Land Use and Water Quality

Examining the Effect of Land Use resulting from Urbanization on Surface Water Quality in Massachusetts

Introduction

Water accessibility is one major component of the global water security issue the other equally important aspect is the quality, and the idea of "access to adequate quantities of acceptable quality water" within the UN Water (2013) definition of water security has thus brought some spatial and temporal dimensions to the concept of water security.

This project will examine water security within the context of surface water since it has been established that surface (fresh) water resource doesn't only account for over 60% of domestic water use nationally in the United States (Dieter et al. 2015), two thirds of Massachusetts residents also rely on it for domestic use and the state being the 14th most populous (US Census Bureau, 2015), over 75 percent of the population lives in the eastern one third of the state (MassDEP, 2017).

Increasing urbanization has been identified as one of the constraints to water quality, therefore, the goal of this project is to determine how urbanization due to population growth has impacted water quality using turbidity measurement in the major sub-basins of Massachusetts.

Spatial Question:

How does land use change resulting from urbanization affect surface water quality (Secchi turbidity measurement) in Massachusetts?

Methodology

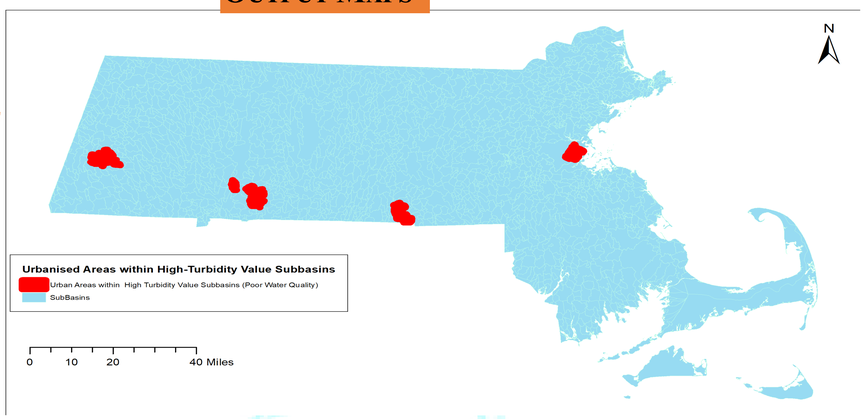
This exercise involved examining the impact of urban development on water turbidity (depicting contamination from erosion runoff) as a measure of relative clarity of a waterbody. With the spatial unit being sub-basins in Massachusetts, the analysis used Water Quality data (2005-2014) and Land Use Land Cover (LULC) (raster) data (2013). The water quality (location) data for the sub-basins was geocoded, and values for sample points that lacked multiyear measurements were generated through interpolation to yield a raster layer.

The LULC layer was reclassified into "urban" and "others", then zonal statistics was done to obtain a table for spatial join between the water quality data and the subbasin polygon. Spatial join was also done between the table of mean water quality and the reclassified land use data (2013) to generate an average water quality values within the sub-basins in 2013.

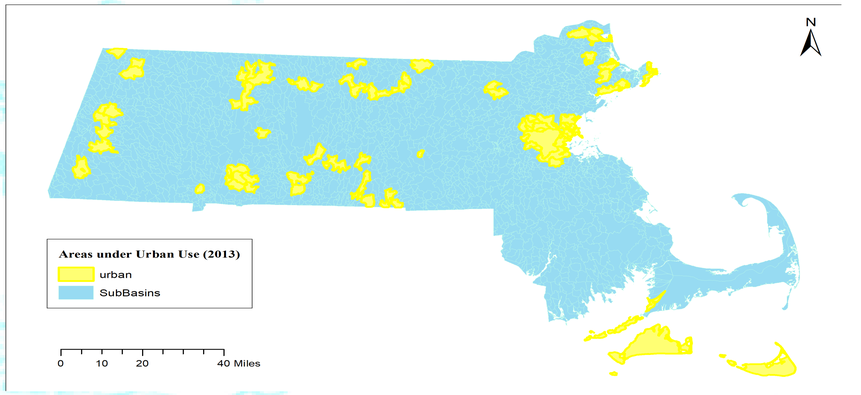
Clustering analysis using Local Moran's I generated areas with poor water quality values of high surrounded by high, etc. The classified urban layer was intersected with poor water quality (high turbidity measurement) layer to assess whether the urban development within a subbasin has an impact on the turbidity measurement of waterbodies.

