Water footprint of cotton production

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Overview and Motivation

After visiting Kazakhstan and the Aral sea region in 2011 I learned about the impacts intensive cotton grow and water regulation can have on a ecosystem. The continuous cultivation of cotton in the Aral Sea basin of Uzbekistan has caused a tremendous decrease in the surface area of the sea - the water volume has been reduced to 10%. The reason is that two of the rivers that formerly fed the Aral Sea (the Amu Darya River and Syr Darya River) were diverted for cotton production. Cotton uses a huge amount of water both to produce and process. It can take 2,700 liters to produce the cotton needed to make a single t-shirt. Estimates indicate that cotton represents more than half of the irrigated agricultural land in the world.

Cotton production and processing are also a major source of pollution of fresh water. Globally, freshwater resources are becoming scarcer due to a growing population, increasing wealth and consumption and hence increasing water withdrawals for human use. The impact of consumption can be quantified with the concept of the “water footprint”, a concept introduced by Hoekstra and Hung (2002), and further elaborated by Chapagain and Hoekstra (2004). The water footprint of a nation has been defined as the total volume of freshwater that is used to produce the goods and services consumed by the inhabitants of the nation (Chapagain et al., 2006).

With my visualization I want to show the world wide cotton production and compare this data with the consumptive water use. The water consumption can be divided into green water (water from rainwater stored in soil) and blue water (fresh water in lakes, rivers, aquifers). Blue water is stress-weighted because it is consumed at rates faster than its short-term replacement and many cotton producing countries have limited blue water resources. I want to compare this 2 types per country and show the result in relative (per capita) and absolute values.

Related Work

papers and other ressources:

- a paper about Aral Sea
- Paper about The water footprint of cotton consumption : http://doc.utwente.nl/58372/1/Report18.pdf
- my trip to Aral sea in 2011
- nasa prictures of Aral sea: http://earthobservatory.nasa.gov/Features/WorldOfChange/aral_sea.php?all=y

Visualizations:

- http://viewer.phildow.net/world-gdp-growth/
- Fresh water supply worldwide: http://www.josephbergen.com/viz/water/
- http://mbostock.github.io/protovis/ex/symbol.html
- http://data.karmi.cz/d3/life-expectancy-map/
- http://bl.ocks.org/KoGor/5685876
- http://chartsbin.com/view/1455

Questions

1. Which countries are the main cotton producers?
2. How much do the produce?
3. How much did this production per country change since 1961?
4. How much green and blue water is used for cotton production in in relation to each other?
5. How much green and blue water is used for cotton production in total? After my Exploratory Data Analysis I discovered that India is using huge amounts of blue water due to its big production. But relatively it is using more green water
6. Finally see which countries are suitable for cotton production

Data

Data sources

- I use cotton production data from http://faostat3.fao.org
- I use population data from http://faostat3.fao.org
- I used data from http://www.waterfootprint.org/?page=files/WaterStat-ProductWater-Footprints to get the water footprint of cotton products
- all the country codes to connect the data with the map I got from : http://www.geonames.org/countries/ and http://wits.worldbank.org/WITS/wits/WITSHELP/Content/Codes/Country_Codes.htm
- Geoinformation (Lat and Lon) I got from https://opendata.socrata.com/dataset/Country-List-ISO-3166-Codes-Latitude-Longitude/mnkm-8ram

Calculation

A friend helped me to calculate the per capita values of cotton production and water consumption.

We have used data on the production of cotton seed and cotton lint (1st Level only to avoid doublecountings), and export data for all 1st and 2nd level (see figure 1) cotton products from FAOSTAT (accessed April 2014) to gather the annual domestic production from 1960 – 2012 for XXX countries on a country level. The data was available in 1000tons/yr. For the water consumption, we have downloaded data from waterfootprint.org (Appendix II. Water footprint per ton of crop or derived crop product at national and sub-national level (m3/ton) (1996-2005); accessed April 2014). Data was only available for 1996-2005 averages for green/blue/grey water consumption, for all 1st level and 2nd level cotton products. We have used these average values for the whole time period which maybe lead to an overestimation for earlier years. For easier readability, we have only calculated green/blue water use for total production.

In order to compare the water consumption of countries we have normalised total values by population (data from FAOSTATS population database). The per capita requirements of water for cotton production can show important links to food security and water shortages, especially in dry regions that are large producers of cotton and cotton derived products.

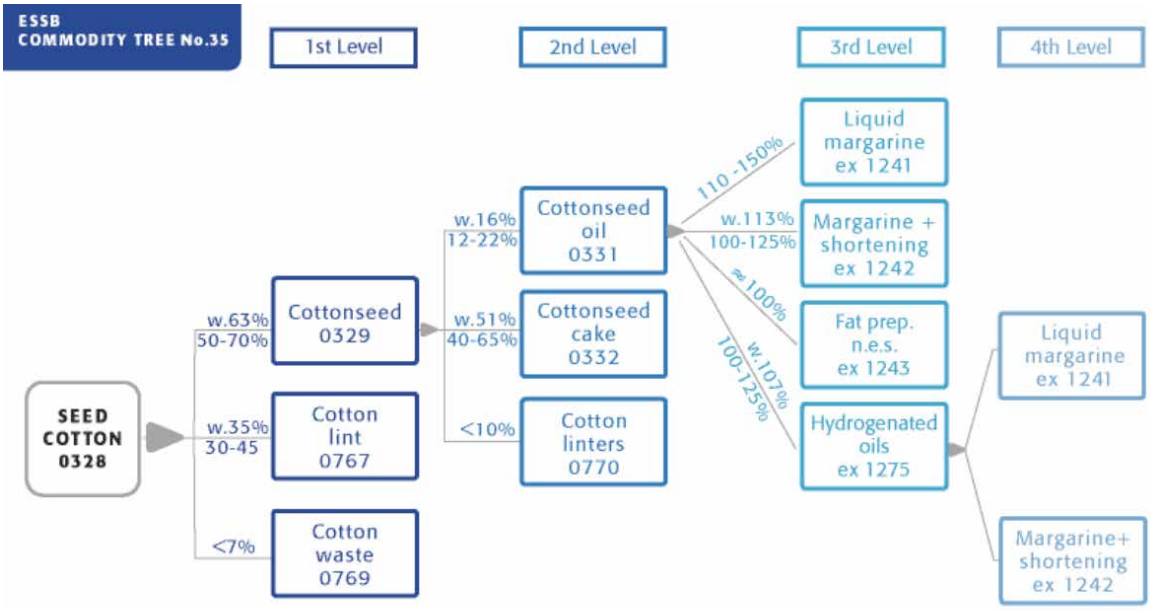


Figure 1: Cotton commodity tree (source: Faostat)

Data cleanup

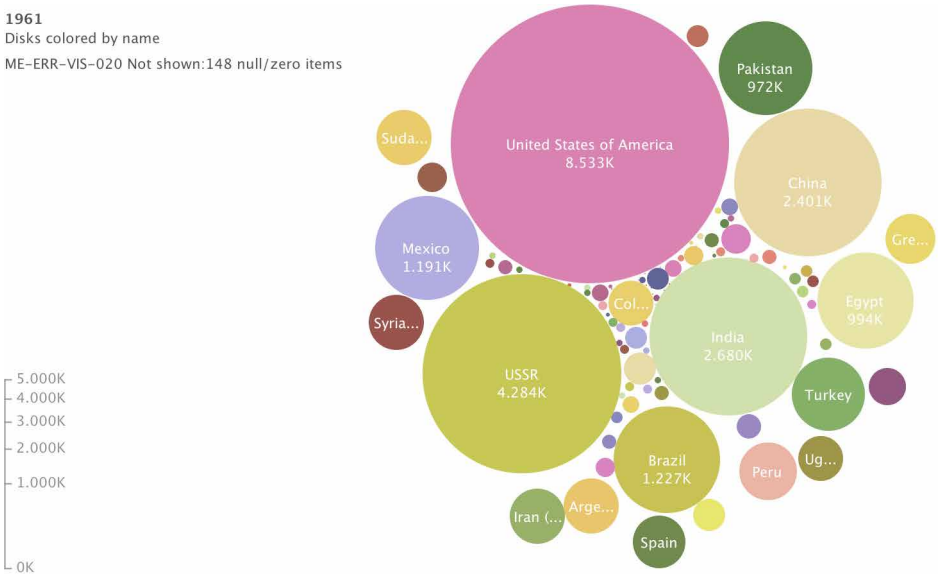
I calclated averages for cotton producing countries that don't have water consumtion data or split up since 1961:

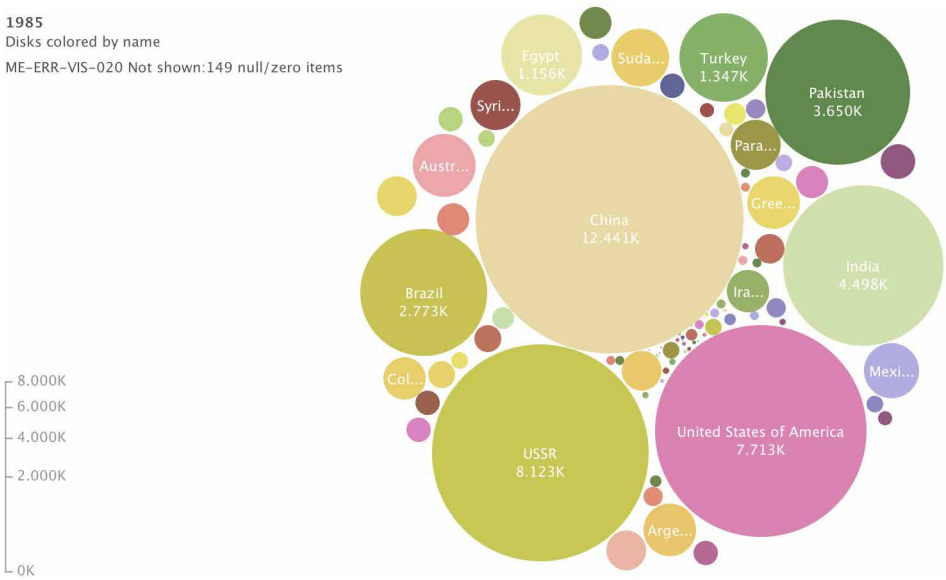
Uruguay: Average of Argentina, Brazil, Paraguay
Sri Lanka: Values of India
Saint Vincent and Grenadines, Saint Kitts and Nevis, Montserrat, Haiti, Guadeloupe, Grenada, Dominican Republic, Cuba, Antigua and Barbuda: Average of Nicaragua, Venezuela, Costa Rica, Colombia, Guatemala, Honduras
Rwanda: Congo, Tanzania, Uganda, Burundi
Philippines: Average of Indonesia, Viet Nam
Nigeria: Average of Benin, Cameroon, Niger
Korea: Values of Korea, Democratic People's Republic of
Italy: Values of Spain
Cyprus: Average of Greece, Turkey
Bangladesh: Average of India, Myanmar
USSR: Average of all cotton producing USSR states
Yugoslav SFR: Average of all cotton producing Yugoslav SFR states

