Disparities in Accessibility and Performance of Public High Schools in Metropolitan Baton Rouge, Louisiana 1990-2010

ABSTRACT

This study uses a Geographic Information Systems (GIS)-based spatial accessibility index to measure the geographic convenience of attending a high school by accounting for the ratio of full-time equivalent (FTE) teachers to students as well as the spatial interaction between them. The index is applied to the Baton Rouge Metropolitan Statistical Area (BRMSA) in 1990, 2000 and 2010 for examining the temporal changes of high school accessibility. The research indicates a significant racial disparity that high schools with more Black students tend to have poorer accessibility. Schools with poorer accessibility are also associated with lower school accountability scores. Urban areas, particularly Baton Rouge, have experienced the lowest accessibility and correspondingly low accountability scores, which in most cases have only continued through time when compared to nonurban high schools. The overall link between access, accountability, race, and geography demonstrates a potential impact of the White flight phenomenon on high-school education disparities.

Key words: educational disparity, spatial accessibility, two-step floating catchment area (2SFCA) method, White flight, Baton Rouge MSA

1. Study Context

A journey through Louisiana’s most impoverished communities reveals a common sight as former high schools have now turned to concrete slabs with inconspicuous remnants of football stadiums. Much of the school volatility can be linked to official or unofficial accountability systems. As early as the antebellum era (1812-1861), the arrival of public education in Louisiana was met with passionate hostility as residents often opposed the simple notion of public funds to support schools. A mixture of academic competitions and standardized tests provided opportunities to rate public schools and went a long way to counter criticisms of public education. The rating of schools eventually became an agent of change as the mere perception of a school being poorly rated riled support for initiatives like consolidations. Despite the extensive history and value of high schools to communities, Louisiana public high schools now represent one of the most inaccessible social institutions. The accountability mechanisms that gave schools legitimacy are now components behind their closures which routinely displace students. As accountability becomes a more salient influence on school change, the role of geography and accessibility has steadily deteriorated.

This paper examines two hypotheses on high school accessibility. First, geographic (spatial) accessibility is poorer in rural or impoverished urban communities. Secondly, poorer accessibility is associated with lower accountability scores. Both have been largely unrecognized in education policymaking.

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2. Study Area and Data Sources

The BRMSA provides an ideal research area due to its demographic and socioeconomic diversity, volatility within the high school landscape, and direct policy influences as the state capital. As shown in Figure 1, this region consists of nine parishes ("parish" is the county equivalent unit in Louisiana). In addition to the capital city of Baton Rouge, the region is also home to a large range of incorporated and unincorporated communities such as: Baker, Denham Springs, Donaldsonville, Greensburg, New Roads, St. Francisville, and White Castle.

The study periods include 1990, 2000, and 2010 due to the credibility of data obtained from various sources. The region's population was 528,264 in 1990, 705,973 in 2000 and 802,484 in 2010. A total of 42 and 38 public high schools served the region in 1990 and 2000, respectively. For 2010, in addition to 31 public high schools within parish level school districts, 3 high schools in independent schools districts (Figure 1) were established in East Baton Rouge Parish during the 2000s.

Louisiana Department of Education (LDOE) school directories provided the primary resource for school location, school enrollment figures, *full-time equivalent (FTE) teachers*, curriculum structures, and the duration of school existence. Data tables were found to cover the research period 1990-2010. The number of FTE teachers provides a standardized method of representing teachers and education received in secondary schools based upon courses offered (Benham, 2005), and is a critical variable to be used in the accessibility calculation. Schools were geocoded into a GIS database by their address locations, which were further validated by the Geographical Names Information System (GNIS http://www.geonames.usgs.gov) and National Center for Education Statistics (NCES http://nces.ed.gov) public school databases. For a small number of former schools that could not be geocoded automatically, a combination of parish and city historical texts along with historical LANDSAT and NAIP imagery were examined to pinpoint former school campus sites.

