# **Report for Forest Query into Global Deforestation, 1990 to 2016**

ForestQuery is on a mission to combat deforestation around the world and to raise awareness about this topic and its impact on the environment. The data analysis team at ForestQuery has obtained data from the World Bank that includes forest area and total land area by country and year from 1990 to 2016, as well as a table of countries and the regions to which they belong. The data analysis team has used SQL to join these tables and to query them in an effort to find areas of concern, as well as areas that present an opportunity to learn from successes.

## 1. GLOBAL SITUATION

According to the World Bank, the total forest area of the world was 41,282,694.90 km2 in 1990. As of 2016, the most recent year for which data were available, that number had fallen to 39,958,245.90 km2, a loss of 1,324,449 km2, or 3.21%. This forest area lost over this time period is slightly more than the entire land area of Peru listed for the year 2016 (which is 1,280,000 km2).

## 2. REGIONAL OUTLOOK

In 2016, the percent of the total land area of the world designated as forest was 31.38%. The region with the highest relative forestation was Latin America and the Caribbean, with 46.16% forestation, and the region with the lowest relative forestation was the Middle East and North Africa, with 2.07% forestation.

In 1990, the percent of the total land area of the world designated as forest was 32.42%. The region with the highest relative forestation was Latin America and the Caribbean, with 51.03% forestation, and the region with the lowest relative forestation was the Middle East and North Africa, with 1.78% forestation.

**Table 2.1: Percent Forest Area by Region, 1990 & 2016**

|  |  |  |
| --- | --- | --- |
| **Region** | **1990 Forest Percentage** | **2016 Forest Percentage** |
| East Asia & Pacific | 25.77 | 26.36 |
| Europe & Central Asia | 37.27 | 38.06 |
| Latin America & Caribbean | 51.03 | 46.16 |
| Middle East & North Africa | 1.78 | 2.07 |
| North America | 35.65 | 36.04 |
| South Asia | 16.51 | 17.50 |
| Sub-Saharan Africa | 32.19 | 27.56 |

The only regions of the world that decreased in percent forest area from 1990 to 2016 were Latin America and the Caribbean (dropped from 51.03% to 46.16%) and Sub-Saharan Africa (32.19% to 27.56%). All other regions actually increased in forest area over this time period. However, the drop in forest area in the two aforementioned regions was so large, the percent forest area of the world decreased over this time period from 32.42% to 31.38%.

## 3. COUNTRY-LEVEL DETAIL

### SUCCESS STORIES

There is one particularly bright spot in the data at the country level: China actually increased in forest area by 527,229.06 km2 from 1990 to 2016. It would be interesting to study what has changed in China over this time to drive this figure in the data higher. The country with the next largest increase in forest area from 1990 to 2016 was the United States, but it only saw an increase of 79,200 km2, much lower than the figure for China.

China and the United States are of course very large countries in total land area, so when we look at the largest *percent* change in forest area from 1990 to 2016, we aren’t surprised to find a much smaller country listed at the top. Iceland increased in forest area by 213.66% from 1990 to 2016.

### LARGEST CONCERNS

Which countries are seeing deforestation to the largest degree? We can answer this question in two ways. First, we can look at the absolute square kilometer decrease in forest area from 1990 to 2016. The following 5 countries had the largest decrease in forest area over this time period:

**Table 3.1: Top 5 Amount Decrease in Forest Area by Country, 1990 & 2016**

|  |  |  |
| --- | --- | --- |
| **Country** | **Region** | **Absolute Forest Area Decrease (km2)** |
| Brazil | Latin America & Caribbean | 541,510.00 |
| Indonesia | East Asia & Pacific | 282,193.98 |
| Myanmar | East Asia & Pacific | 107,234.00 |
| Nigeria | Sub-Saharan Africa | 106,506.00 |
| Tanzania | Sub-Saharan Africa | 102,320.00 |

The second way to consider which countries are of concern is to analyze the data by percent decrease.

**Table 3.2: Top 5 Percent Decrease in Forest Area by Country, 1990 & 2016**

|  |  |  |
| --- | --- | --- |
| **Country** | **Region** | **% Forest Area Decrease** |
| Togo | Sub-Saharan Africa | 75.44 |
| Nigeria | Sub-Saharan Africa | 61.80 |
| Uganda | Sub-Saharan Africa | 59.13 |
| Mauritania | Sub-Saharan Africa | 46.75 |
| Honduras | Latin America & Caribbean | 45.03 |

When we consider countries that decreased in forest area percentage the most between 1990 and 2016, we find that four of the top 5 countries on the list are in the region of Sub-Saharan Africa. These countries are Togo, Nigeria, Uganda, and Mauritania. The 5th country on the list is Honduras, which is in the Latin America and Caribbean region.