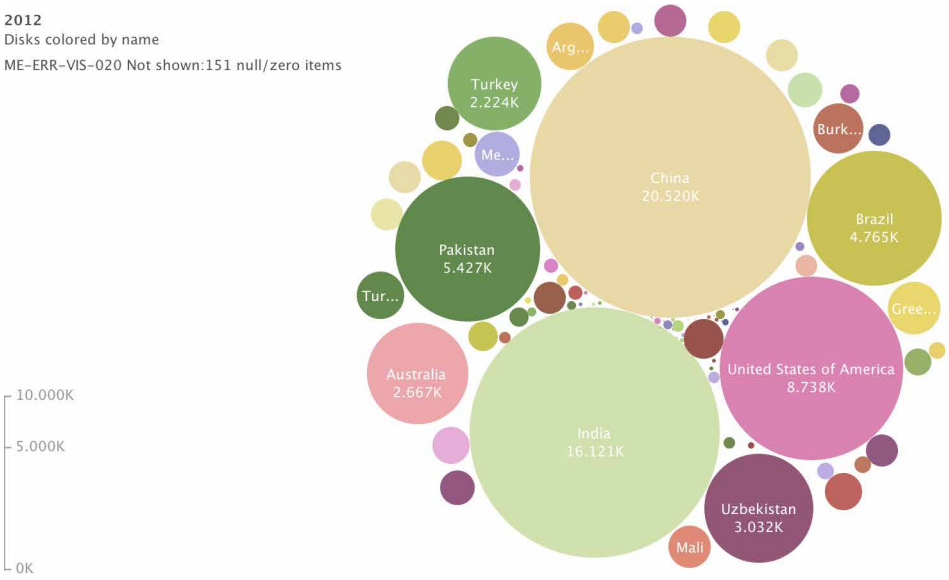
Exploratory Data Analysis

I explored my data with “Many Eyes” http://www-958.ibm.com/software/data/cognos/many-eyes/

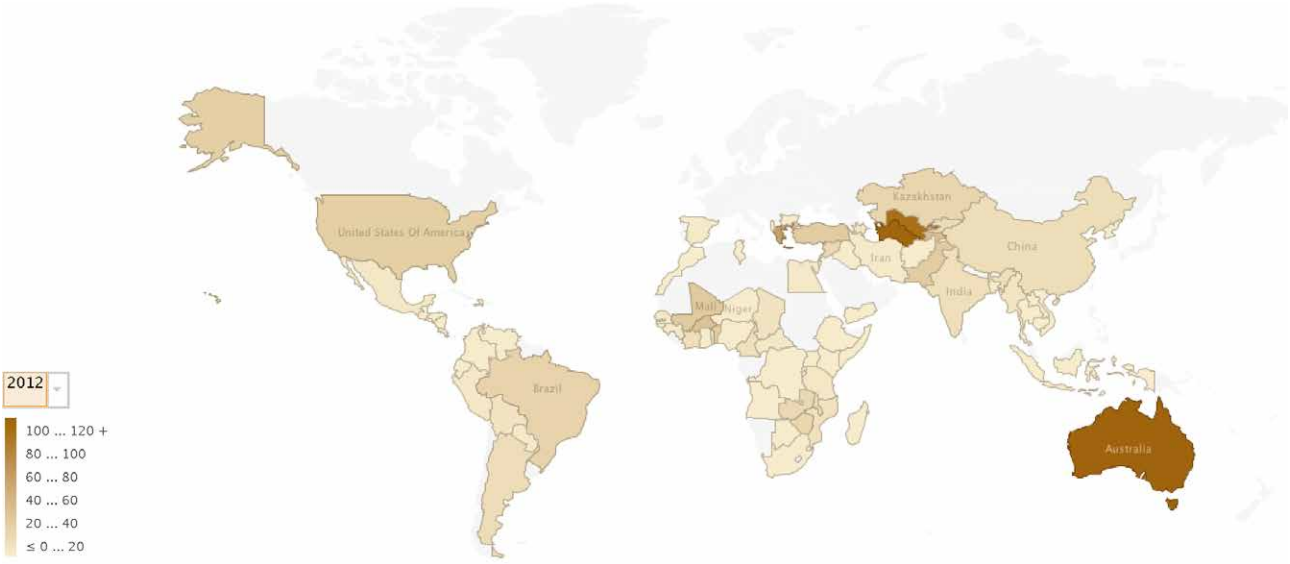
Total cotton production over years







cotton production per capita 2012



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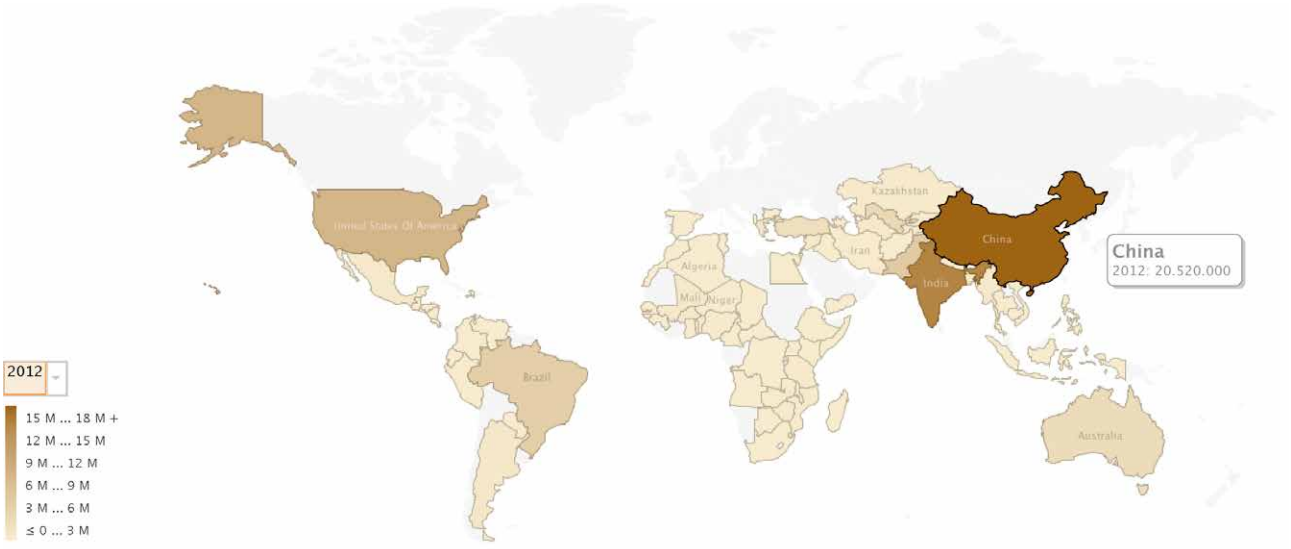

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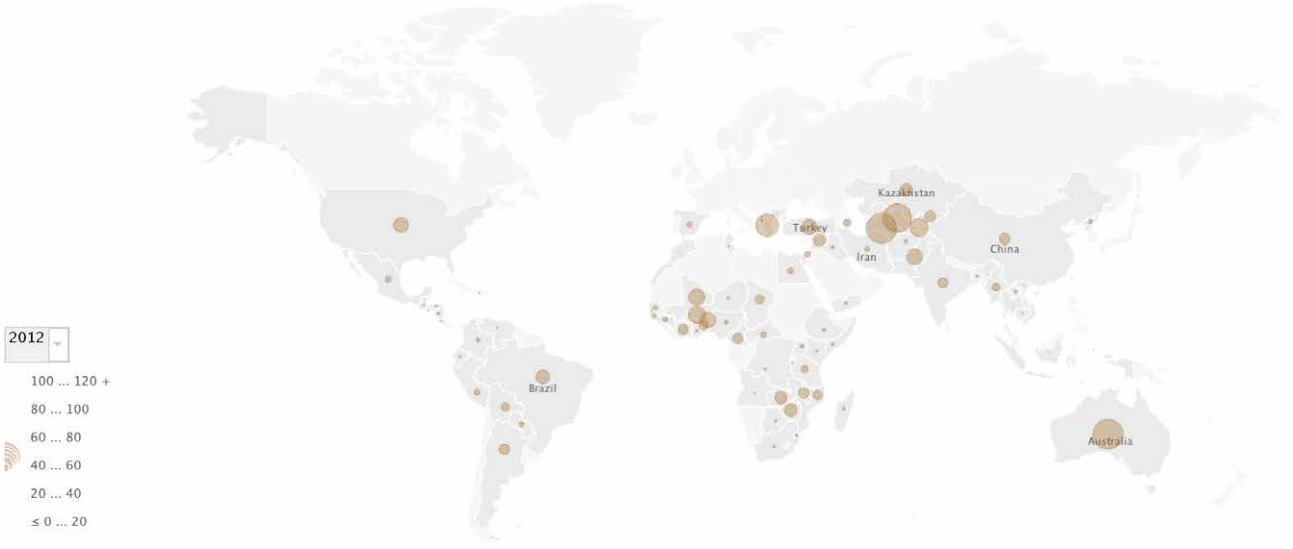

