Urbanization Effects on U.S. Groundwater Resources – Data Core

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ABSTRACT

A data driven analysis led to the intermediate results of several groundwater variables and their relation to socioeconomic variables. Groundwater level (depth to water, feet below land surface) and water use (public supply, million gallons / day) information from the United States Geological Survey (USGS) were analyzed along with population data for 295 US counties for the years 2000 and 2015. Results gave low positive correlation scores for depth to water vs. population (0.063-0.133), higher positive correlation scores for water use vs. population (0.721-0.731), and medium positive correlation scores for depth to water vs. water use (0.171-0.296). These suggest that there is a complex system involved in the relationships between these variables, as a result, there is more data to be studied on the interdependencies of urbanization effects on US groundwater resources.

OBJECTIVES

Data Core Purpose:

To develop a database with national groundwater variables for quality and quantity measures and discover the relationship between socioeconomic factors and these groundwater variables.

Groundwater, or water below the land surface, is less frequently studied than its above land surface counterpart, surface water. Much of the US gets their water from groundwater sources: it makes up 27% of the nation's water use and increasing, according to the National Groundwater Association. Extremely important processes occur in groundwater reservoirs such as storage, recharge, groundwater-surface water interaction, and contaminant transport. Common issues that can occur include groundwater contamination from anthropogenic and natural sources, and groundwater depletion from excessive pumping of the water resource that exceeds recharge rates. We were interested in studying not only groundwater quality and quantity variables but also their relationship with socioeconomic variables that indicate urbanization, such as population and urban land use.

Population data can provide information on population size, growth, density in urban and rural areas, migration, and urbanization. Human population dynamics are known to have a close relationship with environmental change, such as in the case of this research project: as urbanization occurs and cities grow, the demand for water increases and there is the potential for anthropogenic pollution and excessive use of water resources. Environmental effects such as these are what we hope to study with the incorporation of socioeconomic variables such as population in this data driven analysis.

METHODS

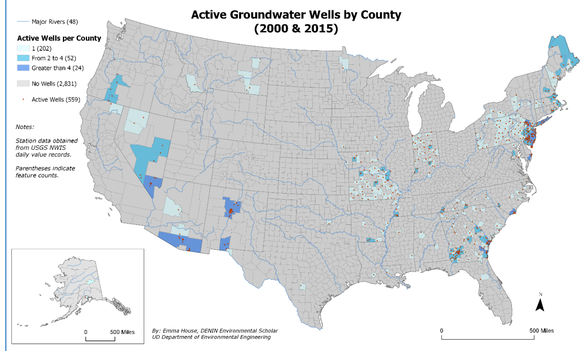
Data:

- **USGS NWIS Daily Value Data for the Nation**
- **USGS Water Use and Availability Reports**
- **UN WPP-Adjusted Population Count**

Tools:

- **R and Rstudio**
- **ArcGIS Pro**
- **Microsoft Excel**

Upon the identification of the USGS as the agency with the most extensive groundwater data with a total of 8,000 NWIS groundwater wells in the U.S., a master dataset was able to be compiled for the years of interest: 2000 and 2015. Aggregated to the county level, results for groundwater parameters depth to water and water use were correlated with a population parameter to determine their relationship and any relevant trends.



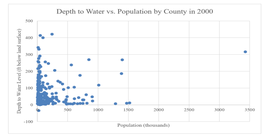
Counties containing active wells for the years 2000 and 2015 resulting from the R data retrieval and data analysis on USGS NWIS daily value observations for U.S. groundwater wells. Densities of well stations are shown in blue scale to give an idea of the reliability of the data.

The UN WPP- (United Nation's World Population Prospects) Adjusted Population Count is available in high resolution global raster format. Aggregating the raster data to county level was done by calculating zonal statistics, with zones being county boundaries sourced from Esri. The counties selected were the 280 of analysis, so population summaries for each county were then extracted to the table.

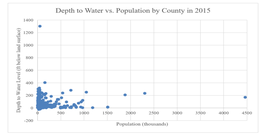
Water use data is available at a 5-year time step, aggregated by county, from the USGS Water Use and Availability reports. The large dataset has water use separated by source and by category and is accompanied by a report detailing water use trends and data analysis. The third variable for this research project was extracted from this dataset in two measures, freshwater groundwater withdrawals for public supply, and total freshwater groundwater withdrawals.

RESULTS

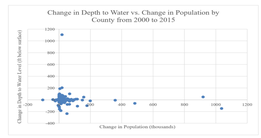
The result of this data core focus was the development of a large dataset of physical and socioeconomic parameters for 295 counties with observational groundwater data. To perform an analysis on the variables, county values are plotted on scatter plots and correlation scores are determined to represent the strength of their relationships.



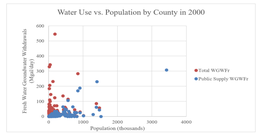
DTW vs. POP (2000)
Corr. Coeff. = **0.133**



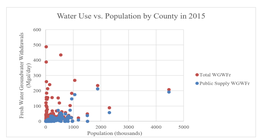
DTW vs. POP (2015)
Corr. Coeff. = **0.063**



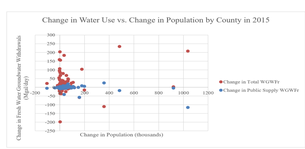
DTW vs. POP (change)
Corr. Coeff. = **-0.084**



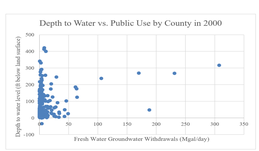
USE vs. POP (2000)
Public Supply
Corr. Coeff. = **0.731**
Total Supply
Corr. Coeff = **0.150**



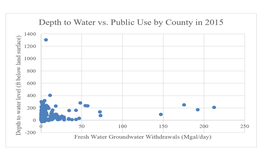
USE vs. POP (2015)
Public Supply
Corr. Coeff. = **0.721**
Total Supply
Corr. Coeff = **0.282**



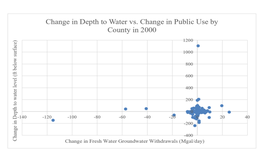
USE vs. POP (change)
Public Supply
Corr. Coeff. = **-0.548**
Total Supply
Corr. Coeff = **0.485**



DTW vs. USE (2000)
Corr. Coeff. = **0.296**



DTW vs. POP (2015)
Corr. Coeff. = **0.171**



DTW vs. POP (change)
Corr. Coeff. = **0.094**

CONCLUSIONS

In this data analysis, most correlations are exhibiting low to medium positive relationships. However, it is important to note that correlation among variables does not always imply causation.

Based on the correlations of the three variables found, it may be determined with some measure of uncertainty that depth to water level is not very closely related to population, but it is more closely related to groundwater use for public supply. This may be due to increased water use of groundwater resources leading to more drawdown in the water table. Population is still a factor, as water use does show a strong positive correlation with population, but the relationship must encompass other variables as well.

This project will be continuing into the coming year. With the amalgamation of additional databases, the study will incorporate measures of groundwater quality and urban land use, as well as potentially weather and seasonal variability components, saltwater intrusion at the coast, and / or effects of subsurface geological materials on groundwater, in order to effectively study the effects of urbanization on groundwater resources in the U.S.

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