From the above analysis, we see that Nigeria is the only country that ranks in the top 5 both in terms of absolute square kilometer decrease in forest as well as percent decrease in forest area from 1990 to 2016. Therefore, this country has a significant opportunity ahead to stop the decline and hopefully spearhead remedial efforts.

### QUARTILES

The table below shows the number of countries in each forestation percent quartile for 2016 (i.e., number of countries with their percentage of land designated as forest under 25%, between 25% and 50%, between 50% and 75%, or above 75%).

**Table 3.3: Count of Countries Grouped by Forestation Percent Quartiles, 2016**

|  |  |
| --- | --- |
| **Quartile** | **Number of Countries** |
| Under 25% | 85 |
| Between 25% to 50% | 72 |
| Between 50% to 75% | 38 |
| Over 75% | 9 |

The largest number of countries in 2016 were found in the first quartile, with less than 25% of their land designated as forest. There were nine countries in the top quartile in 2016. These are countries with a very high percentage of their land area designated as forest. The following is a list of countries and their respective forest land, denoted as a percentage.

**Table 3.4: Top Quartile Countries, 2016**

|  |  |  |
| --- | --- | --- |
| **Country** | **Region** | **% Designated as Forest** |
| Suriname | Latin America & Caribbean | 98.26 |
| Micronesia, Fed. Sts. | East Asia & Pacific | 91.86 |
| Gabon | Sub-Saharan Africa | 90.04 |
| Seychelles | Sub-Saharan Africa | 88.41 |
| Palau | East Asia & Pacific | 87.61 |
| American Samoa | East Asia & Pacific | 87.50 |
| Guyana | Latin America & Caribbean | 83.90 |
| Lao PDR | East Asia & Pacific | 82.11 |
| Solomon Islands | East Asia & Pacific | 77.86 |

## 4. RECOMMENDATIONS

Analysing World Bank data on forest and total land area from 1990 and 2016 revealed that the percentage of land designated as forest area worldwide has decreased by almost 1,325,000 km2 in this time period, a decrease of 3.21%. A closer look at the data by regions shows that five out of seven world regions actually saw an increase in their percentage of land designated as forest. Nevertheless, the decrease in the other two world regions – Latin America and the Caribbean, and Sub-Saharan Africa – were large enough that the worldwide forestation percentage from 1990 to 2016 was negative.

In the case of Latin America, given that this world region was consistently the one with the greatest relative forestation, its decrease in designated forest area from 1990 to 2016 should be particularly concerning. When looking at country-level details, Brazil stood out as the country with the greatest absolute forest area decrease. In fact, its decrease of over 541,000 km2 is so significant, that it almost doubles that of its runner-up Indonesia, and it accounts for approximately 40% of the lost forest area worldwide from 1990 to 2016. Similarly, when considering the percentage decrease in forest area rather than the absolute forest area itself, Honduras emerged as the 5th most affected country, showing a percentage forest area decrease of 45%. The remaining four most affected countries in percentage of forest area lost were Mauritania, Uganda, Nigeria, and Togo, all countries in Sub-Saharan Africa. Nigeria was also the 4th country with the greatest absolute forest area decrease. These findings suggest that ForestQuery should focus on forestation efforts in Latin America (particularly in Brazil) and Sub-Saharan Africa as a whole.

There are three potential routes that could inform ForestQuery’s efforts. The first and most apparent one is to examine countries that have shown great success in its reforestation. China showed an incredible increase in absolute forest area of almost 528,000 km2, with the second greatest increase coming from the United States with just over 79,000 km2. Regarding percentage of forest area, Uruguay, Bahrain, French Polynesia and Iceland more than doubled their percentage of land designated as forest, with the latter tripling it. Studying the conservation efforts in these countries could provide insights into effective interventions.

