# Impact of Water Quality, Hygiene, and Sanitation on Drinking Water Across the Globe

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## Abstract

Over 2 billion people reside in water-stressed countries and lack access to safely managed drinking water at home (CDC). This number is expected to increase over the next decade due to conflict, climate change, and population growth. Contaminated water and poor sanitation are linked to the transmission of preventable diseases. Accessibility to clean water is a health and development issue, impacting both rural and urban areas nationally, regionally, and at local levels (Wolf et al., 2022). Access to safe-drinking water is a basic human right and essential for public health. This study sought to determine the service levels of drinking water worldwide. This investigation will examine the impact of water quality, hygiene, and sanitation (WASH) on drinking water across the globe. More specifically, Nigeria, Ethiopia, Kenya, India, and China were selected to analyze due to the lowest service levels of drinking water. The results demonstrate a need to continue developing and implementing strategies and programs to provide clean drinking water to citizens in these countries.

**Keywords:** water safety, public health, drinking water, water resources, sanitation, hygiene

## I. Introduction

2.1 billion people globally lack safe water at home (WHO, 2019). Safe and readily available water is important for public health, whether it is used for drinking, domestic use, food production or recreational purposes. Safe drinking water is a global concern impacting every country on every continent. Recently, 42 percent of individuals living in Sub-Saharan Africa were found to drink from unimproved water sources. In this same study, 72% were found to not have access to basic sanitation (Eberhard, 2019). Water quality can be affected by natural sources such as mineral deposits (Chen et al., 2019), climate, erosion (Giri et al., 2016), and biological processes, as well as by human activities such as agriculture (Parris, 2011, Moss, 2008), industry (Chowdhary et al., 2020), and urbanization (Sun et al., 2016, Vadde et al, 2018, WHO, 2004, Wu et al., 2020) . Lin et al., reports an approximately 80% discharge of untreated industrial and municipal wastewater into the environment. The quality of water in the United States and across the globe is a public health concern. There is a direct correlation between water quality and human health and quality of life. A recent econometric model showed a reduction in health status in households where water purification equipment was reduced (Brown and Clasen, 2012).

Many other factors affecting water quality include pollution both chemical and biological, as well as changes in pH, temperature, turbidity, and dissolved oxygen levels. Water quality can be measured through various indicators, including the presence of specific contaminants (Ustaoglua et al., 2020), the levels of dissolved oxygen and pH, and the amount of nutrients and organic matter in the water. Governments and other organizations typically monitor water quality and enforce regulations to protect the quality of water sources. This can include regulations on industrial and agricultural practices, wastewater treatment, and drinking water standards. Drinking water quality should meet physicochemical pollutants criteria and be free of harmful pathogens.

Improving water quality can involve measures such as reducing pollution sources, increasing the availability of safe drinking water, and implementing sustainable water management practices.Water quality is typically analyzed based on physicochemical and biological parameters using the water quality index (WQI). This index was first implemented in 1965 (Boyacioglu, 2007, Tyagi et al., 2013, Noori et al., 2019). The WQI has been modified and adopted around the world. For example, Canada implemented the Canadian Council of Ministers of the Environment Water Quality Index (CCME WQI) (Noori et al., 2019, Tyagi et al., 2013). The states in the US have also modified and implemented the WQI. Oregon implemented the Oregon Water Quality Index (OWQI) (Said et al., 2004). These measures should aid water users, policymakers, and infrastructure planners in monitoring and improving water source quality.

### Significance and Rationale

Each year, over two million people die from diseases associated with poor sanitation, with children being the most at risk. Unsafe drinking water was found to be the result of almost 90 % of all these cases (United Nations, 2016). There are over 50 kinds of diseases that are caused by poor drinking

water, poor sanitation, and hygiene (Sweileh et al., 2016, Zhang et al., 2022). Many of these diseases can lead to severe diarrhea, skin diseases, malnutrition, and even cancer. The lack of water and sanitation services increases the incidence of diseases such as cholera and schistosomiasis (Kumar et al., 2022). This is true for both rural and urban areas. Previous studies show a direct relationship between cholera and contaminated water (Okello et al., 2019, Ferdous et al., 2018, Christaki et al., 2020) . Data from these studies demonstrate reductions in the number of cholera cases in areas where household water treatment was implemented (Lantagne and Yates, 2018, Taylor et al., 2015). It is necessary to study the impact of the quality of drinking water on human health. This investigation will examine the impact of water quality, hygiene, and sanitation on drinking water across the globe. More specifically, the results shown in this paper demonstrate that most countries around the world have unimproved water quality, sanitation, and hygiene. The latter indicates the lack of proper development and implementation of methods that ensure access to safe drinking water to their citizens.

