Country Water Footprint Profile

Mali

October 2016
Introduction

This project was conducted to support the Netherlands Ministry of Foreign Affair’s Inclusive Green Growth aim of increasing water use efficiency by 25% in Dutch financed projects. The project includes development of Country Water Footprint Profiles for seven sub-Saharan countries: Benin, Ethiopia, Ghana, Kenya, Mali, Mozambique and Rwanda.

The water footprint is a flexible indicator that can build understanding of the water consumed and polluted in producing goods and services, the impact of that water use on maintaining environmental water requirements and water quality standards, and the opportunities for improving water efficiency and land productivity. The water footprint can also be used to understand the interdependencies between countries from the water perspective through the export and import of goods. Finally, the water footprint can be used to understand if water use in a specific location, whether it be a catchment, aquifer or an entire nation, is sustainable.

The analyses that follow provide an overview of water use in Mali, from the perspective of the goods produced within the country, the consumption of goods, in particular agricultural crops, by Malians and whether these goods are produced domestically or imported from other countries. The Country Water Footprint Profile can be used in discussions with ministries and departments concerned with water resource development and management, agriculture and economic development, trade and environmental protection and can support planning and policy development. It is also useful to companies as they develop their corporate water strategy.

The country profile is a starting point. Further analyses could investigate each area presented more deeply and/or focus on questions that arise specific to Mali.
Content

• General country information
• Introduction to the water footprint
• Water footprint of production and major crops
• Water footprint benchmarks
• Blue water scarcity
• Virtual water flows
• Water footprint of consumption
• Key learning and next steps
• Data sources, limitations and references
General country information
Mali

- **Population**: 17.1 million (World Bank, 2014)
- **Economic value of agriculture**: 40% of GDP (World Bank, 2014)
- **Employment in agriculture**: 66% of total employment (World Bank, 2006)
- **Major agricultural crops by tonnes produced**: millet, rice, sorghum, cotton, maize (FAOSTAT, 2016)
- **Major crops by export value**: groundnut oil, oilseeds (FAOSTAT, 2016)

*average for 1996-2005
• **Country area**: 1,240,190 km\(^2\) (World Bank, 2014)

• **Land area**: 1,220,190 km\(^2\) (World Bank, 2014)

• **Agricultural land**: 34% of land area (World Bank, 2014)

• **Arable (under cultivation) land**: 6,411,000 hectares (World Bank, 2014), which represent 5.3% of land area

• **Actual irrigated Land**: 138,000 hectares (1998, [www.nationsencyclopedia.com](http://www.nationsencyclopedia.com))
Introduction to the water footprint
Water footprint

• The ‘water footprint’ measures the appropriation of freshwater resources for producing goods and services.

• Water footprint measures the volume of water consumed or polluted.

• It tells us where and when water is used, which allows it to be compared to the water available.

• The water footprint can measure both direct & indirect water use of either a consumer or producer.

• A water footprint can be calculated for a process, a product, a producer (e.g. a company), a consumer, group of consumers (e.g. a nation) or a geographic area (e.g. a river basin).
Water footprint components

The water footprint can be measured for three components: the green and blue water footprint measure water quantity, the grey water footprint measures water quality.

Green water footprint: volume of rainwater evaporated or incorporated into product

Blue water footprint: volume of surface or groundwater evaporated or incorporated into product, lost return flow

Grey water footprint: volume of water needed to meet water quality standards*

* Grey water footprint is not included in the country profiles
Water footprint of production and major crops
Water footprint of production

The water footprint (WF) of production is the amount of local water resources used to produce goods and services within the country. This includes the water footprint of agriculture, industry and domestic water use and it tells us the total volume of water consumed within the borders of the country through evapotranspiration, incorporation into the product or by returning water to a different place or in a different time.
The total annual green and blue water footprint of production in Mali is 21.6 billion m$^3$. 94% of this is green water footprint, that is the use by plants of rainfall stored as soil moisture. The remaining 6% of the water footprint is the use of surface and groundwater for agriculture, industry and domestic water supply.
Green water can be used by natural ecosystems or for the production of crops, livestock grazing, forestry and horticulture.

Since the green water footprint is related to the land where rain has fallen, the green water footprint tells us for what purposes both land and water is being used.