One point to consider when looking at success stories is that of country differences. Iceland is vastly different – geographically, culturally, and economically – to our countries of interest in Latin America and Sub-Saharan Africa. Thus, the second route is to not only consider success stories, but specifically success stories closest to our countries of interest. China and the United States could be of interest to Brazil, for example, as these three countries are very large and thus may have similar challenges when it comes to the logistics of applying policies throughout vast territories. Suriname and Guyana, which were in the 4th quartile of countries by forestation percentage (i.e., over 75% of their territory was forest), are geographically similar to northern Brazil, being located within the Guiana Shield and possessing extensive tropical rainforests. Southern Brazil and Uruguay also have similar landscapes, and Uruguay and Brazil share parallels in their economic and political development (Bastian & Bastian, 2019). Researching more about forestation efforts in Suriname and Guyana, and in Uruguay can shed light on which policies and campaigns may work best in northern and southern Brazil, respectively, as well as what forestation obstacles to expect (e.g., southern Brazil and Uruguay have experienced deforestation due to agricultural expansion, particularly for soybean and cattle ranching).

Finding successful countries for Sub-Saharan Africa proves more difficult. Gabon and Seychelles were both in the top quartile for forest percentage, yet both were in higher income brackets – upper middle and high, respectively – which in turn may help address deforestation concerns more easily through greater funding (e.g., Le et al., 2012). Rather than only looking at geographically similar countries, it might be worth looking at other Sub-Saharan countries of lower middle and low income and see if any have increased their designated forest land area percentage. Filtering the data accordingly (see Appendix 6.5) reveals that the most successful countries, in descending order, have been Cabo Verde, Rwanda, Eswatini, and Lesotho, which saw increases in forest area percentage between 36% and 20%. Less successful countries in this world region and income bracket with increases below 10% were The Gambia, Ghana, and Cote d’Ivoire. If considering geographical proximity, Ghana and Cote d’Ivoire could offer insights regarding Togo and perhaps Nigeria to a lesser extent, while Rwanda could do the same for Uganda. Overall, Sub-Saharan Africa proves challenging, as only 8 countries were able to increase their percentage of forest area. Successful efforts from ForestQuery will likely need to heavily rely on past literature reviewing the challenges of reforestation in this area and any past successful strategies (e.g., see Djenontin et al., 2018).

The last route to inform ForestQuery’s efforts is to draw more information from within our countries of interest. A time period of 1990 to 2016 is still an extensive one where a lot can happen. For example, between the 1990s and early 2000s, Brazil went through a deforestation crisis due to rampant logging, land clearing for agriculture, cattle ranching, and infrastructure development (Fearnside, 2005). Starting in the late 2000s, presidents like Luiz Ignacio Lula da Silva and Dilma Rousseff began implementing significant measures to combat deforestation (de Castro, 2014; Viola & Franchini, 2014). It is possible that, while Brazil’s overall forest area decrease from 1990 to 2016 was massive, the biggest decrease was in the decade of 1990 to 2000, and that after 2000 Brazil began slowing its deforestation or recovering compared to a decade prior, even if it is yet to fully return to its 1990 levels of forestation. Time series analyses and visualisations of our countries of interest (or even of the Sub-Saharan African region as a whole given it is the region with the most countries with significant forest percentage decrease) would allow us to pinpoint more specific time periods where deforestation sharply increased or decreased. With these time periods highlighted, we would be able to research the social, economic, and political background that may have led to these sharp increases or decreases, which in turn would inform how to allocate our efforts in these countries.

Latin America and the Caribbean, specifically Brazil, and Sub-Saharan Africa more generally are areas of concern regarding deforestation. Forestation efforts and awareness campaigns should consider investigating countries with successful reforestation that share similarities – geographical, cultural, or economic – to these countries and regions of concern.

## 5. References

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## 6. APPENDIX: SQL Queries Used

### 6.1 Main *forestation* View

A new view called *forestation* was created by joining all tables together. Years were filtered for 1990 and 2016, and two new columns were created. Firstly, *total\_area\_sqkm* transformed *total\_area\_sq\_mi* from the *land\_area* table to ensure consistency across units of measurement (miles vs kilometres). Next, the percentage of land forest was computed as *pct\_forest*.

DROP VIEW IF EXISTS forestation;

CREATE VIEW forestation AS

SELECT forest.country\_code, forest.country\_name,

forest.year, ROUND(forest.forest\_area\_sqkm, 2) AS forest\_area\_sqkm,

ROUND(land.total\_area\_sq\_mi \* 2.59, 2) AS total\_area\_sqkm,

ROUND(forest.forest\_area\_sqkm/(land.total\_area\_sq\_mi \* 2.59) \* 100, 2)

AS pct\_forest,

reg.region, reg.income\_group

FROM forest\_area AS forest

JOIN land\_area AS land

ON forest.country\_code = land.country\_code

AND forest.year = land.year

JOIN regions AS reg

ON forest.country\_code = reg.country\_code

WHERE forest.year IN (1990, 2016);

### 6.2 Querying Global Info

A new view called *world\_data* was created by filtering the two rows where country equalled “World.” This view was used as an inner query to obtain differences between 1990 and 2016 and to obtain scalars to filter the forestation view. Another query filtered data for 2016 and land area to find the country with a land area close to the forest area lost worldwide between 1990 and 2016.

