Trends in Population Density and Dam Concentration within International River Basins

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I. Introduction

An International River Basin (IRB), simply put, is a watershed which extends across national borders. The Transboundary Freshwater Dispute Database (TFDD) defines an international river basin according to two criteria: 1) area that drains to a common outlet and 2) perennial tributary crossing the border (McCracken and Wolf, Forthcoming). There are 310 IRBs identified by the TFDD and defined by topography and current national borders. The basin area within individual countries that share an IRB is known as a Basin Country Unit (BCU); this means that one IRB is comprised of at least two BCUs, depending on the number of riparians sharing the basin. These areas identify locations where sharing water can be more complex, since multiple nations are involved.

The purpose of this research is to update parts of the TFDD, a multifaceted global database that began in 1996 and includes a collection of international freshwater treaties, a database of water conflict-cooperation events, and a spatial database. Two aspects of the spatial database were updated: population density and dam concentration. Rapidly rising populations can be an indicator for increased water stress. Dam statistics provide further insight into the management of shared waters and have been used as an indicator for potential conflict (UNEP, 2016). Thus, these factors provide valuable insight into global trends in internationally shared waters.

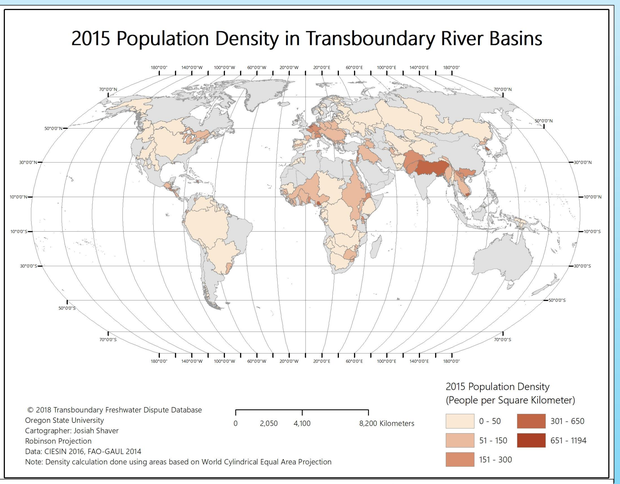

Figure 1: Population Density in transboundary river basins for 2015.

Figure 2: Projected 2020 population density in transboundary river basins.

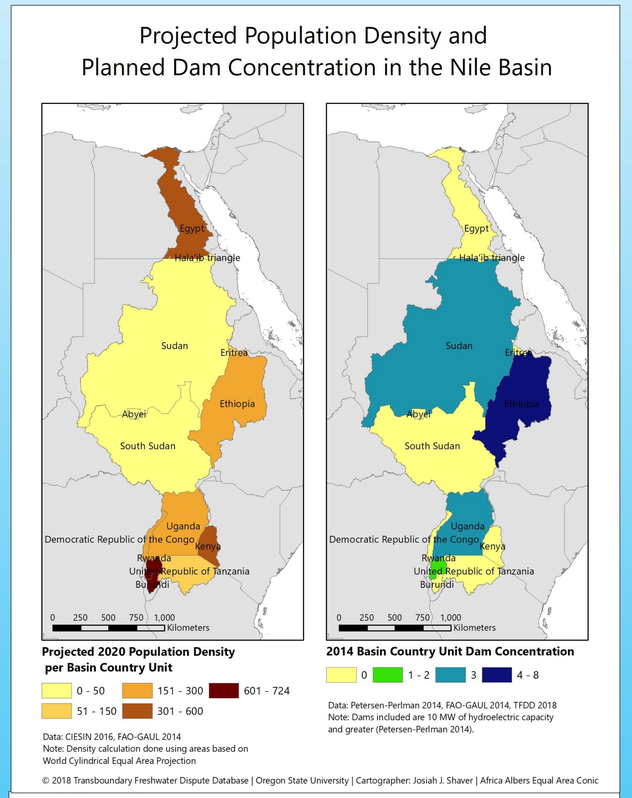

Figure 5: The Nile River Basin, showing population density (left) and dam concentration (right) within individual BCUs.

Table 1: Nile Basin Statistical Comparison

Basin Country Unit / Country	Projected BCU Population Increase from 2015 to 2020	*National* 2016 GDP (in billions of US dollars) (World Bank, 2017)	Number of Existing Dams in the BCU	Number of Planned and Proposed Dams in the BCU
Nile / Ethiopia	12%	*72*	2	8
Nile / Sudan	12%	*96*	4	3
Nile / Uganda	17%	*24*	1	3
All BCUs / United States	3%	*18,624*	1,128	0

Table 1: Comparison between Ethiopia, Sudan, Uganda, and the United States in terms of the population increase, national GDP, and number of planned dams.