Output Maps

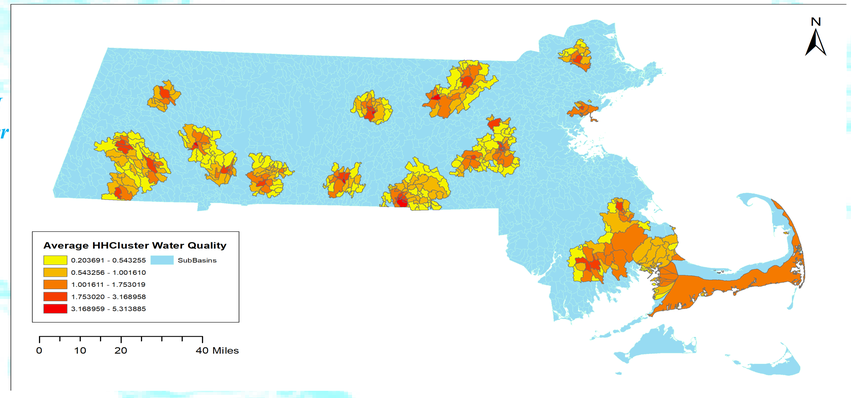
Urbanized Areas within High-Turbidity Value Sub-basins



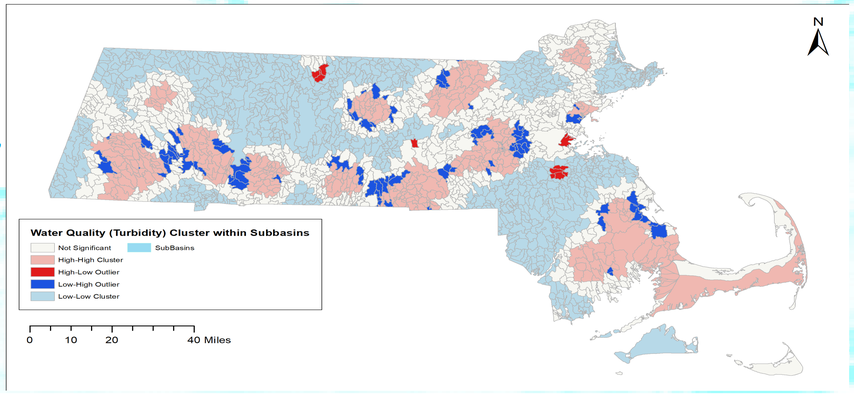
Urbanized Areas



Mean of HH Cluster Water Quality



Water Quality Cluster



Results, Analysis & Limitation

The hypothesis of this exercise is that the more the developed space that are present in or highly urbanized a sub-basin is, the higher will be the turbidity measurement (poorer water quality) of water bodies within the sub-basin. However, the result of the intersect between areas of poor water quality and urban areas revealed the contrary. More sub-basins within areas classified as "Others" tend to have higher turbidity values suggesting that the volume or size of the developed space within Massachusetts doesn't necessarily contribute to degraded water quality in terms of turbidity.

The Lack of a good time spread in the water quality measurements was a limitation, because the mere fact that the of range interpolated values cannot exceed the range of observed values forecloses the possibility of obtaining values for missing locations where actual measurements could have been higher or lower than interpolated values.

Conclusion

Based on the analysis, the level of land use conversion for urbanized activities as of 2013 didn't impact significantly on the water quality in terms of turbidity level between 2005-2014 in the sub-basins within Massachusetts. Rather areas within the sub-basins where land use is for other activities than urbanization purposes even had higher level of turbidity measurement in adjoining water bodies.

Therefore, given the level of limitation on the water quality data obtained, this suggests that all other things being equal (factors that affect wrong measurement in Secchi turbidity measurement e.g. the time of the day and season) there are other factors that cause water quality degradation in terms of turbidity measurement contrary to my hypothesis that the level of urbanization in Massachusetts would negatively impact water quality in the sub-basins.

Data Sources

- Subbasin_Poly: from M Drive Tufts Data Lab
- Land Use Land Cover data: from (National Land Cover Database) NLCD Database. Accessed online at https://www.mrlc.gov/data?f%5B0%5D=year%3A2016
- Water Quality Data: from Mass.gov database. Accessed online at: https://www.mass.gov/doc/water-quality-laboratory-data-2005-2014

Projection & Coordinates System

Lambert_Conformal_Conic

NAD_1983_StatePlane_Massachusetts_Mainland_FIPS_2

Cartographer

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References

Coles, J.F. McMahon, G, Bell, A.H, Brown, L.R.; Fitzpatrick, F.A.; Scudder E, Barbara C.; Woodside, M.D.; Cuffney, T.F.; Bryant, W.L.; Cappiella, Karen; Fraley-McNeal, Lisa; Stack, W.P. (2012): Effects of Urban Development on Stream Ecosystems in Nine Metropolitan Study Areas across the United States; 2012; CIR; 1373

Dieter, C.A., and Maupin, M.A., 2017, Public supply and domestic water use in the United States, 2015: U.S. Geological Survey Open-File Report 2017-1131, 6 p

What is Water Security? Infographic (2013): UN Water Publications. Accessed online : https://www.unwater.org/publications/water-security-infographic/