-- Obtain information for the world in 1990 and 2016

CREATE VIEW world\_data AS

SELECT year, forest\_area\_sqkm, total\_area\_sqkm, pct\_forest

FROM forestation

WHERE country\_name = 'World';

-- Compute difference in metrics from 1990 to 2016

SELECT

(SELECT forest\_area\_sqkm FROM world\_data WHERE year = 2016) -

(SELECT forest\_area\_sqkm FROM world\_data WHERE year = 1990)

AS forest\_difference,

((SELECT forest\_area\_sqkm FROM world\_data WHERE year = 2016) -

(SELECT forest\_area\_sqkm FROM world\_data WHERE year = 1990))/

(SELECT forest\_area\_sqkm FROM world\_data WHERE year = 1990) \*100

AS pct\_change

FROM world\_data;

-- Alternative computation of metrics difference using a self join  
SELECT past.country\_name,   
 (present.forest\_area\_sqkm - past.forest\_area\_sqkm)   
 AS forest\_difference,  
 (present.forest\_area\_sqkm - past.forest\_area\_sqkm)/  
 past.forest\_area\_sqkm \*100  
 AS pct\_change,   
FROM forestation AS past  
JOIN forestation AS present  
ON past.country\_name = present.country\_name  
WHERE past.year = 1990 AND present.year = 2016  
 AND country\_name = 'World'

-- Find the country with a total area similar to the world forest area lost between 1990-2016

SELECT country\_name, total\_area\_sqkm

FROM forestation WHERE year = 2016

AND total\_area\_sqkm <=

(SELECT

(SELECT forest\_area\_sqkm FROM world\_data WHERE year = 1990) -

(SELECT forest\_area\_sqkm FROM world\_data WHERE year = 2016)

AS forest\_difference

FROM world\_data)

ORDER BY total\_area\_sqkm DESC;

### 6.3 Regional Outlook

A quick inspection ordering the forestation view by forest area in descending order, and then by total area in descending order showed missing values across both fields. Thus, when grouping data to create a new *regional\_change* view to find regional forest percentages, rows with either missing forest area or missing total area were excluded. With the *regional\_change* view created, a simple query filtered any world regions where forest area showed a decrease from 1990 to 2016.

CREATE OR REPLACE VIEW regional\_change AS

WITH forest\_percentage\_1990 AS (

SELECT region,

SUM(forest\_area\_sqkm)/SUM(total\_area\_sqkm)\*100

AS pct\_forest\_1990

FROM forestation

WHERE year = 1990

AND forest\_area\_sqkm IS NOT NULL

AND total\_area\_sqkm IS NOT NULL

GROUP BY region),

forest\_percentage\_2016 AS (

SELECT region,

SUM(forest\_area\_sqkm)/SUM(total\_area\_sqkm)\*100

AS pct\_forest\_2016

FROM forestation

WHERE year = 2016

AND forest\_area\_sqkm IS NOT NULL

AND total\_area\_sqkm IS NOT NULL

GROUP BY region)

SELECT past.region, past.pct\_forest\_1990,

present.pct\_forest\_2016

FROM forest\_percentage\_1990 AS past

JOIN forest\_percentage\_2016 AS present

ON past.region = present.region;

-- Cases where forest area decreased from 1990 to 2016

SELECT \*

FROM regional\_change

WHERE pct\_forest\_2016 < pct\_forest\_1990

### 6.4 Country-Level Detail

Two new views were created to look at details at the country level. First, for *country\_change*, two CTEs were created. Each CTE contained data for either 1990 only, or for 2016 only. These CTEs were then joined and new columns were created computing the differences in forest area, forest percentage, and total area percentage. Positive numbers signalled an increase while negative numbers showed a decrease. With this view created, different queries showed which countries had the greatest increase and the greatest losses in forest area and forest percentage.

The second view created, *quartiles*, added a new column to *country\_change* where each country was assigned to a quartile according to their percentage of forest in 2016 (countries with this information missing were removed). This view was then used to group data by quartiles.