## II. METHODS

### DATASET AND FEATURES

The data we used for our study is a publicly available dataset from the World Health Organization. The dataset can be accessed at https://washdata.org/data/household#!/table?geo0=region&geo1=sdg. The data consists of the features(variables):

- ISO3 - country's 3-letter code
- Country
- Residence type
    - Urban
    - Rural
    - Total
- Service Type
    - Drinking water
    - Sanitation
    - Hygiene
- Year
    - 2015 to 2020
- Coverage
- Population, and
- Service level
    - At least basic
    - Basic service
    - Limited service
    - Safely managed service

- Surface water
- Unimproved

There are 15,107 samples collected over a six-year period.

## Data Preprocessing.

The figure below, outlines our overall preprocessing strategy:

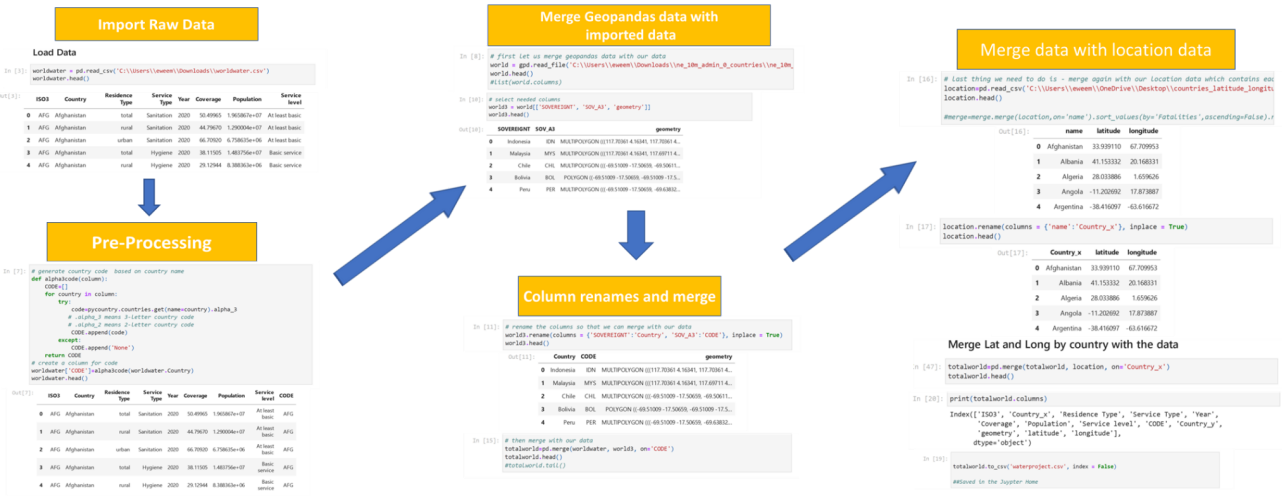


**Figure 1. Schematic of data preprocessing**

| Drinking Water Service Level | | Definition |
|---|---|---|
| Safely Managed | **4** | Drinking water from an improved source that is accessible at home, available when needed, and free from fecal and priority chemical contamination |
| Basic | **3** | Drinking water from an improved source, provided collection time is not more than 30 minutes for a round trip, including lining up and waiting |
| Limited | **2** | Drinking water from an improved source, provided collection time exceeds 30 minutes for a round trip, including lining up and waiting |
| Unimproved | **1** | Drinking water from an unprotected dug well or unprotected spring |
| Surface | **0** | Drinking water directly from a river, dam, lake, pond, stream, canal, or irrigation canal |

**Table 1. Drinking water service level (1-4).**

## Graph Generation

Both python and the UN JMP website listed above were used to generate the graphs shown in the results section. The data obtained from the UN JMP website and processed will be used for further analysis and generation of additional data visualizations.

## III. EXPERIMENTS & RESULTS

**Background:**

Drinking Water Sources

According to the World Health Organization and UNICEF, 90% of the world's population used at least basic drinking water services, increasing from 88% in 2015. This is expected to increase to above 90% by 2030. By 2020, 84 countries achieved universal access to the basic drinking water services. However, there are millions of people who remain without access to clean drinking water services.

Total service level coverage for drinking water, sanitation, and hygiene in both rural and urban areas in 2015 and 2020 is shown in Figure 2. Overall, all of the service levels were higher in urban areas than in rural areas.