The green water footprint of agriculture indicates that the available green water, and the land that is associated with it, is being used to produce crops or livestock and is no longer available for other uses, e.g., for supporting biodiversity and ecosystem services.
25% of the annual green water footprint of agricultural production in Mali is used for grazing. 75% is consumed in crop production.

82% of the annual green water footprint of production is for products used within Mali while 18% is consumed in producing products for export.
The annual green water footprint of agricultural crop production in Mali is 15.1 billion m$^3$. The map of the green water footprint indicates where rain-fed agriculture is occurring.
Millets are the crop using the most green water in Mali with 35% of the total green water footprint consumed in its production. Millets are the largest crop in terms of volumes of production in Mali and are primarily used domestically.

Sorghum is the second largest user of green water with 20% of the total green water footprint.

Cotton and rice follow at 17% and 12%, respectively.
Blue water footprint: lakes, rivers and aquifers

Blue water, i.e., water from lakes, rivers and aquifers, can be used by natural ecosystems or for the production of crops, livestock water supply, forestry and horticulture as well as industry and domestic water supply.

The blue water footprint tells us for what purposes surface and groundwater resources are being used.

The blue water footprint of production indicates that the available blue water is being used to produce crops or livestock, industry or domestic water supply and is no longer available for other uses, e.g., supporting biodiversity and ecosystem services.
The total annual blue water footprint of production is **1.34 billion m³**. Of this **85.7%** is used for producing crops, **9.7%** is used for animal water supply, **4.4%** is used for domestic water supply and **0.2%** is industrial water use.

**98%** of the annual blue water footprint of production is for products used within Mali while **2%** is consumed in producing products for export. A small percentage of this is for industrial products.
The annual blue water footprint of agricultural crop production in Mali is 1.15 billion m$^3$. The map shows where irrigated farm lands are located and how much blue water is consumed in crop production.
Rice is the crop that uses the largest share of blue water in Mali with 88% of the total blue water footprint consumed in its production. Rice is the second largest crop by volume produced in Mali.

Sugar cane is the second largest user of blue water with 6% of the total blue water footprint.
Water footprint benchmarks
Benchmarks: water footprint efficiency

Global water footprint benchmarks tell us how efficiently water is being used in producing a crop and the potential for increasing water (and land) productivity through reasonable means. Water footprint benchmarks are determined for the green plus the blue water footprint combined as this represents the total water consumed in crop production. The water footprint of a crop is compared to the 25th percentile water footprint for production globally for that crop. This is used as the global benchmark. The global average also indicates whether the water footprint per unit of production is exceeding the average of all production, worldwide.

When the water footprint in cubic metres of water consumed per tonne of production is high in comparison to the global benchmark, this indicates low water productivity and can indicate low yields per hectare of land.

Following are benchmark comparisons for three major crops selected for their share of the total crop production green water footprint for Kenya and three major crops selected for their share of the total crop production blue water footprint.
Millets : water footprint efficiency

Millets consume the largest proportion of green water in Mali. They have an average green+blue water footprint of **5336 m³ per tonne** of production. The 25th percentile benchmark green+blue water footprint is **2905 m³ per tonne** of production and the global average is **4363 m³ per tonne**.

875,223 tonnes* of millets were produced annually.

Comparison with the global benchmark suggests that there are significant opportunities for increasing water use efficiency through improving yields per unit of water consumed.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Green-blue water footprint (m³/tonne) at different production percentiles</th>
<th>Global average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10th</td>
<td>20th</td>
</tr>
<tr>
<td>Millets</td>
<td>2292</td>
<td>2741</td>
</tr>
</tbody>
</table>

*average for 1996-2005

Source: Mekonnen and Hoekstra (2014)
Sorghum: water footprint efficiency

Sorghum is the crop that uses the second largest share of green water in Mali and has a green+blue water footprint of $4448 \text{ m}^3/\text{tonne}$ of production. The 25$^{th}$ percentile benchmark green+blue water footprint is $1122 \text{ m}^3/\text{tonne}$ of production and the global average is $2960 \text{ m}^3/\text{tonne}$.

613,547 tonnes$^*$ of sorghum were produced annually.