#### 6.4.1 The *country\_change* view

CREATE OR REPLACE VIEW country\_change AS  
WITH forest\_1990 AS (  
 SELECT country\_name,  
 forest\_area\_sqkm AS forest\_area\_1990,  
 total\_area\_sqkm AS total\_area\_1990,  
 pct\_forest AS pct\_forest\_1990,  
 region, income\_group AS income\_1990  
 FROM forestation  
 WHERE year = 1990),  
forest\_2016 AS (  
 SELECT country\_name,  
 forest\_area\_sqkm AS forest\_area\_2016,  
 total\_area\_sqkm AS total\_area\_2016,  
 pct\_forest AS pct\_forest\_2016,  
 region, income\_group AS income\_2016  
 FROM forestation  
 WHERE year = 2016)  
SELECT past.country\_name,  
 (present.forest\_area\_2016 - past.forest\_area\_1990)   
 AS forest\_area\_change,  
 (present.forest\_area\_2016 - past.forest\_area\_1990)/  
 past.forest\_area\_1990 \* 100  
 AS forest\_pct\_change,   
 past.income\_1990,  
 past.region  
FROM forest\_1990 AS past  
JOIN forest\_2016 AS present  
ON past.country\_name = present.country\_name  
WHERE (present.forest\_area\_2016 - past.forest\_area\_1990)   
 IS NOT NULL  
 AND past.country\_name <> 'World';

-- Countries with the greatest increase in forest area

SELECT country\_name, forest\_area\_change

FROM country\_change

ORDER BY 2 DESC;

-- Countries with the greatest forest area percentage increase

SELECT country\_name, forest\_pct\_change

FROM country\_change

ORDER BY 2 DESC;

-- Top 5 countries with the greatest loss of absolute forest area

SELECT country\_name, region, forest\_area\_change

FROM country\_change

ORDER BY 3

LIMIT 5;

-- Top 5 countries with greatest decrease in forest area percentage

SELECT country\_name, region, forest\_pct\_change

FROM country\_change

ORDER BY 3

LIMIT 5;

#### 6.4.2 The *quartiles* view

CREATE OR REPLACE VIEW quartiles AS

SELECT country\_name, region, pct\_forest\_2016,

CASE WHEN pct\_forest\_2016 BETWEEN 0 AND 24.99 THEN 'Under 25%'

WHEN pct\_forest\_2016 BETWEEN 25 AND 50 THEN 'Between 25% to 50%'

WHEN pct\_forest\_2016 > 50 AND pct\_forest\_2016 < 75 THEN 'Between 50% to 75%'

ELSE 'Over 75%' END AS forest\_quartile

FROM country\_change

WHERE pct\_forest\_2016 IS NOT NULL AND country\_name NOT LIKE 'World'

ORDER BY 3 DESC;

-- Group by quartiles and count the number of countries in each

SELECT forest\_quartile, COUNT(\*) AS number\_countries

FROM quartiles

GROUP BY 1

ORDER BY 2 DESC;

#### 6.5 A closer look at Sub-Saharan Africa

-- Sub-Saharan Africa low and lower middle countries ordered by greatest increase in forest area

SELECT country\_name, forest\_pct\_change, forest\_area\_change  
FROM country\_change  
WHERE forest\_area\_change IS NOT NULL AND country\_name NOT LIKE 'World'  
 AND region = 'Sub-Saharan Africa'   
 AND (income\_2016 = 'Low income' OR income\_2016 = 'Lower middle income'  
 AND forest\_area\_change > 0  
ORDER BY 2 DESC

**Table 6.1: Increased Percent Forest Area and Absolute Forest Area in Low and Lower Middle Income Countries in Sub-Saharan Africa**

|  |  |  |  |
| --- | --- | --- | --- |
| **Country** | **% Forest Area Decrease** | **Absolute Forest Area Decrease (km2)** | **Income group** |
| Cabo Verde | 36.44 | 331.10 | Lower middle |
| Rwanda | 34.68 | 1,688.00 | Low |
| Eswatini | 20.08 | 1,186.00 | Lower middle |
| Lesotho | 20.00 | 100. | Lower middle |
| The Gambia | 9.72 | 476.00 | Low |
| Ghana | 7.88 | 7,384.00 | Lower middle |
| Cote d’Ivoire | 1.72 | 1,786.00 | Lower middle |

One observation worth mentioning is that when looking at Sub-Saharan countries regardless of income, the countries above, with the addition of Gabon, were the only countries in the region that had increased their forest area between 1990 and 2016. This implies even Sub-Saharan countries in upper and upper middle income brackets are not seeing successful reforestation efforts.