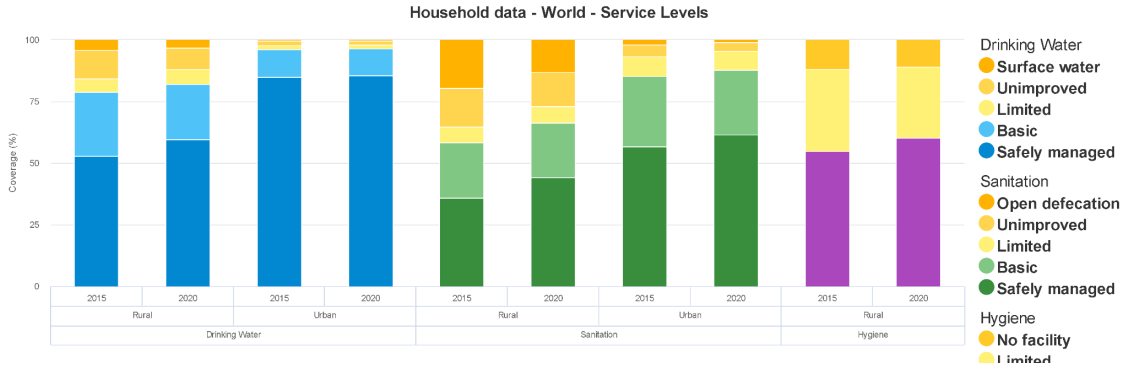


**Figure 2. Household Service Levels 2015 and 2020.** Drinking Water, Sanitation, Hygiene (WASH) around the world.

We also looked at the total household drinking water access across the globe (Figure 3). The data that was generated shows inequalities in access to clean drinking water. Many of the countries with higher inequalities have recently experienced civil unrest and infrastructure changes.