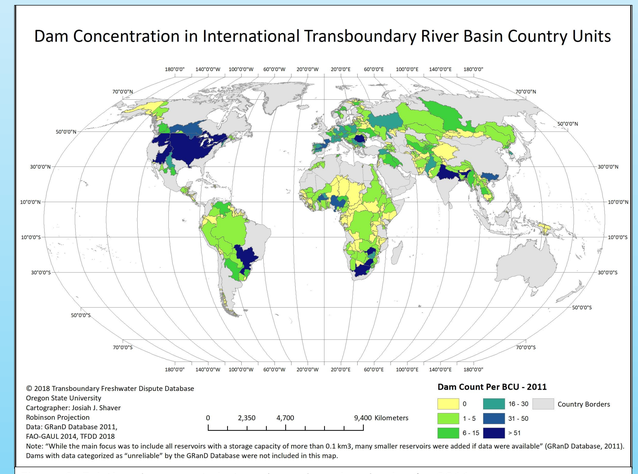

Figure 3: Existing dam counts in transboundary river basins for 2011.

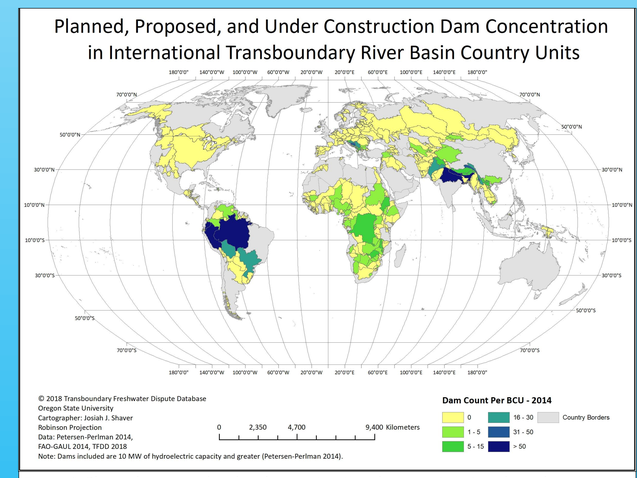

Figure 4: Planned, proposed and under construction dam counts in transboundary river BCUs for 2014.

II. Methods

Population density and dam concentration were updated using ArcGIS 10.5.1. Additionally, spatial data was utilized from the following key sources:

- National Borders: UN Food and Agriculture Organization's Global Administrative Unit Layers (GAUL) (2014)
- Population: 2007 & 2012: Oak Ridge National Laboratory's LandScan (2009, 2014)
- Population: 2015 & 2020 Projection: Center for International Earth Science Information Network (CIESIN, 2016)
- Current Dams: Global Reservoir and Dam (GRanD) Database (2011)
- Planned Dams: *Mechanisms of Cooperation for States' Construction of Large-Scale Water Infrastructure Projects in Transboundary River Basins* (Petersen-Perlman, 2015).

The general workflow of this project involved finding the appropriate spatial data, totaling the data within each IRB and BCU, categorizing each area accordingly, and formatting the resultant maps in a clear, presentable way.

Population density was calculated by dividing the total population within the IRB or BCU by the area represented (in kilometers squared). The dam concentrations, however, are simply a count of the dams in each—not a density calculation.

Overall, this research process involves the manipulation of large datasets, numerous creative solutions to ArcGIS problems, and a constant revision process.

III. Analysis

Although most basins are projected to have a population increase between 2015 and 2020, populations in some IRBs are expected to grow quite significantly. For example, both the Zambezi and the Juba-Shibeli basins are expected to increase in population enough to be in the next density category with at least 151 people per square kilometer. Statistical analysis reveals that about 46% of BCUs are expected to increase in population by at least 5% between 2015 and 2020, and 26% of BCUs will increase by 10% or more.

Figures 3 and 4 contrast both the existing and planned dams in BCUs. Note that North America has a dense dam concentration, yet there are absolutely no planned dams within the IRBs of North America. Inversely, South America is expected to dramatically increase in dam count, given the number of planned and proposed dams, such as in the Mira River Basin.

Synthesis of these new datasets reveals IRBs and BCUs with quickly increasing populations in conjunction with where there is intent to build dams in the near future. These two factors can be important indicators for an increased potential for conflict or tension between basin states.

The Nile River Basin in northern Africa (pictured in Figure 5) is one such place. Eleven countries share the massive Nile basin. Three of these 11 countries plan to build more three or more dams and have populations projected to increase by at least 12% from 2015 to 2020. These three nations are Ethiopia, Sudan, and Uganda. While many industrialized nations, like the United States, are choosing to remove dams for environmental and efficiency reasons, countries that are still in the process of industrializing are generally trying to build *more* dams (Zarfl et al, 2015). Table 1 summarizes these data by comparing projected population increases, national Gross Domestic Product (GDP), existing dams, and planned dams in Ethiopia, Sudan, Uganda and the United States.

IV. Conclusions

Analysis of these datasets—population density and dam concentration in IRBs and BCUs—indicate a general global rise in population (Figures 1-2), with 46% of BCUs expected to grow by at least 5% between 2015 and 2020. Additionally, as illustrated by the example of the Nile River Basin, industrializing countries are planning to build more dams than countries that have *already* industrialized. However, whether these dams will be realized is another matter.

With the global dependence on shared transboundary waters, it is important to be aware of trends that can impact the management of shared waters, such as population and dam construction.

As the impacts of climate change are felt around the world and population continues to increase, the demand for safe, clean water will increase simultaneously, while likely becoming increasingly challenging to access and provide. Rising populations, existing dams, and dam planning are some of the factors that can influence either potential tension and conflict or international negotiation and cooperation over internationally shared waters.

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