Comparison with the global benchmark suggests that there are significant opportunities for increasing water use efficiency through improving yields per unit of water consumed.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Green-blue water footprint (m$^3$/tonne) at different production percentiles</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10$^{th}$</td>
<td>20$^{th}$</td>
</tr>
<tr>
<td>Sorghum</td>
<td>1001</td>
<td>1082</td>
</tr>
</tbody>
</table>

Source: Mekonnen and Hoekstra (2014)

*average for 1996-2005
Cotton: water footprint efficiency

Cotton production is the fourth largest user of green water in Mali and has a green+blue water footprint of 4740 m$^3$ per tonne of production. The 25$^{th}$ percentile benchmark green+blue water footprint is 1898 m$^3$ per tonne of production and the global average is 3589 m$^3$ per tonne. 495,157 tonnes* of cotton were produced annually.

Comparison with the global benchmark suggests that there are opportunities for increasing water use efficiency through improving yields per unit of water consumed.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Green-blue water footprint (m$^3$/tonne) at different production percentiles</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>10$^{th}$</td>
<td>20$^{th}$</td>
</tr>
<tr>
<td>Cotton</td>
<td>1666</td>
<td>1821</td>
</tr>
</tbody>
</table>

*average for 1996-2005

Source: Mekonnen and Hoekstra (2014)
When the water footprint of primarily rain-fed crops such as millets, sorghum and cotton is greater than the global benchmark, it indicates that the land and water resources used to grow these crops are being used inefficiently. The use of green water can become more efficient through improvements in a range of agricultural practices, e.g., seed selection, mulching, tilling, improved soil condition and nutrients application.

Implementing agricultural practices that improve the yield per hectare without increasing the green+blue water footprint will increase the productivity of the land and water resources used in crop production. With millets and sorghum being important food crops, increasing land and water productivity will increase food security. Cotton is an important fibre and higher water efficiency in cotton production will improve its sustainability.
Rice is the crop that uses the largest share of blue water and is the third largest user of green water in Mali. It has a green+blue water footprint of **3460 m³ per tonne** of production. The 25th percentile benchmark green+blue water footprint is **952 m³ per tonne** of production and the global average is **1486 m³ per tonne**. 763,796 tonnes* of rice were produced annually.

Comparison with the global benchmark suggests that there are significant opportunities for increasing water use efficiency through improving yields per unit of water consumed.

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10th</td>
<td>20th</td>
</tr>
<tr>
<td>Rice</td>
<td>599</td>
<td>859</td>
</tr>
</tbody>
</table>

*average for 1996-2005

Source: Mekonnen and Hoekstra (2014)
Sugar cane uses the second largest share of blue water in Mali and has a green+blue water footprint of 282 m$^3$ per tonne of production. The 25$^{th}$ percentile benchmark green+blue water footprint is 128 m$^3$ per tonne of production and the global average is 197 m$^3$ per tonne. 315,726 tonnes* of sugar cane were produced annually.

Comparison with the global benchmark suggests that there are significant opportunities for increasing water use efficiency through improving yields per unit of water consumed.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Green-blue water footprint (m$^3$/tonne) at different production percentiles</th>
<th>Global average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10$^{th}$</td>
<td>20$^{th}$</td>
</tr>
<tr>
<td>Sugar cane</td>
<td>112</td>
<td>123</td>
</tr>
</tbody>
</table>

*average for 1996-2005

Source: Mekonnen and Hoekstra (2014)
Water footprint benchmarks: blue water use

Rice has the largest proportional blue water footprint of all major crops grown in Mali and its green+blue water footprint exceeds the global benchmark both for the 25th percentile and the global average. Rice production is the second largest crop in the country, so improving the productivity of land and water resources used in rice production will increase its sustainability and improve food security as well.

Sugar cane has a blue water footprint larger than its green water footprint. This means that in Mali sugar cane production depends heavily on irrigation. Its green+blue water footprint is greater than the global benchmark, indicating that the land and water resources are inefficiently used in sugar cane production. Improving the land and water productivity will increase the sustainability of its production.
Blue water scarcity
Sustainable water use

Blue water scarcity compares the blue water footprint to the blue water available after environmental flows are met. The blue water available takes into account surface water flows and the connected surficial aquifers. It does not take into account deep groundwater aquifers. It also does not consider storage capacity and releases from dams.