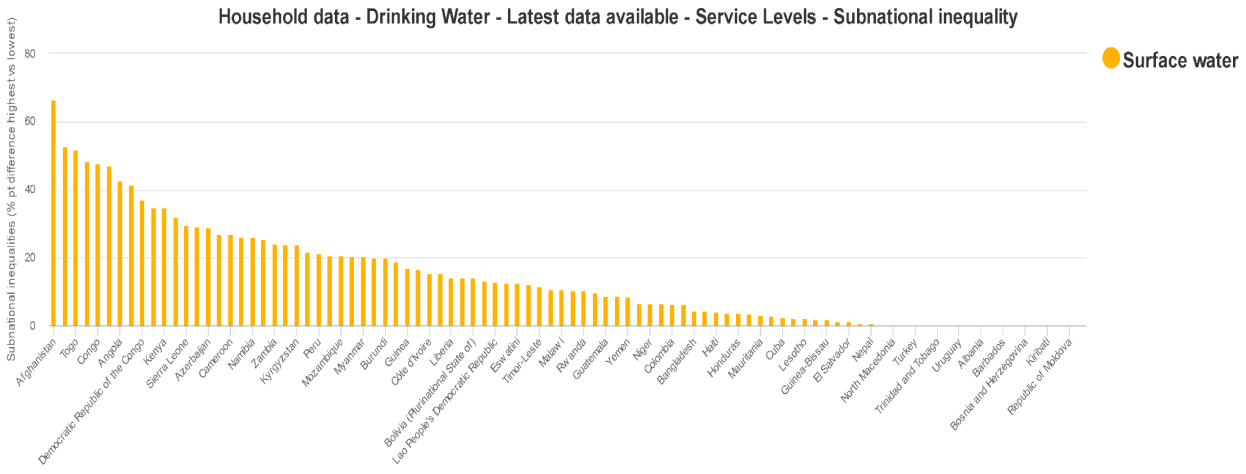

**Figure 3. Drinking Water Inequality.** The highest inequalities can be observed in Afghanistan.

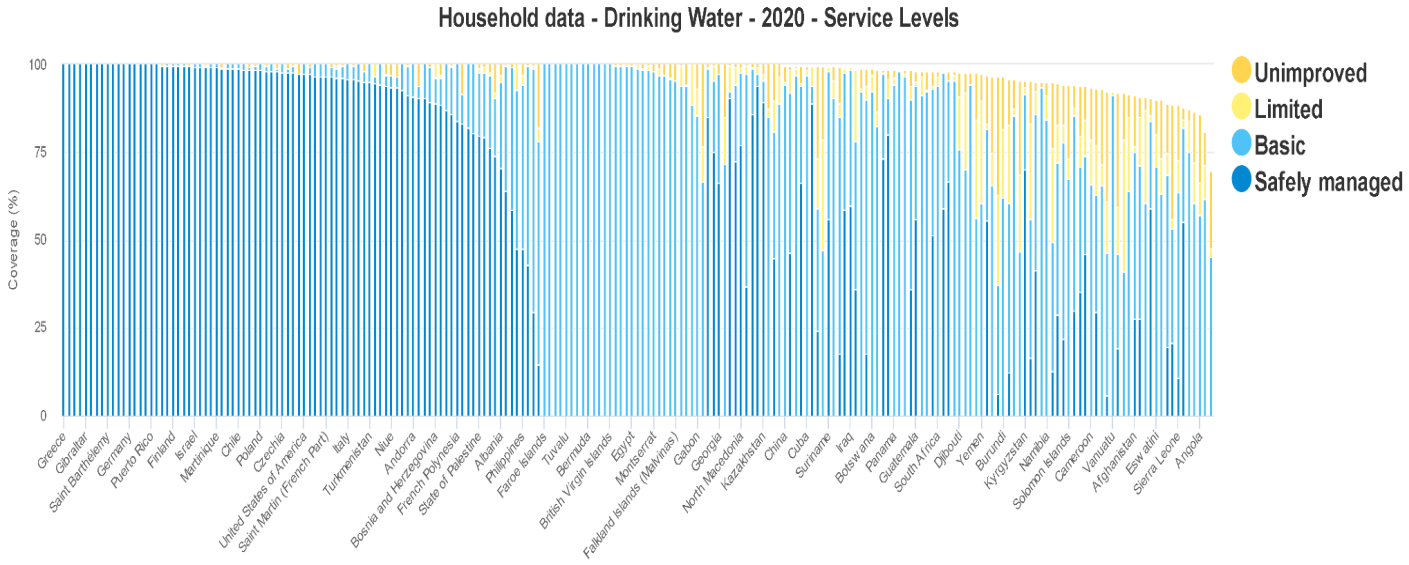


**Figure 4. Household drinking water by country for 2020.**

Households around the world have experienced a slight increase in drinking water services from the years 2000 to 2020. Basic service levels also increased over the time interval. Over fifty percent of households have access to drinking water that is safely managed (Figure 5).

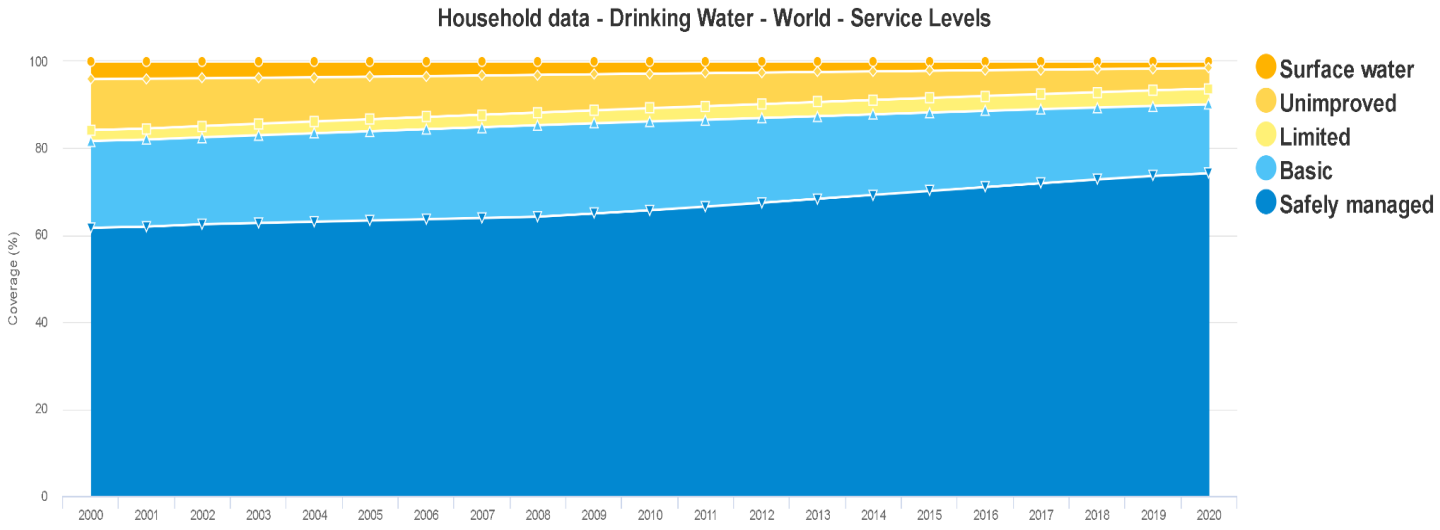

**Figure 5. Drinking water data from 2000 - 2020.**

We wanted to compare drinking water accessibility coverage, 2015 and 2020 in rural versus urban areas. Results show that in urban areas, drinking water is safely managed. Those in rural areas experienced higher incidence of unimproved, limited access to water service levels (Figure 6).