total cotton production 2012

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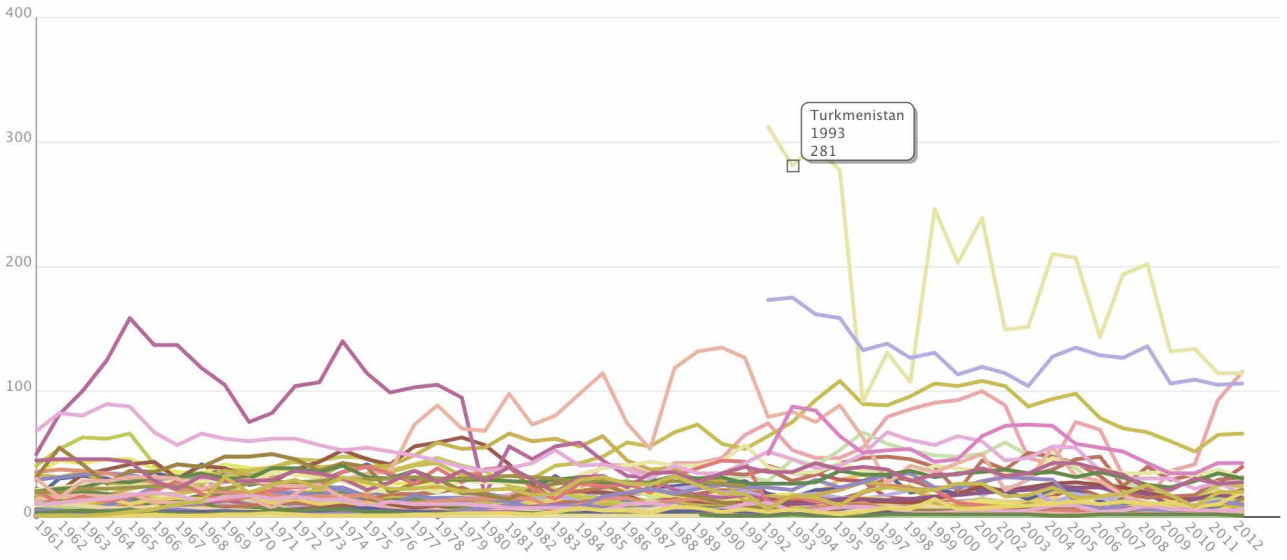
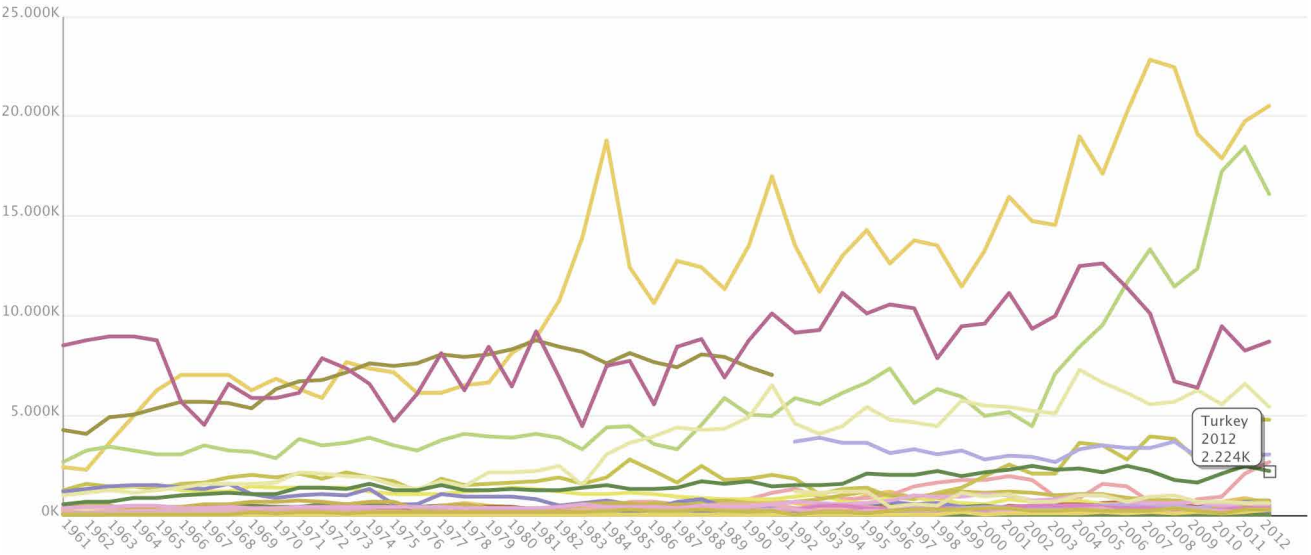
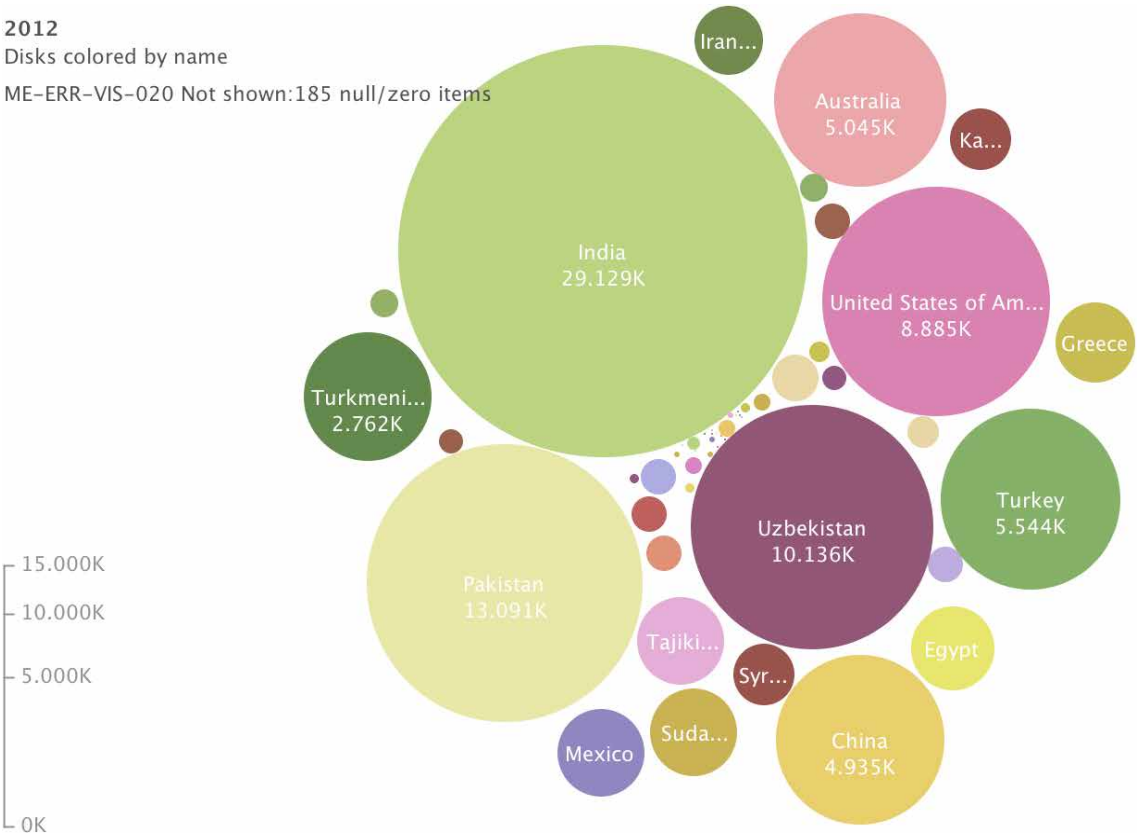


total cotton production



blue water consumption total (1000 m^3)



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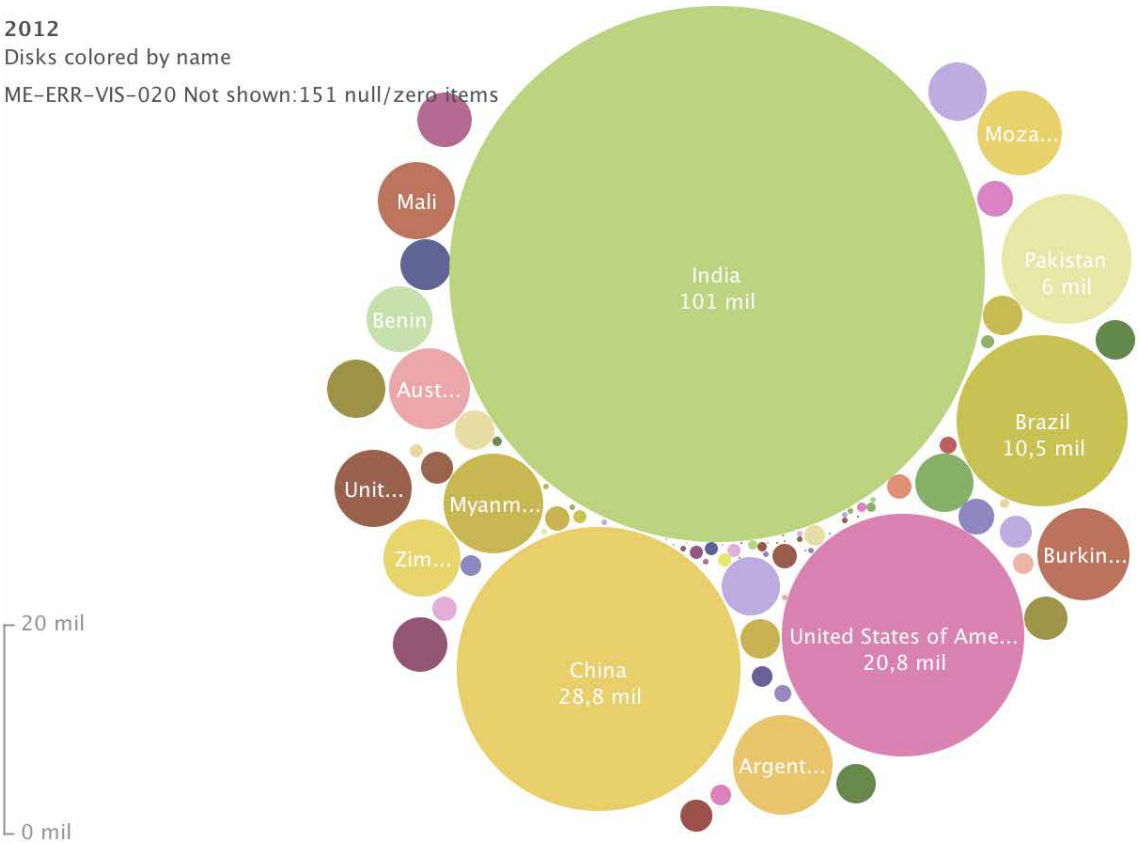