When blue water scarcity is <1, environmental flows are met. With increasing levels of water scarcity above 1, the potential for ecosystem degradation and loss of ecosystem services also increases.

Average annual blue water scarcity indicates the general trend toward blue water scarcity while monthly blue water scarcity indicates the variability of blue water scarcity across the twelve months of the year.

Increasing dependence on blue water resources during time periods and/or in areas already experiencing blue water scarcity will increase the environmental, economic and social impacts of blue water scarcity.
Mali faces significant (orange) to severe (red) levels of annual average blue water scarcity. Almost the entire country, especially the north, experiences severe levels of blue water scarcity throughout the year. These are areas where the blue water footprint is already greatly exceeding the available blue water resulting in violation of environmental flow requirements.

Source: Mekonnen and Hoekstra, 2016
In Mali, February, March, April and May are the months with the highest blue water scarcity. From June through January more than half of the country (particularly in the north) has a blue water scarcity greater than the sustainability threshold. This occurs even though the blue water footprint of production is only 6% of the total water footprint of production.

Source: Mekonnen and Hoekstra, 2016
Virtual water flows
Virtual water flows

The virtual-water export from a country is the volume of virtual water associated with the export of goods from the area. It is the total volume of freshwater consumed or polluted to produce products for export.

The virtual-water import into a country is the volume of virtual water associated with the import of goods into the area. It is the total volume of freshwater used (in the export areas) to produce the products.

Virtual water flows indicate the balance of water consumed for production within Mali versus the water consumed in countries exporting to Mali. The water footprint of production in Mali can be either for goods consumed within Mali or for export products. The water footprint of export products becomes a virtual water flow to the countries the products are exported to.
Mali exports a total of **3688 million m³** per year of green water and **23 million m³** of blue water through its exported goods. It imports **469 million m³** per year of green water and **92 million m³** of blue water through the goods it imports. This makes Mali a **net virtual water exporter of green water** and a **net virtual water importer of blue water**.
Virtual water flows are useful for understanding the proportion of dependency on domestic water resources for food and other goods versus the dependency on water resources in other countries. Virtual water flows assist with considerations of self sufficiency versus external reliance, i.e., import dependency for goods and in prioritising sustainable use of water resources domestically versus externalising the water footprint and its impacts to other countries.

Producing food and other goods domestically provides self sufficiency but may lead to unsustainable pressure on local freshwater resources. Importing food and other goods from other countries may put less pressure on domestic water resources but increases import dependency and reliance on water resources external to the country. Unsustainable use of water resources in exporting countries may lead to vulnerability in the supply of those goods and risks associated with access to and pricing of the desired goods.
Water footprint of consumption
Water footprint of consumption

The water footprint of consumption is the amount of water used to produce all the goods and services that are consumed by the people living in a country. This water footprint may be partly inside the country and partly in other countries, depending on whether the products are locally produced or imported.
The total annual green and blue water footprint of consumption in Mali is **21.2 billion m³**. 92% of this is green water footprint; the remaining 8% is blue water footprint.
The annual green water footprint of consumption in Mali is **19.5 billion m³**. This means that the per capita green water footprint is **1824 m³ per year**. Of that, 97% comes from internal green water resources while 3% comes from external green water resources through imported goods.
The total annual blue water footprint of consumption is **1.7 billion m³**. Of this **96.2%** is for agricultural crops, **3.5%** is for domestic water supply and **0.3%** is industrial water use. The per capita blue water footprint of consumption is **156.7 m³ per year**.

93% of the annual blue water footprint of consumption is from products produced within Mali while 7% is from products produced elsewhere.
Where Mali’s water footprint lands

The majority of Mali’s green water footprint of consumption comes from inside the country, with an external dependency of only 3% of the total green water footprint. Similarly, Mali’s blue water footprint of consumption comes from within the country with only 7% from external dependency. This indicates that the national consumption of Mali is mainly reliant on its own production using its own water resources. This implies that the country has little dependency on other countries for the supply of goods.