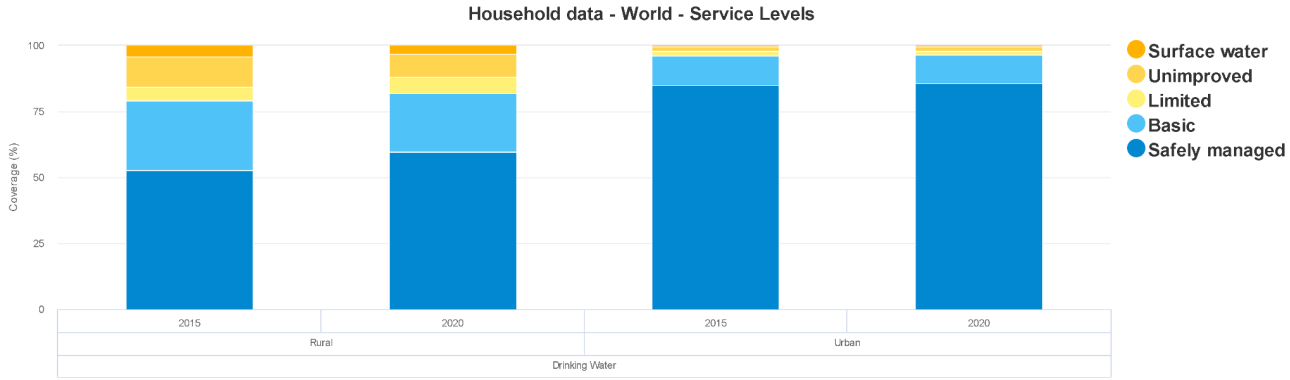


**Figure 6. Increased coverage in urban areas versus rural, 2015 and 2020.**

Sanitation and hygiene practices are essential for maintaining good health and well being. Figure 7 shows the countries that have basic hygiene facilities in their homes. A basic hygiene facility includes access to fresh water and soap. The majority of the countries analyzed had either no facility or limited facility (Figure 7).