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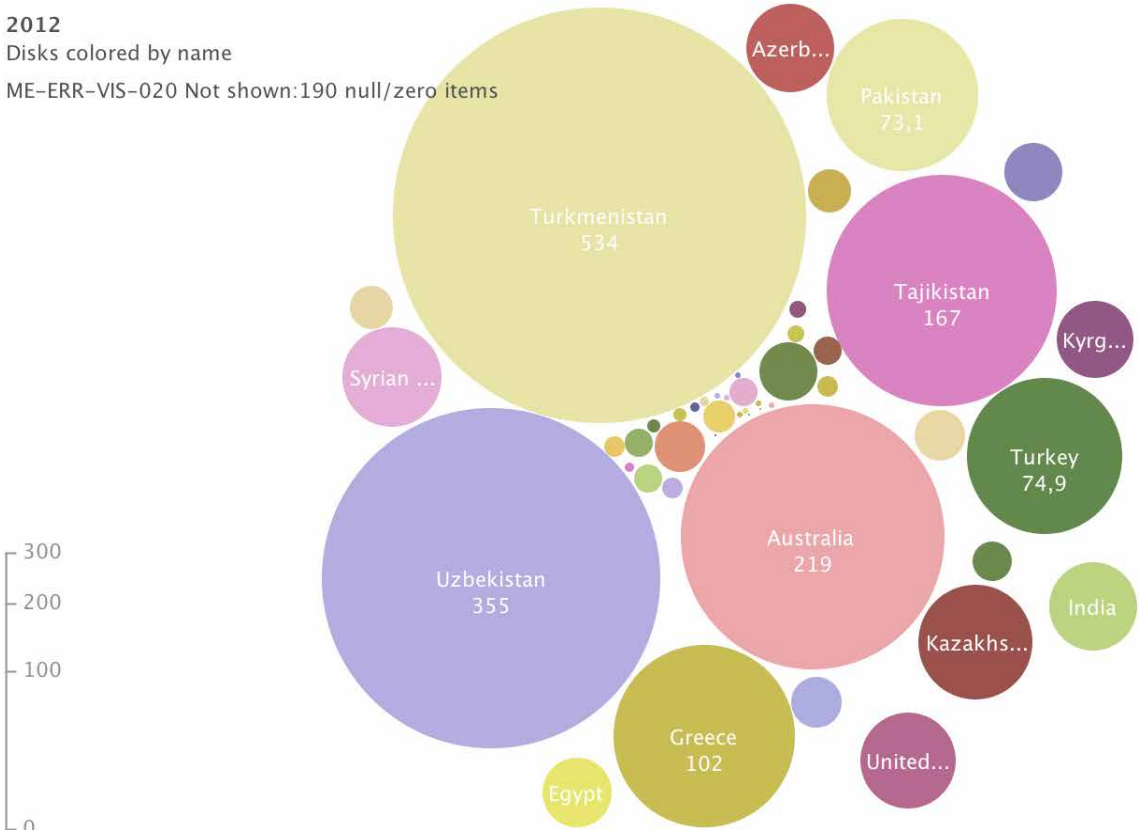

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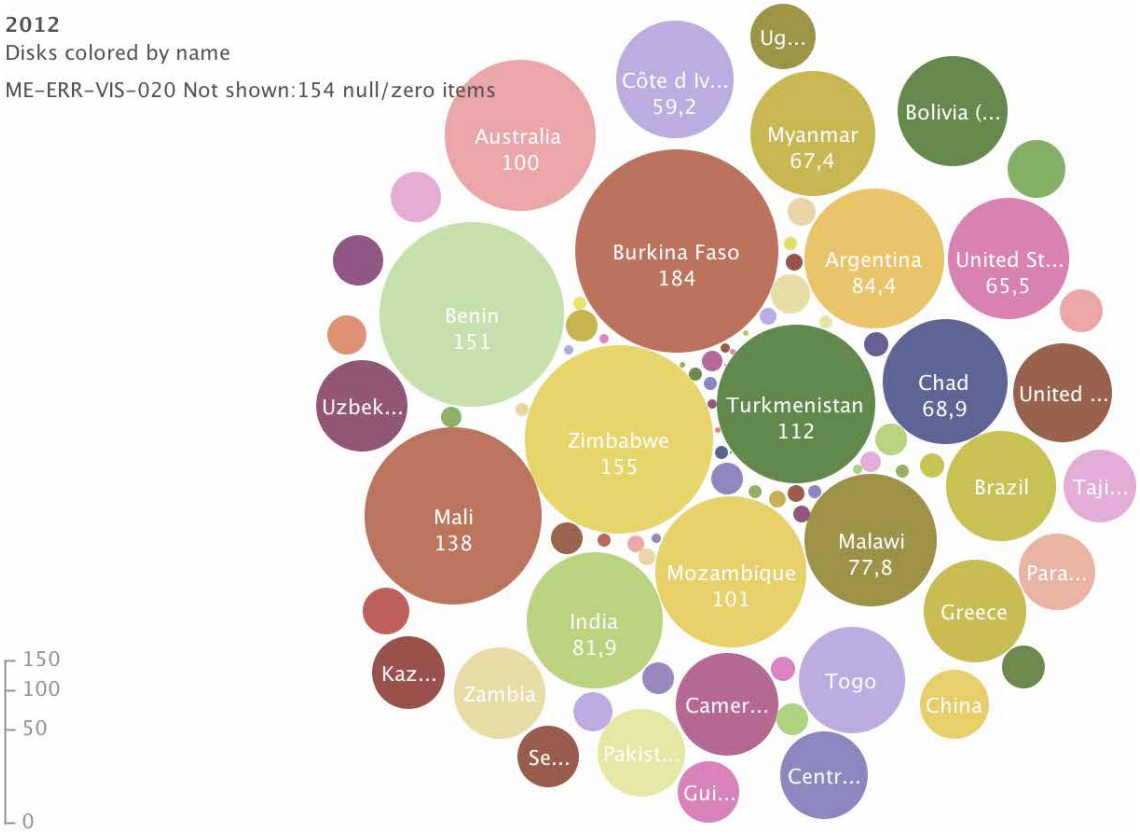

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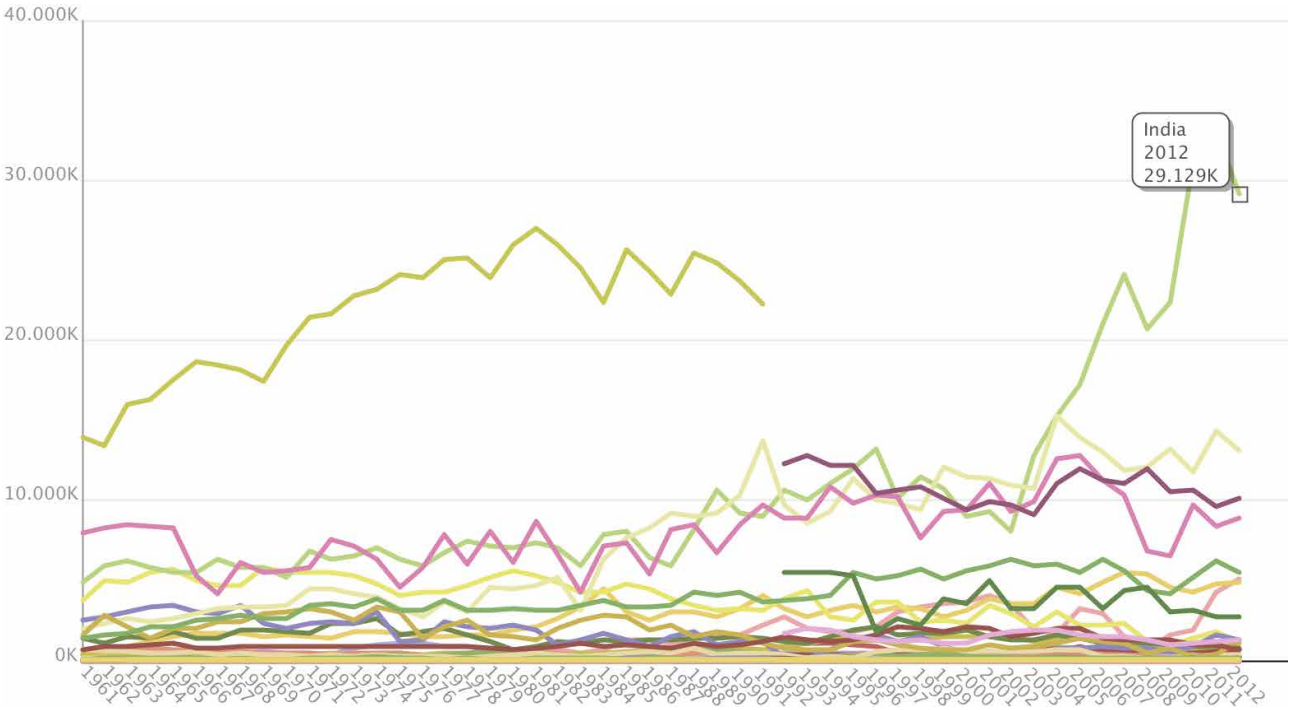