The *school accountability data* were collected from the LDOE website, and only the datasets for 2000 and 2010 were available. The variables consist of performance test scores and graduation indexes at the school and district levels. This aggregated data set dictates the ecological nature of our study since data of individual student data were not available due to us due to geo-privacy restrictions. The formulation of accountability data has changed throughout time for high school grade levels of Louisiana. However, graduation (30%) and assessment (70%) measurables represented the general categories of accountability inputs for high school ratings (school performance scores or SPS) in 2000 and 2010.

The 1990 and 2000 *socio-demographic data* at the census block group level integrated in GIS were downloaded from the National Historic Geographic Information System (NHGIS) online database (https://www.nhgis.org). The 2010 data (both demographic and GIS data) were downloaded from the U.S. Census website (https://www.census.gov) separately and then integrated together. Specifically, data of population at high-school ages in 1990, 2000 and 2010 were based on the Summary File 1 (SF1); data of other socioeconomic variables for defining aspatial accessibility factors were based on Summary File 3 (SF3) for 1990 and 2000, but the American Community Survey (ACS) five-year (2006-2010) data for 2010. The 2010 census no longer reports sample data such as the SF3. The block group level focus is consistent with previous school accessibility studies such as Talen (2001). For more accurate representation of block group locations, their weighted population (high school student age group) centers instead of geographic centers were computed by using the block-level data (Luo and Wang, 2003).

3. Spatial Accessibility to High Schools

The advancement of Geographic Information Systems (GIS) technology has modernized the measurement of spatial accessibility. One method widely used in recent literature is the *two-step floating catchment area (2SFCA)* method (Luo & Wang, 2003; Wang & Luo, 2005). Despite various refinements proposed (Wang, 2012; McGrail, 2012), the 2SFCA is more intuitive to interpret and easier to implement than its more advanced forms (Luo & Qi, 2009). In essence, the 2SFCA measures spatial accessibility as a ratio of amount of service supplied to population in demand of the service while accounting for the complex interaction between them within a certain distance range. Like other spatial accessibility measures, three factors are critical in defining the 2SFCA method: supply, demand, and the distance between them. Here, the supply capacity is defined as the number of FTE teachers in each high school extracted from the LDOE data set, and the demand is population in the high-school age group (i.e., 15-18 years old) based on the census data. "Accessible schools" are assumed to be within a certain distance (i.e., catchment area) from prospective students in each block group.

As the name makes clear, the 2SFCA method is implemented in two steps. In step 1, define the catchment of school location j as an area composed of all population locations (k) within a threshold distance (d_0) from j, and compute the teachers-to-students ratio (R_j) within the catchment area such as

$$R_j = S_j / \sum_{k \in \{d_{kj} \le d_0\}} P_k \ .$$

In step 2, for each population (student) location (block group) i, search all school locations (j) within the catchment of threshold distance (d_0) from i, and sum up the ratios R_j at these locations:

$$A_i = \sum_{j \in \{d_{ij} \le d_0\}} R_j = \sum_{j \in \{d_{ij} \le d_0\}} (S_j / \sum_{k \in \{d_{kj} \le d_0\}} P_k) \qquad (1)$$

Note that equation (1) is basically a ratio between teachers *S* and prospective student *P*, which interact with each other only within a catchment area (e.g., 5-mile distance). A higher accessibility score from equation (1) indicates better accessibility for prospective students in a block group. The method is easy to implement in a GIS environment as detailed in Wang (2006). Vouk and Dulaney (2009) also used a 5-mile threshold distance in their study on school accessibility in Wake County, North Carolina. Deerenberg et al. (2010) adopted a 5-km (approximately 3-mile) threshold to examine secondary school accessibility, but the study was in Netherlands. Future work may consider different threshold distances for rural and urban areas as Luo and Qi (2009) did for assessing primary health care accessibility. Such an approach would call for extensive fieldwork and consultation with schools and parents to select adequate thresholds. Euclidean distance is utilized in this study to measure the spatial impedance due to lack of digital historical road network data for the study area (e.g., in 1990). We tested the accessibility results using the presumably more accurate measure such as travel time through the actual road network in 2000, and confirmed that this only resulted in "a moderate loss of accuracy" reported in a review of 2SFCA applications by McGrail (2012).