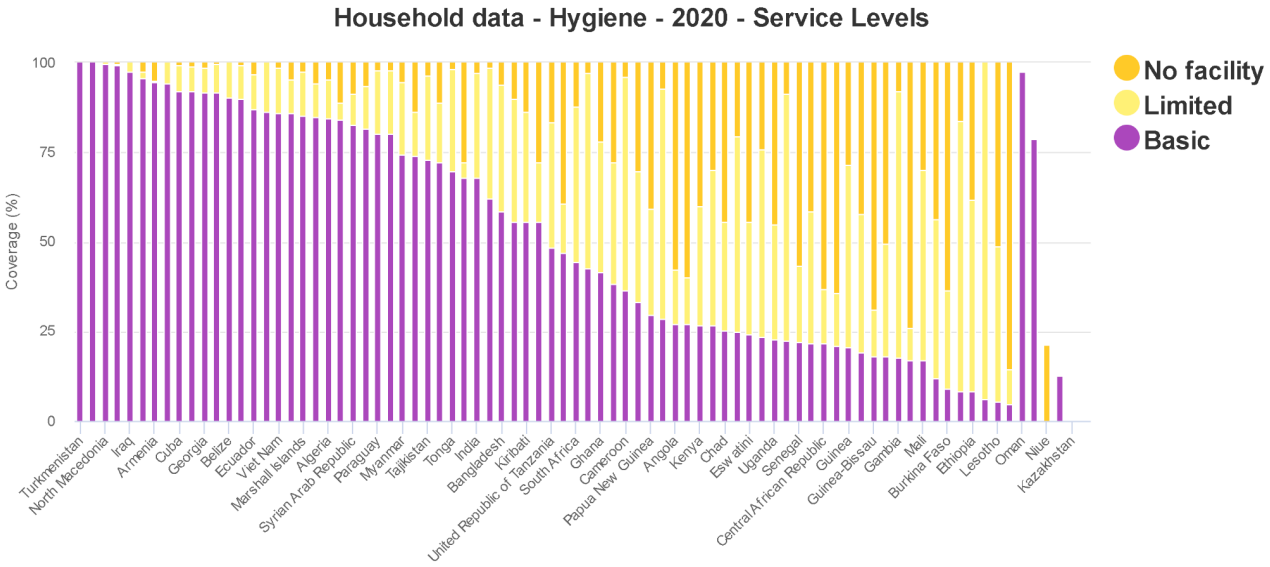

**Figure 7. Counties with basic hygiene accessibility, 2020.**

The populations of people with no hygiene facility were higher in the following countries compared to others; Nigeria, Ethiopia, Democratic Republic of the Congo, India, Kenya, Uganda, Angola, Colombia, Burkina Faso, and Rwanda. Nigeria had the highest population of people with no access to a hygiene facility (Figure 8).

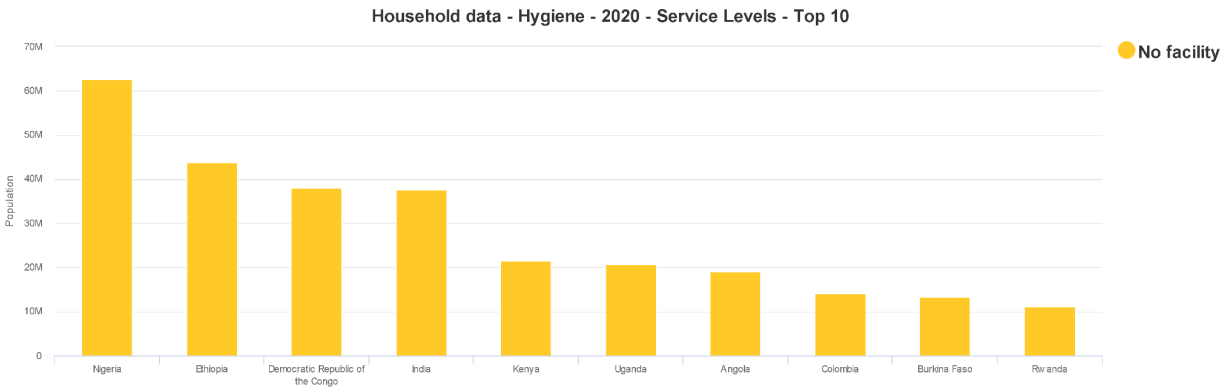


**Figure 8. Top 10 countries where most of the population has no access to hygiene facilities.**

We found a direct correlation between open defecation and lack of service levels. Figure 9 shows the percentage point change from 2000-2020 in countries around the world. Ethiopia is shown to have the greatest percent change in open defecation..