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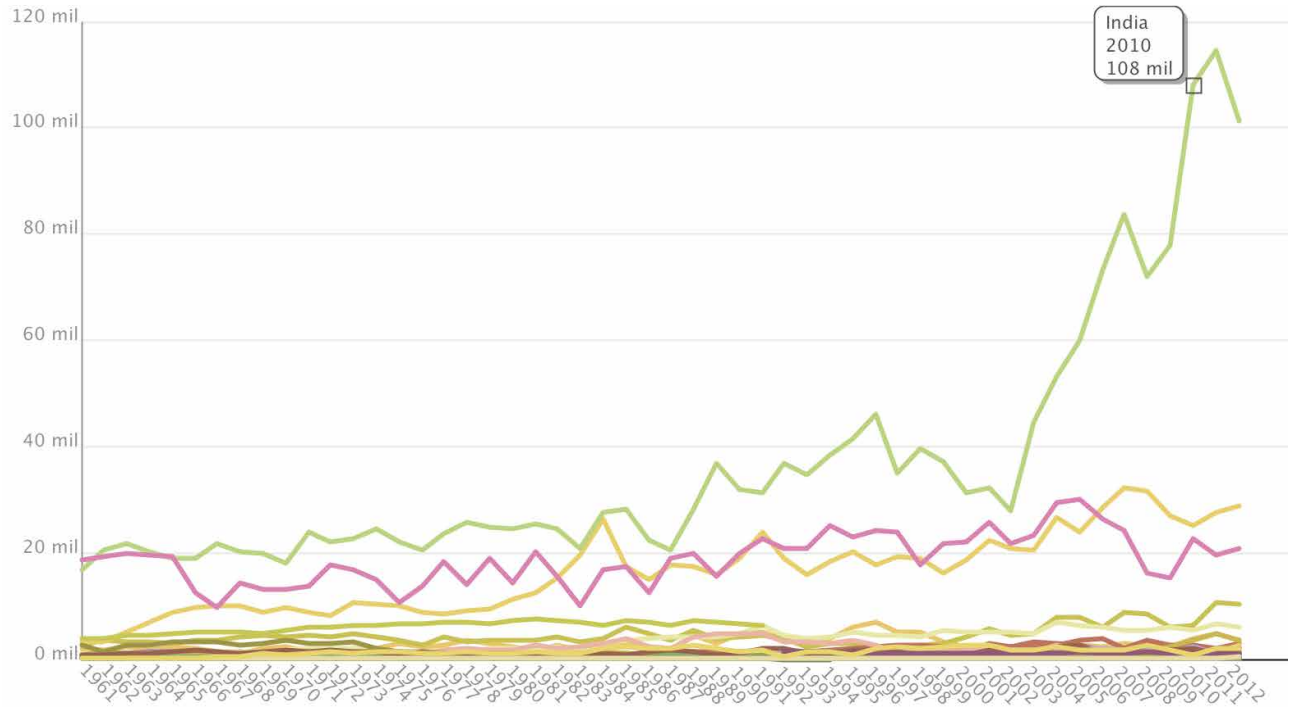

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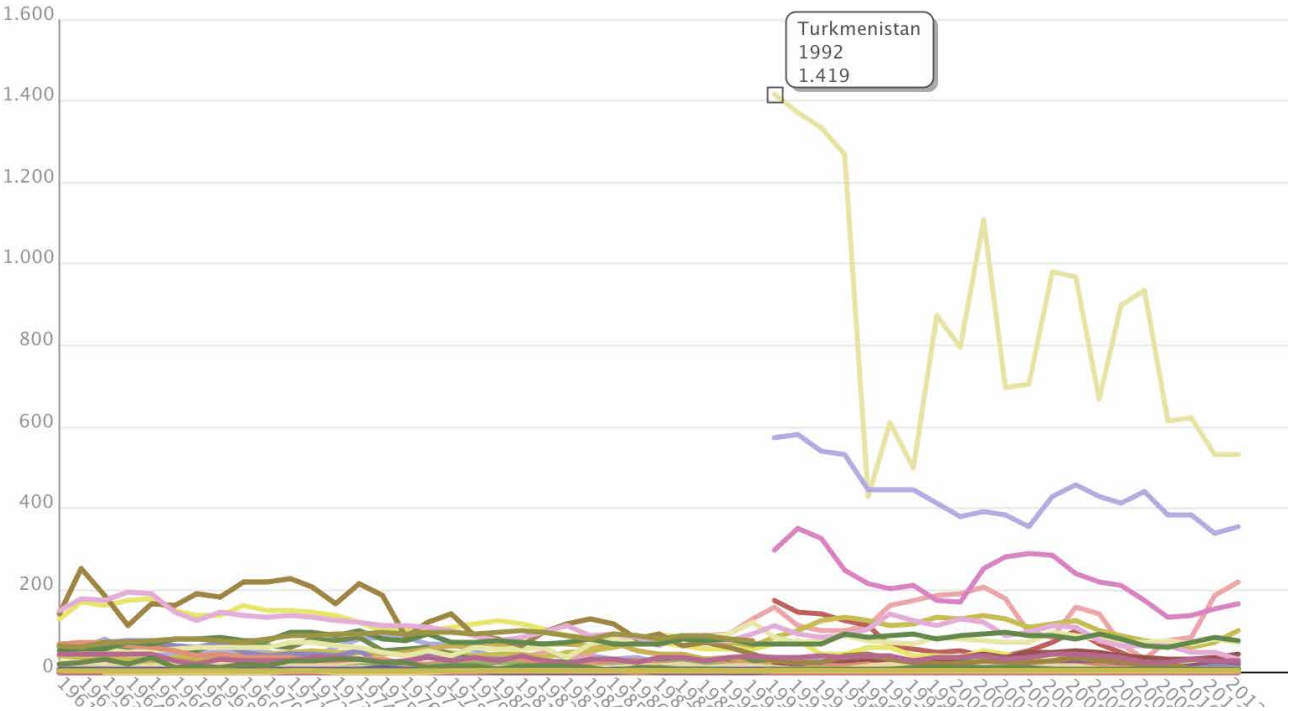

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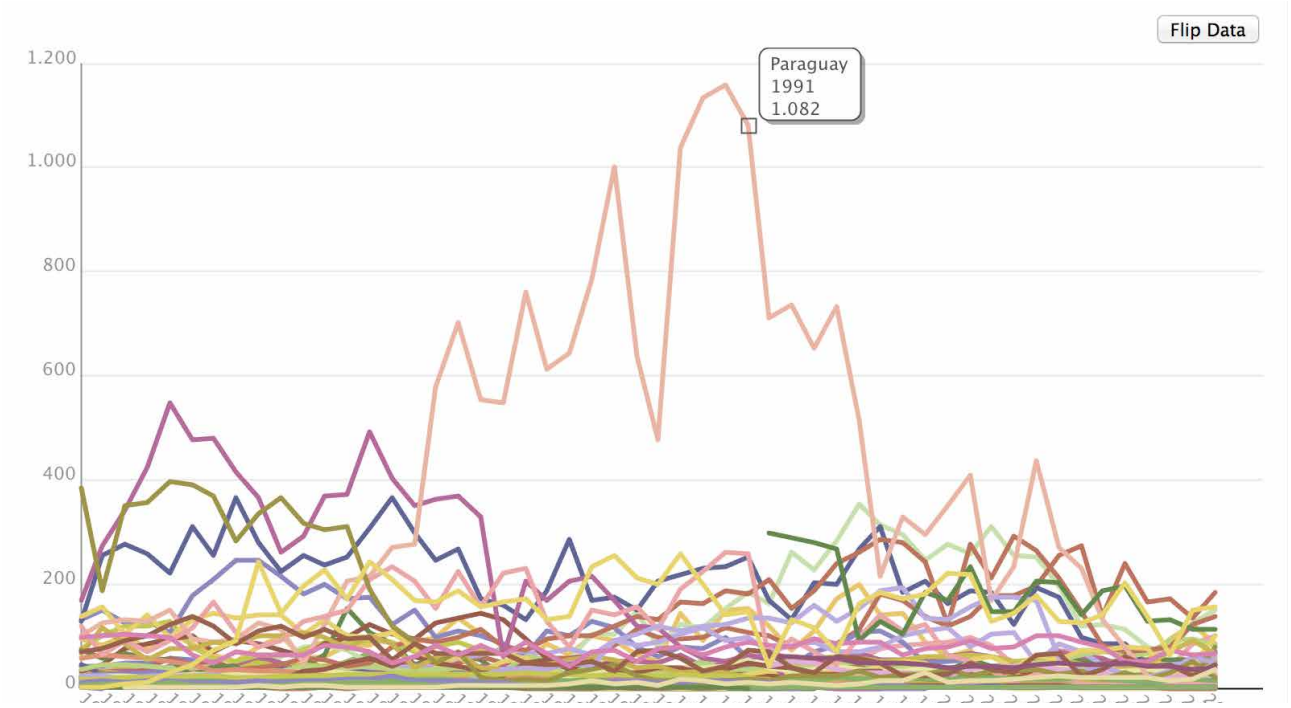

