99.59%
Luxembourg	99.46%

Guam	99.44%
Israel	99.32%
France	99.25%
Slovak Republic	99.24%
South Korea	99.19%
Canada	99.04%
Bahrain	98.98%
Austria	98.90%
Chile	98.77%
Norway	98.64%
Japan	98.57%
American Samoa	98.36%
Poland	98.33%
Slovenia	98.27%
Virgin Islands (U.S.)	97.94%
Czech Republic	97.88%
Bulgaria	97.62%
Ireland	97.33%
United States	97.33%
Isle Of Man	97.21%
Greenland	96.74%
Denmark	96.73%
St. Martin (French Part)	96.70%

New Caledonia	96.64%
Latvia	96.29%
Qatar	96.18%
Italy	95.82%
Estonia	95.76%
Portugal	95.35%
Lithuania	94.92%
Turkmenistan	94.83%
Belarus	94.61%
Switzerland	94.25%
Iran	93.98%
Malaysia	93.82%
Hungary	92.59%
Palau	91.31%
Andorra	90.64%
Oman	90.56%
Northern Mariana Islands	90.53%
Kazakhstan	89.33%
Ukraine	89.02%
Bosnia	88.87%
Azerbaijan	88.32%
Armenia	86.91%
Brazil	85.77%
Jordan	85.70%
Montenegro	85.07%
French Polynesia	83.86%

Romania	81.99%
Costa Rica	80.52%
Morocco	79.95%
West Bank And Gaza	79.70%
Tunisia	79.29%
North Macedonia	76.83%
Russia	76.10%
Serbia	75.04%
Moldova	74.07%
Colombia	73.01%
Algeria	72.38%
Albania	70.67%
Kyrgyz Republic	70.09%
Ecuador	66.83%
North Korea	66.38%
Georgia	66.35%
Paraguay	64.08%
Iraq	59.66%
Myanmar	58.83%
Uzbekistan	58.83%
Bangladesh	58.51%
Guatemala	55.83%
Suriname	55.76%
Nicaragua	55.52%
Tajikistan	55.24%
Peru	51.26%
Lebanon	47.70%
Philippines	47.46%

Samoa	46.23%
Republic Of Congo	45.90%
Gambia	44.72%
Mexico	43.03%
Ghana	41.41%
Bhutan	36.65%
Sao Tome And Principe	36.17%
Pakistan	35.84%
Mongolia	30.06%
Zimbabwe	29.54%
Tonga	29.50%
Lesotho	28.91%
Cambodia	27.76%
Afghanistan	27.59%
Guinea-Bissau	24.33%
Nigeria	21.67%
Madagascar	20.54%
Togo	19.56%
Democratic Republic Of Congo	18.99%
Lao PDR	17.68%
Nepal	17.58%
Uganda	16.65%
Kiribati	14.69%
Ethiopia	12.58%
Rwanda	12.10%
Sierra Leone	10.62%

Central African Republic	6.18%
Chad	5.59%
Grenada	0.00%
Channel Islands	0.00%

Appendix 2

GNI Per Capita, current, PPP $

Country	GNI
Malta	51590
Greece	36600
San Marino	61060
Hong Kong	73940
Iceland	65560
New Zealand	50380
Kuwait	64590
Singapore	107030
Germany	65300
Macao	70930
Netherlands	66750
Belgium	60020
Puerto Rico	27830
United Kingdom	54920
Cyprus	45960
Sweden	67040
Finland	58950
Spain	45950
Luxembourg	97750
Israel	48820
Mongolia	12470
Zimbabwe	2460
Tonga	7160
Lesotho	3160

Cambodia	5080
Afghanistan	1690
Guinea-Bissau	2220
Nigeria	5650
Madagascar	1720
Togo	2610
Democratic Republic Of Congo	1280
Lao PDR	8810
Nepal	4750
Uganda	2650
Kiribati	4520
Ethiopia	2800
Rwanda	2730
Sierra Leone	1900
Central African Republic	1020
Chad	1640

Appendix 3

People using at least basic sanitation services (% of population)

Country	Sanitation %
Malta	100
Greece	99
San Marino	100
Hong Kong	97
Iceland	99
New Zealand	100
Kuwait	100
Singapore	100
Germany	99
Macao	100
Netherlands	98
Belgium	99
Puerto Rico	100
United Kingdom	99
Cyprus	99
Sweden	99
Finland	99
Spain	100
Luxembourg	98
Israel	100
Mongolia	70
Zimbabwe	35
Tonga	95
Lesotho	50

Cambodia	77
Afghanistan	56
Guinea-Bissau	28
Nigeria	47
Madagascar	15
Togo	19
Democratic Republic Of Congo	16
Lao PDR	80
Nepal	80
Uganda	21
Kiribati	45
Ethiopia	9
Rwanda	74
Sierra Leone	23
Central African Republic	14
Chad	13

Appendix 4

Persistence to last grade of primary, female (% of cohort)

Country	Female Education
New Zealand	NA
Malta	97
Greece	99
San Marino	94
Hong Kong	97
Iceland	98
Kuwait	92
Singapore	100
Germany	96
Macao	99
Netherlands	96
Belgium	80
Puerto Rico	84
United Kingdom	100
Cyprus	99
Sweden	100
Finland	100
Spain	100
Luxembourg	84
Israel	98
Mongolia	99
Zimbabwe	91
Tonga	91

Lesotho	81
Cambodia	85
Afghanistan	78
Guinea-Bissau	7
Nigeria	67
Madagascar	33
Togo	58
Democratic Republic Of Congo	61
Lao PDR	84
Nepal	73
Uganda	36
Kiribati	86
Ethiopia	35
Rwanda	71
Sierra Leone	40
Central African Republic	45
Chad	75

Appendix 5

Net ODA received per capita (current US$)

Paraguay	26
Iraq	42
Myanmar	28
Uzbekistan	33
Bangladesh	30
Guatemala	30
Suriname	47
Nicaragua	110
Tajikistan	56
Peru	9
Lebanon	250
Philippines	14
Samoa	380
Republic Of Congo	33
Gambia	93
Mexico	4
Ghana	37
Bhutan	163
Sao Tome And Principe	313
Pakistan	12
Mongolia	84
Zimbabwe	61
Tonga	1067
Lesotho	78
Cambodia	82

Afghanistan	116
Guinea-Bissau	81
Nigeria	16
Madagascar	36
Togo	39
Democratic Republic Of Congo	37
Lao PDR	77
Nepal	52
Uganda	55
Kiribati	565
Ethiopia	33
Rwanda	98
Sierra Leone	83
Central African Republic	120
Chad	42

Appendix 6

Government Expenditure, % of GDP

Malta	19.04
Greece	19.3
Hong Kong	14.33
Iceland	25.9
Singapore	10.02
Germany	21.94
Macao	29.86
Netherlands	25.45
Belgium	24.18
Puerto Rico	6.87
United Kingdom	21.05
Cyprus	18.8
Sweden	25.08
Finland	24.32
Spain	20.53
Luxembourg	17.39
Israel	20.87
France	23.68
Slovakia	20.61
South Korea	18.73
Bangladesh	5.7
Guatemala	11.52
Nicaragua	13.78
Peru	13.49
Phillipines	15.01
Samoa	21.78

Republic of Congo	15.41
Mexico	11.48
Ghana	10.05
Pakistan	10.15
Mongolia	13.91
Cambodia	8.35
Madagascar	14.94
Togo	13.03
Democratic Republic Of Congo	9.88
Nepal	8.49
Uganda	9.79
Ethiopia	7.36
Rwanda	17.04
Chad	3.95