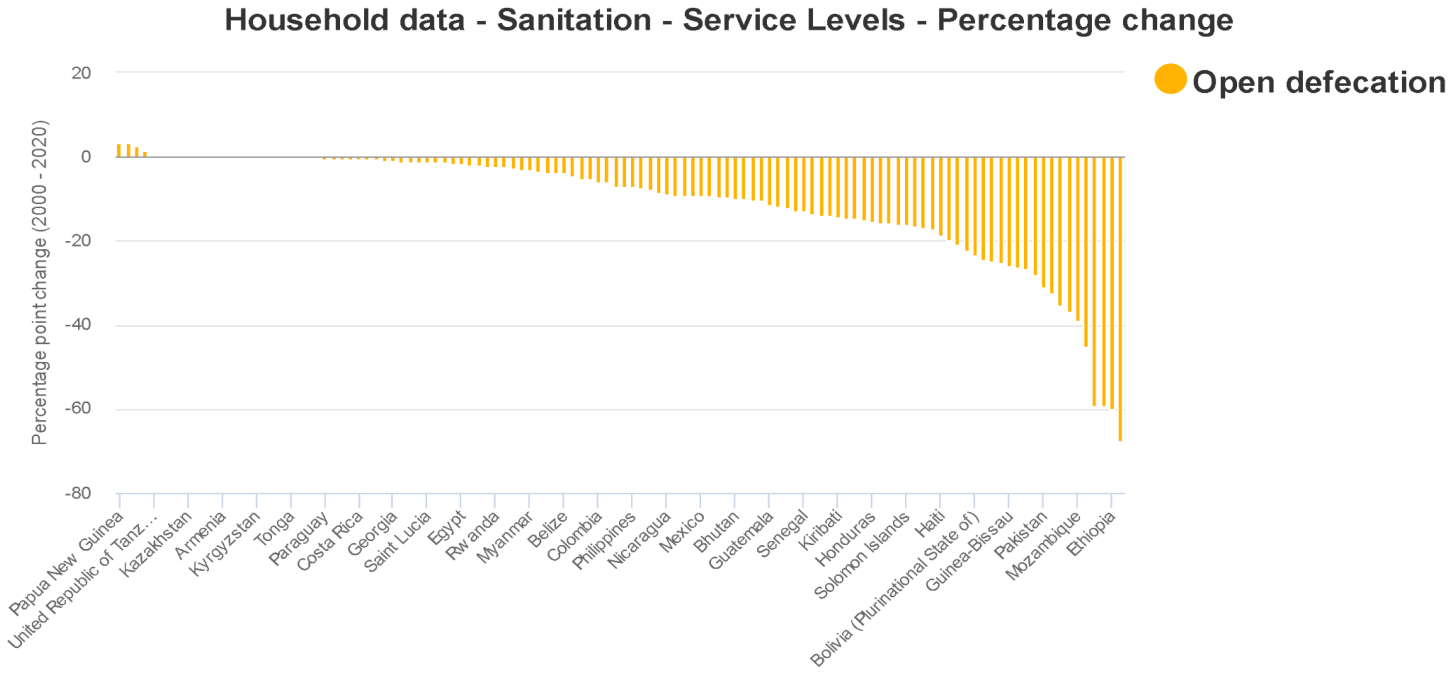

**Figure 9. Percent change in open defecation from 2000-2020 worldwide.**

We looked at the percent coverage for the service levels of drinking water in five countries, Nigeria, Kenya, India, China, and Ethiopia. These countries were chosen due to their high populations of citizens with only surface water access (Figure 10). Figure 10 shows that both Nigeria and Ethiopia have programmes in place to safely manage household drinking water. Despite the high percentages of either limited access, unimproved or surface water access in both countries. Kenya, India, and China all have basic service levels for drinking water.