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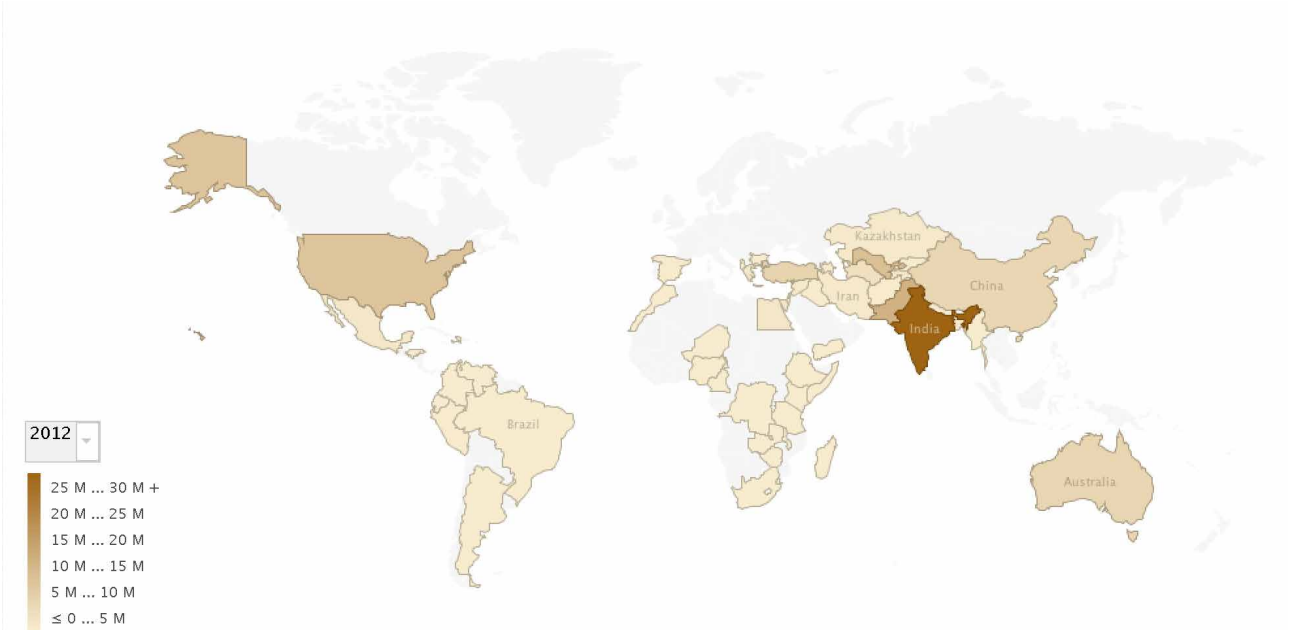

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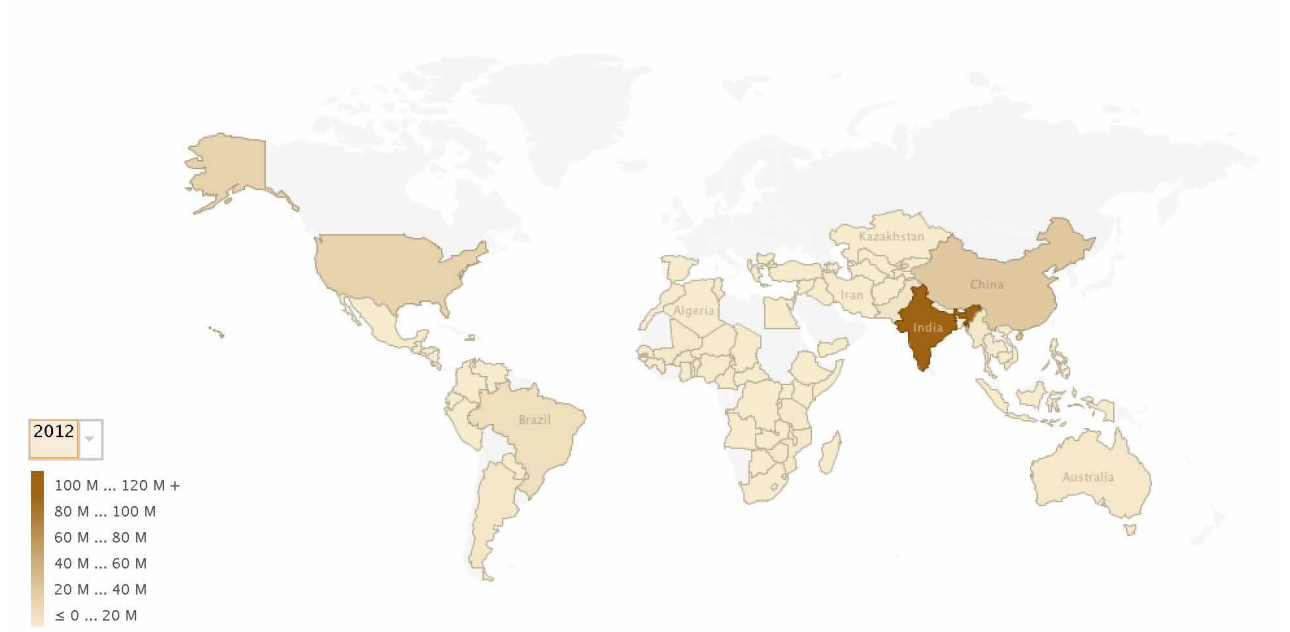

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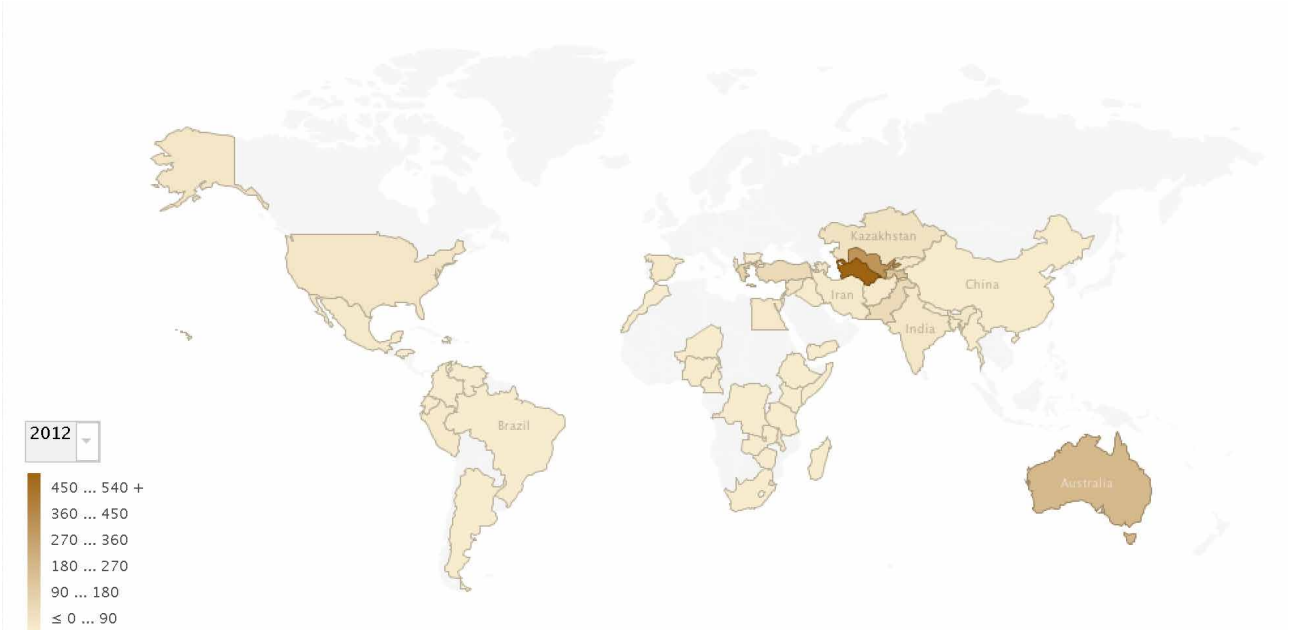