Given that the blue water resources of the country are under high pressure, it would be worth investigating the potential of importing some goods that are highly water demanding to produce, while domestically producing other goods with a better water comparative advantage. This way, the pressure on Mali’s blue water resources could be lessened while a balanced level of dependency on other countries is maintained. Additionally, improving the efficiency of irrigated crops such as rice and sugar cane could reduce pressure on Mali’s limited blue water resources.
Key learning and next steps
Key learning

• In Mali, the water resources (green and blue water) are mainly consumed for crop production.

• The major crops grown in Mali which consume the largest proportion of green and blue water resources are millets, sorghum, cotton, rice and sugar cane.

• These crops are produced primarily for domestic consumption.

• Water productivity for these crops is low when compared with the global water footprint benchmarks.

• The blue water resources of Mali are under pressure with high blue water scarcity throughout the country. Its blue water consumption is unsustainable and little protection has been given to environmental flow requirements.

• Improving water and land productivity can improve water use sustainability and help ensure food security.

• Mali is a net virtual water exporter for green water and net virtual water importer for blue water.

• Mali’s national consumption water footprint shows that the country has a low external water dependency while its own blue water resources are under pressure.
Further exploration

• Agriculture development: Evaluate agricultural practices and identify those that will improve yields and reduce water footprints.

• Economic development: Assess agricultural crops for their comparative advantage in terms of water footprint from the global perspective and internally to Mali.

• Water resource management: Conduct a geographic Water Footprint Assessment to inform water resource management and planning and enhance ecosystem services.

• Trade: Investigate trade-offs between reliance on internal and external water resources for food and supply chain inputs.
Data sources, limitations and references
Available data was used in the preparation of this report. Water footprint data was sourced from WaterStat: http://waterfootprint.org/en/resources/water-footprint-statistics/ (see References and Data Sources). The data covers the years 1996-2005.

- Water footprint of production (Mekonnen, M.M. and Hoekstra, A.Y, 2011): The data includes 126 crops modeled at a 5 by 5 arc minute grid for the years 1996-2005 using a grid-based dynamic water balance model to calculate crop water use over time, with a time step of one day. The model takes into account the daily soil water balance and climatic conditions for each grid cell. It does not differentiate between surface and groundwater use.

- Blue water scarcity (Mekonnen, M.M. and Hoekstra, A.Y, 2016): Global water scarcity was assessed on a monthly basis at the level of grid cells of 30x30 arc minute. Water scarcity as locally experienced is calculated as the ratio of the blue water footprint in a grid cell to the total blue water availability in the cell. Total blue water availability is the sum of the runoff generated within the grid cell plus the runoff generated in all upstream grid cells minus the environmental flow requirement and minus the blue water footprint in upstream grid cells. The available water includes surface and surficial groundwater. Blue water scarcity does not take into account the use of deep groundwater aquifers.

- Virtual water flows (Mekonnen, M.M. and Hoekstra, A.Y, 2014): International virtual water flows were calculated by multiplying, per trade commodity, the volume of trade by the respective average WF per ton of product as in the exporting nation. Data on international trade in agricultural and industrial products have been taken from the Statistics for International Trade Analysis database available from the International Trade Centre.

- Water footprint of consumption (Mekonnen, M.M. and Hoekstra, A.Y, 2014): Data on national consumption of agricultural products per country for the period 1996–2005 were taken from the Supply and Utilization Accounts of the Food and Agriculture Organization of the United Nations. For industrial commodities, the WF of national consumption is calculated based on the top-down approach as the WF of industrial processes taking place within the nation plus the virtual water import related to import of industrial commodities minus the virtual water export.
Limitations

- The water footprint data used in this report come from peer reviewed scientific literature and have been accessed from publicly available global databases. In many cases, models have been used to produce the data. These data have not been verified using local data and will contain the inaccuracies and uncertainties inherent in datasets produced using data aggregated from local sources to the country scale.

- As all data were developed using the same models, they do support comparative analysis. The data are averages from the country over the years in the studies: 1996-2005. Variation will be found in the water footprints of individual producers and consumers both within one year and across years.

- The results presented in this report should be considered indicative, not accurately representative, of the actual situation. However, they are useful for identifying the general conditions within the country and can be useful in determining where studies should be undertaken using more accurate data.
References


