

## 1. Introduction

The legacy of inequitable water policy under apartheid continues to impact water services in economically less developed and rural areas in South Africa. Previous studies typically examine this relationship either by using data collected at a national level for large-scale research or by using aggregated data collected at the provincial or municipal level for a specific locality only. This study attempts to perform a nationwide analysis using fine-scale (water management level) data to give a spatial representation of the efficacy of water policies in South Africa. National level or province-level research cannot be used to tackle economic and/or the legacies of racial injustices, as within each province there is considerable diversity across economic prosperity and areas related to former apartheid colonization.

The analysis is based on the assumption that economic development may degrade water quality through some water polluting land use and it may improve water policies and therefore improve water quality. Since water quaternary management areas are the smallest unit of policy implementation, a positive relationship indicates effective water quality regulation policies and/or legacies of the effectiveness of water policies implemented during the apartheid era, while a negative correlation may indicate poor or ineffective policy. Hence, by controlling for land use activities appearing as main pollution causes, we attempt to evaluate the efficacy of water policies which can be explained by economic development.

## 2. Methodology

With a sample collected by the Water Resources Commission in South Africa, we use the natural logarithm of Total Dissolved Solids (TDS), Sulfate, Nitrogen, and phosphorus concentrations in main surface water as water pollutant indices. We use the natural logarithm of satellite night-time light digital number as economic development proxy. According to the literature, they are the finest proxy variables for our study unit. Finally, the surface of land use, population density, runoff, and the total area of the water quaternary were used as control variables.

To investigate the impact of economic development on water pollutants, we used two spatial econometric models. First, a Geographically Weighted Regression (GWR) was applied to estimate the spatially varying relationship between water quality and economic development in the country. It allows to graphically detect the water management areas in which there might be a positive correlation between economic development and water pollution.

Second, a spatial Durbin Model (SDM) was performed to test the significance of the results of the GWR. In the SDM, we assumed a correlation of the water pollutants with neighboring observation described by a contiguity matrix. Concerning the independent variables, we assume a correlation of economic development between the different areas characterized by a Euclidean distance matrix. The land use variables are estimated by an inverse-

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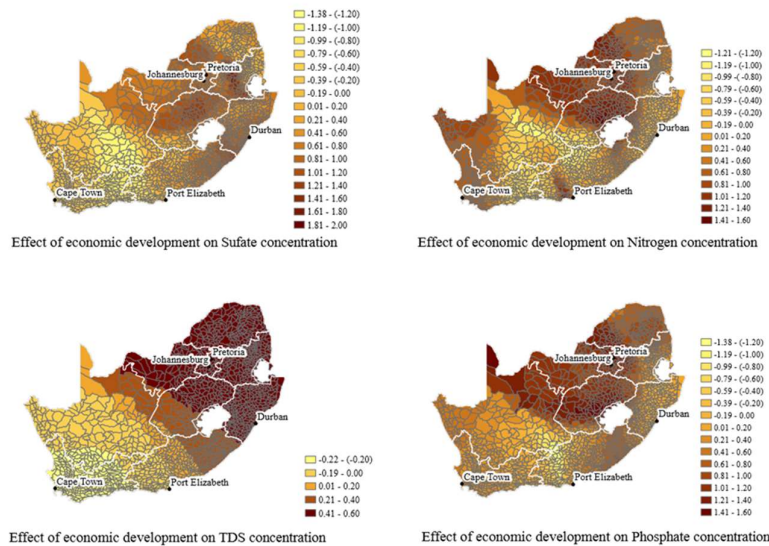
distance-weighted metrics of the land use relative to the nearest water bodies in each region. This metric allows land uses closer to water bodies to have a stronger impact on water quality.

### 3. Results

The predictions of the GWR approximately show that the relationship between economic development and water pollutants is negative in the West of the country and positive in the East. This pattern could be the results of a substantial difference in human activities (land use) between the two parts of the country. Alternatively, it could be related to the former separation of land during the apartheid era as black dominated regions were roughly concentrated in the eastern part of the country.

We then test for the significance of these results and their possible causes with the SDM. The results of the SDM highlights that mining, agricultural, and industrial activities are significantly related to water pollution. However, even after controlling for the effect of land use, the relationship between economic development and water quality in the Eastern part of the country is significantly greater than in the west.

Subsequently, by matching a racial concentration map in 1970 with the water management areas (unit of this study), we investigate the hypothesis that the former black dominated areas could have the lowest surface water quality. However, the results rejected this hypothesis.



**Figure 1** The GWR of water quality on economic development while controlling for the effect of runoff

### 4. Concluding remarks

Our findings highlight a significantly stronger positive relationship between water quality and economic development in the East of the country. Then, after controlling for types of pollutant-causing land use, we suggest that the variation in this impact of economic development can be found in the structure of the water management institutions in South Africa. Upon further investigation, we deduce that the causal relationship varies at the level of local and provincial water management institutions.