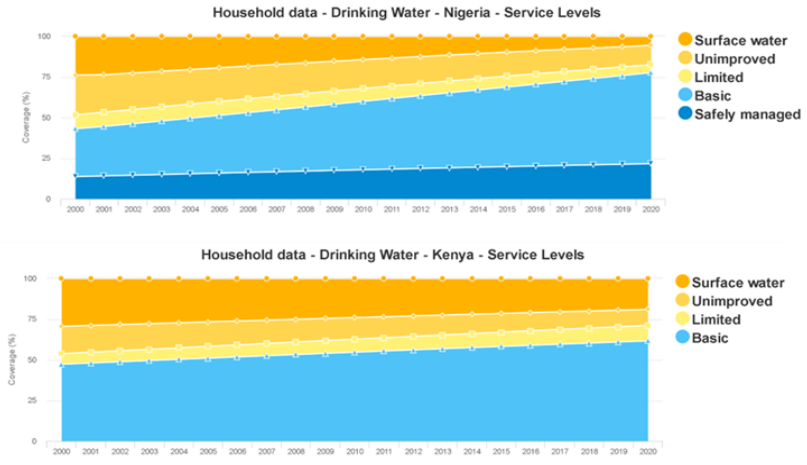


**Figure 10. Differential drinking water access in two of five key countries, Nigeria and Kenya.**

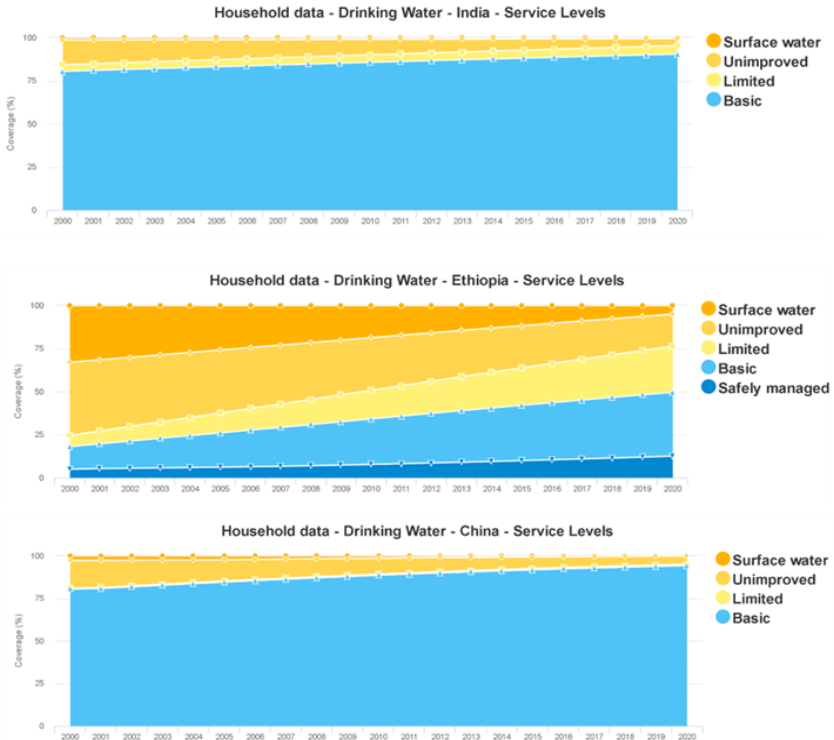

**Figure 10. Differential drinking water access in three of five key countries, India. Ethiopia, and China.**

There are many organizations devoted to providing safe drinking water to the people around the world. The UN and WHO are two of those organizations. Figure 11 shows the progress of the countries of the world in achieving universal basic water services by 2030. According to the data, only 23 countries are on track. Progress is too slow in 81 countries and there is negative progress in 15 countries (Figure 11).

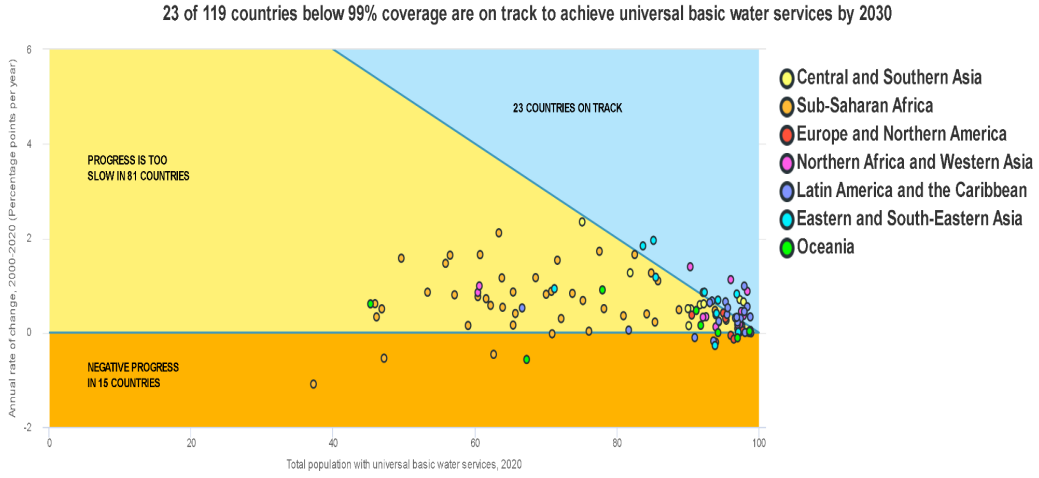


**Figure 11. Only 23 countries around the world are on track to achieve basic water services.**

## V. CONCLUSION AND FUTURE WORK

In the future work for this project, we'd be interested in creating a time series map that interactively shows change over time of the selected countries. Creating this type of map would provide an even more comprehensive understanding of the changes in water service levels in different countries over time. It could also be helpful to further explore the reasons behind the changes in water service levels in each country, such as changes in infrastructure or government policies. In the future, we would also be interested in more closely examining the most highly-populated countries that primarily have access to surface water (Nigeria, Ethiopia, Kenya, India, China). Learning more about how any one of these aforementioned countries' drinking water service levels changed over time could be helpful in informing similar positive change in any of the other aforementioned countries. Additionally, it could be interesting to compare the water service levels of different

countries with their socio-economic and political factors to better understand the complex relationship between water access and development.

We would also be interested in looking specifically at urban areas in a given country compared to rural areas. This view would help us in better identifying where a country's aid should go when it comes to access to safe drinking water.

Access to clean water is essential for human survival and well-being. Unfortunately, there are still many areas in the world where access to safe and reliable water services is limited. According to the World Health Organization and UNICEF, between 2000 and 2017, the proportion of the global population with access to basic water services increased from 76% to 90%. However, regional disparities around the world still exist. Based on our review of the data, we see that many low-income countries in Africa and Asia face a significant challenge when it comes to accessing water services as a whole. Overall, while progress has been made in improving access to water services globally, there is still a significant way to go. Addressing the disparities in access to water services, particularly in low-income countries, will require continued investment and innovation.

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