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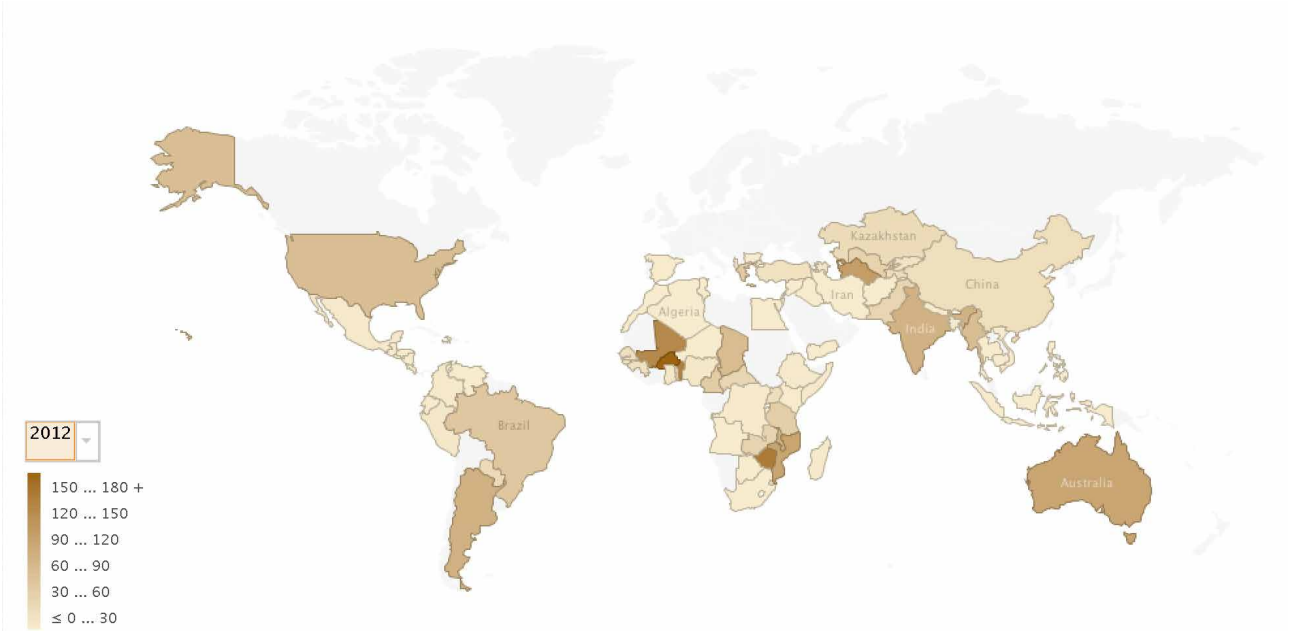
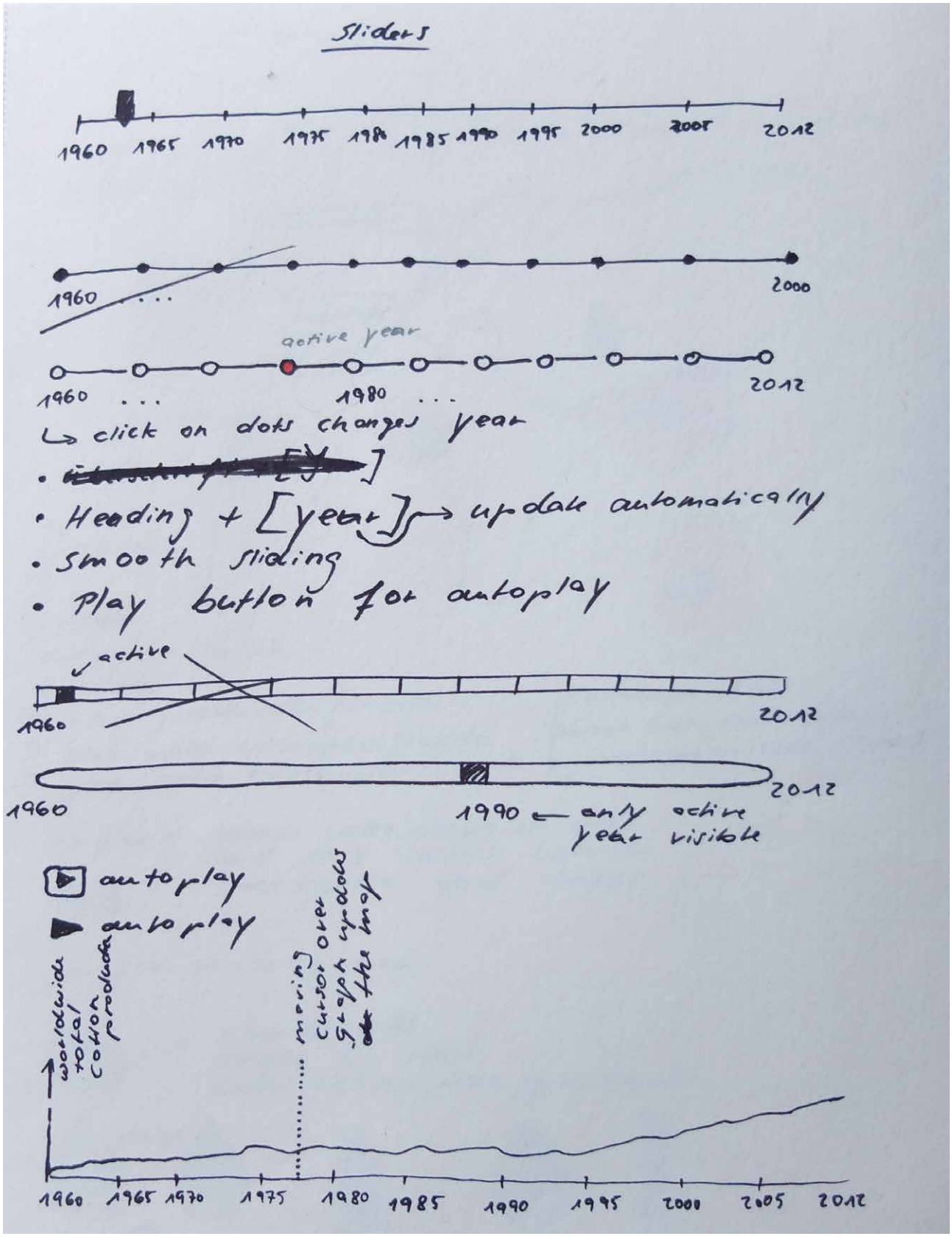
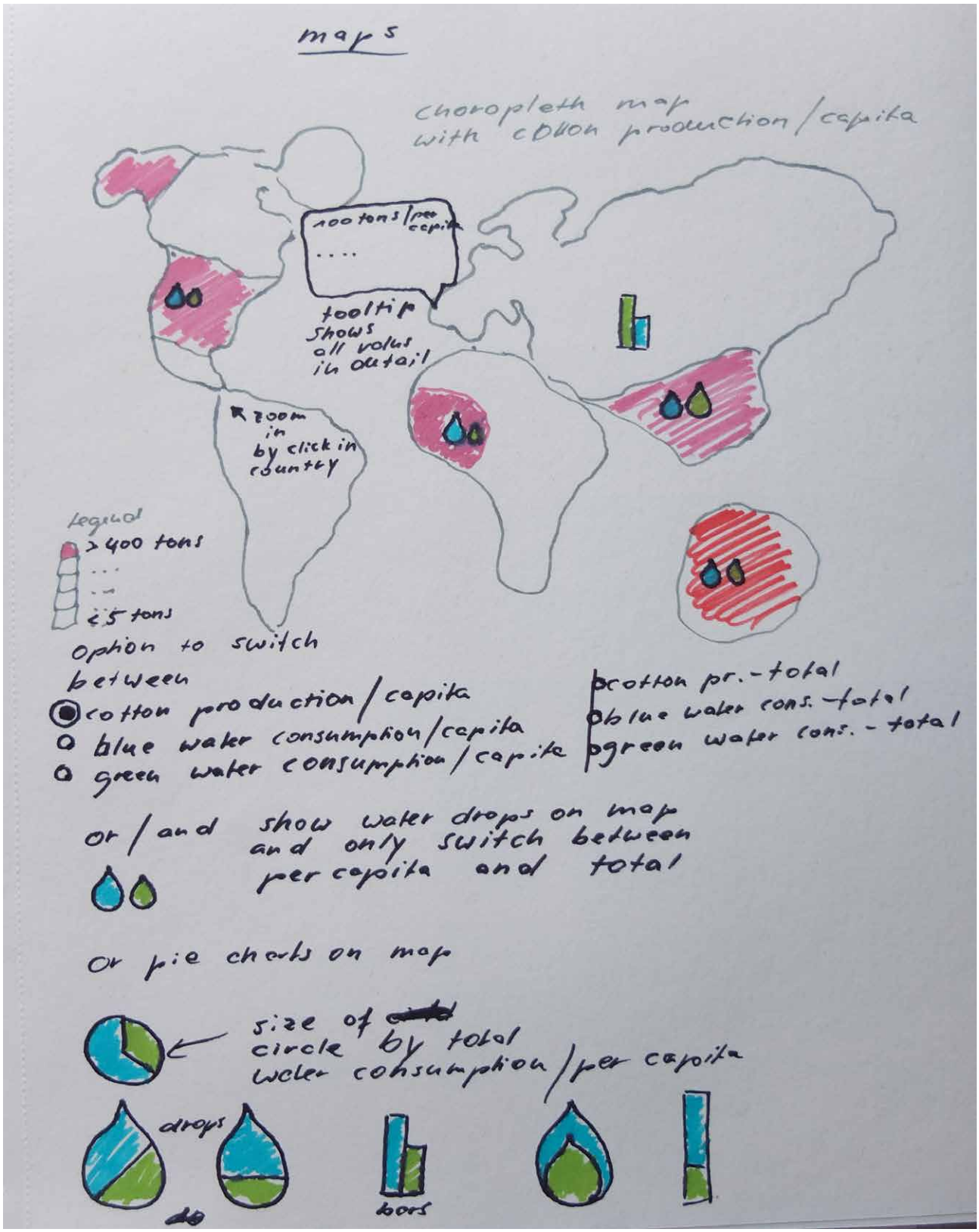


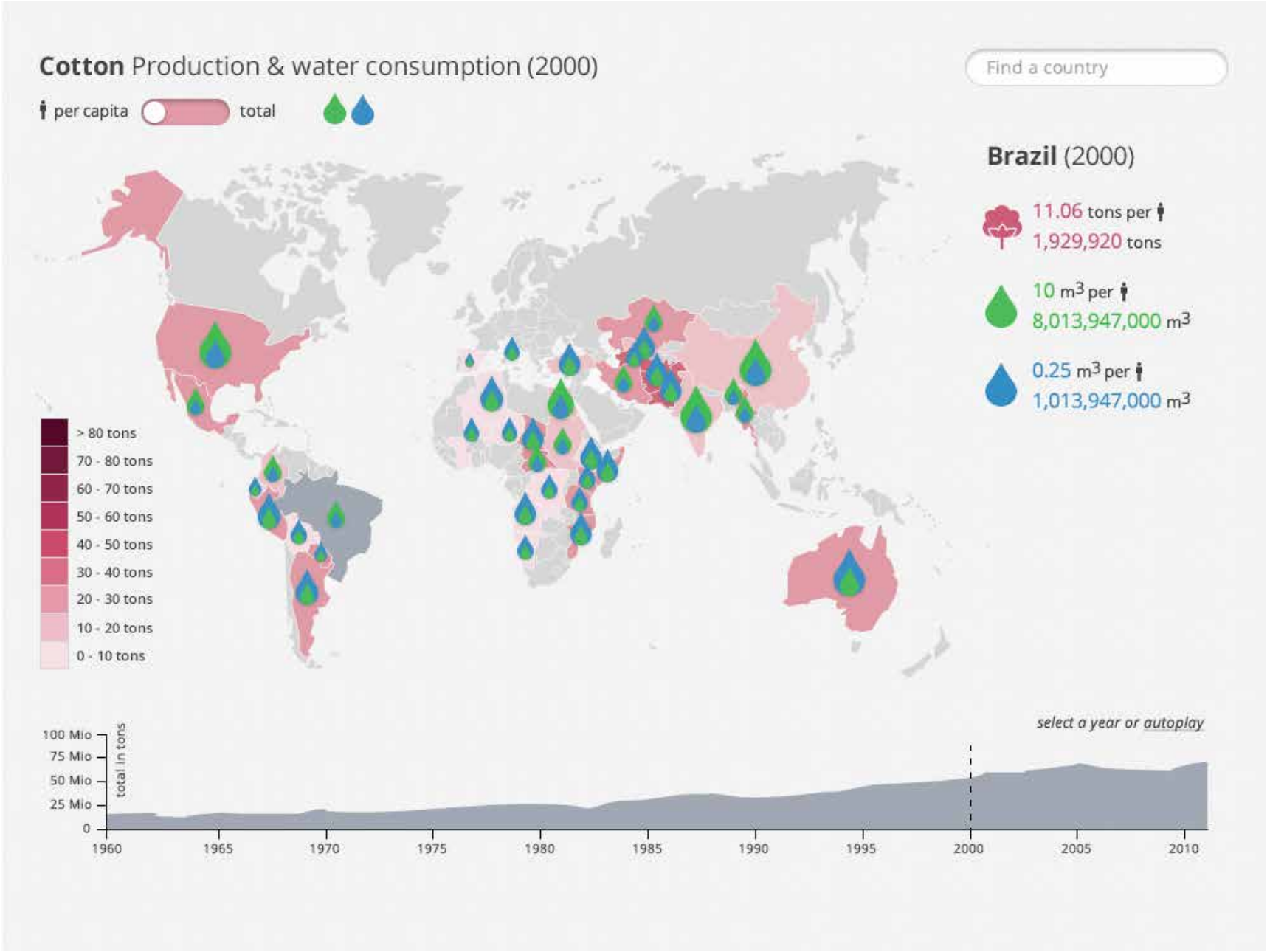
Design Evolution

Sketches of possible time sliders



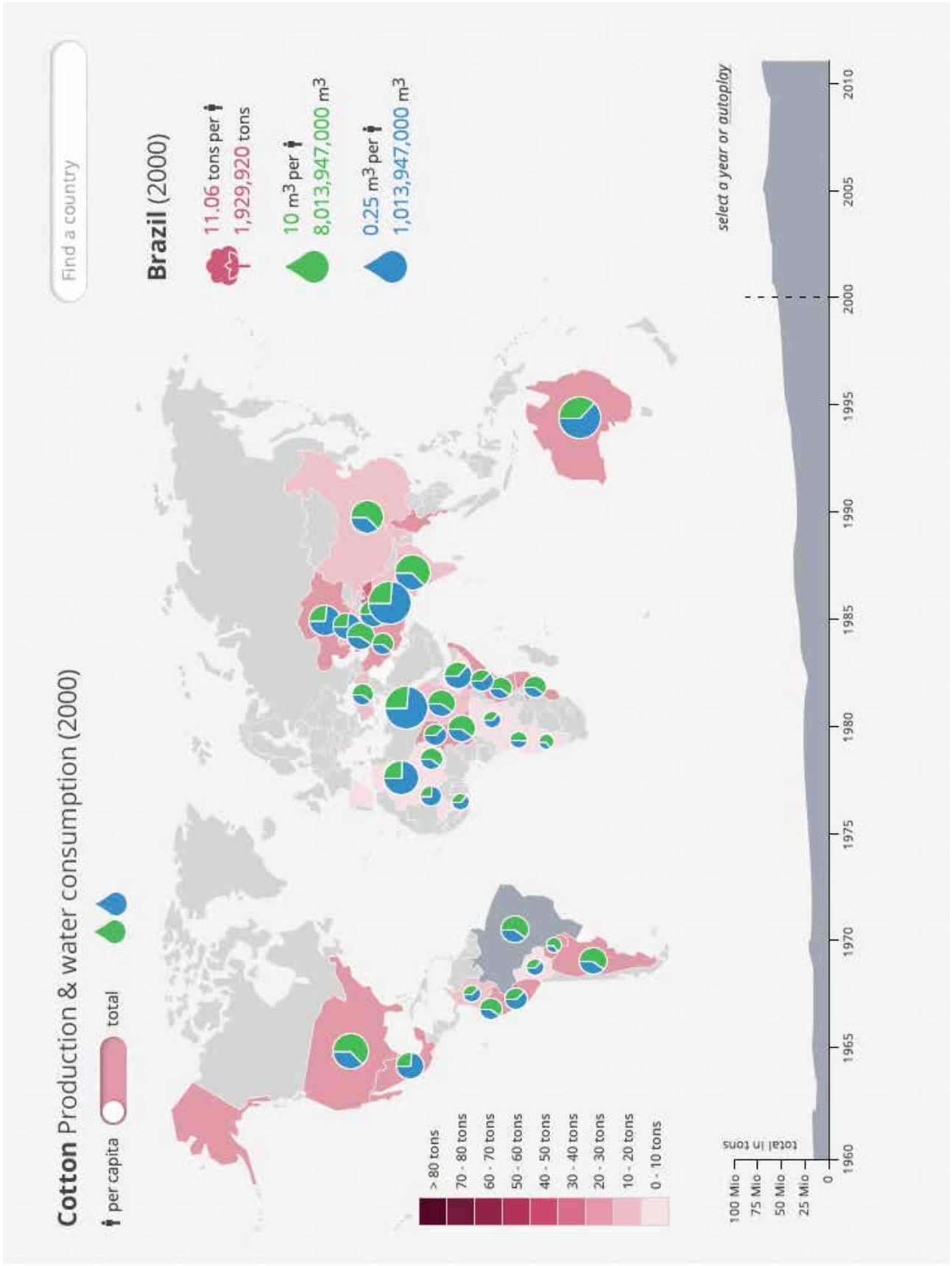
choropleth map sketch and display of water values
possible integration of filters and switches



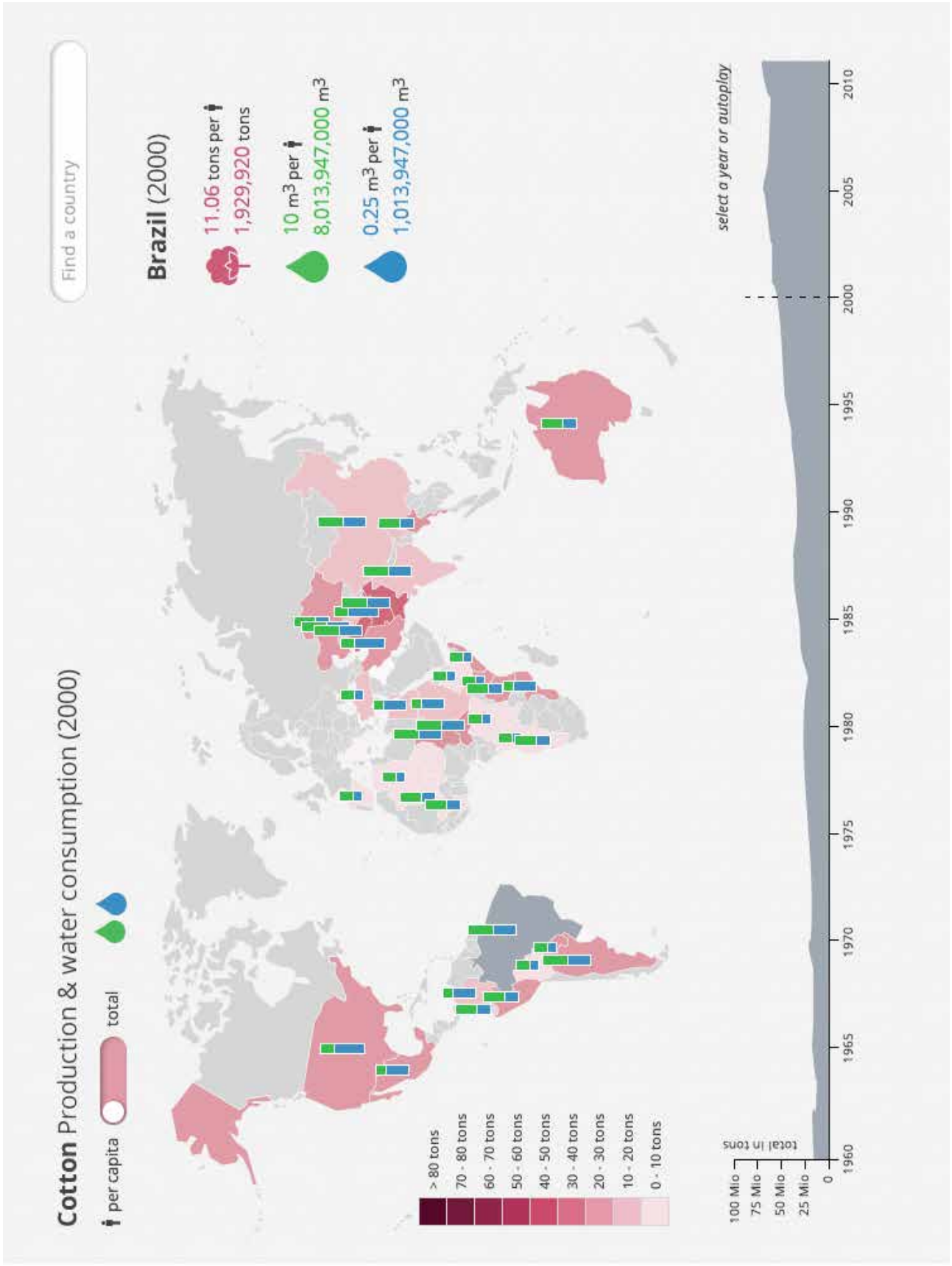


final design with drops

final design with pie charts



final design with stacked bar charts



Design explanation

I will implement a choropleth map in combination with symbol map to show all 3 values in relation to each other. I will choose between pie charts and stacked bar charts because with drops it will be difficult to compare the values for blue and green water. At the bottom of the map there is a area or line chart with the total production worldwide. This chart is also the time slider but there is also the possibility to navigate via arrow keys or cycle through years via autoplay. The year values in the heading and the right side will update autmatically. At the top of the map you can choose between per capita and total values to compare the differences for each country in each year. I will implement a zoom via scroll and click. By hovering over a country you can see all values for that country on the right side of the map and the bottom graph will only display the values for that country. I will implement a country search that instantly gives me the values of the country and highlights it on the map. By clicking the green or blue drop on the top you can disable/enable the display of that values on the map.

Implementation

Evaluation