Figure 2 displays 2010 accessibility based upon 5-mile catchments in the primary map, attendance zones (Inset Map A), and school districts (Inset Map B). School attendance zone accessibility was an initial step for district level calculations. This map highlights the apparent vulnerability (darker shades) of urban area high schools to serve local students; however, note the rural shift of vulnerable areas with attendance zone and district perspectives. Unlike the urban-rural dynamics, suburban schools are revealed as models of consistency (lighter shades).

Regardless of the analysis scale, suburban area high schools are shown to be the most accessible schools in the Baton Rouge region. In fact, Inset Maps A and B only bolster this argument as independent suburban districts are also overwhelmingly revealed to be highly accessible schools. The one suburban region school with poor accessibility is Baker High School, which serves a majority African-American student population.

During the 1990s, a bevy of landscape changes impacted high school accessibility throughout the Baton Rouge region. Key influences behind the instability experienced included: desegregation initiatives in East Baton Rouge Parish, White flight into suburban areas, rural school consolidations, and the arrival of high stakes standardized examinations. Table 1, which provides a breakdown of accessibility scores, shows the downturn of accessibility was particularly impactful on rural populations through school closures and consolidations. The spatial distributions of 1990s accessibility changes, shown in Figure 3, were concentrated within three regions of the study area. These areas included: (1) Baton Rouge, (2) Mississippi River communities, and (3) eastern Livingston Parish Interstate-12 corridor communities.

Figure 4 displays the change of accessibility scores over the 2000s. These results, if taken without examining previous landscapes, may provide substantial misrepresentations of accessibility. For example, improved accessibility within the central section of Iberville Parish was a result of a consolidation between two high schools. While the 2SFCA captured the increased staffing at the consolidated site as a positive gain, note that the primary map of Figure 2 reveals an increase in communities beyond the school's catchment. Unlike the 1990s analysis, improvements were scattered within all parishes during the 2000s..

4. Consolidation of Aspatial Variables and Interaction with Spatial Accessibility

In reflecting previous studies in school accessibility (Baschieri & Falkingham, 2011; Logan, Mina, & Adar, 2012) as well as accessibility to healthcare (Wang & Luo, 2005) and food (Dai & Wang, 2011) that shares similar disparities across socio-demographic groups, 11 variables are chosen to account for aspatial challenges for access to public high schools. These variables are selected also for their availability across three decennial censuses 1990-2010 though some of the measures varied slightly. All the variables are measured in percentage:

(1) Demographic: nonwhite population;

(2) Socioeconomic status: household below poverty level, single parent household, owner occupied household, population over age 16 employed in primarily outdoor rural-oriented jobs, population between ages 16-19 not enrolled in school, population over age 25 lacking a high school degree;

(3) Environment: overcrowded household (household room occupancy of more than 1), household lacking adequate kitchen facilities;

(4) Linguistic barrier: households with little to no English spoken (2000 and 2010), or household with kids age 5-17 who speak English "not well" or "not at all" (1990); and

(5) Transportation: household lacking private vehicles.

As some of the variables are correlated with each other and contain duplicated information, a factor analysis is performed to consolidate these variables and uncover the aspatial factors salient in the interpretation of unique social groups within the study area. The factor analysis is implemented in the IBM SPSS Software (www.ibm.com/software/analytics/spss/). Two rules may guide the selection of an adequate number of factors to retain. One is to retain the factors with greater than 1 eigenvalue, and another is to keep the factors before their eigenvalues begin to flatten on the scree plot curve (Wang, 2006, 129-130). Both rules help us to use three factors for this study. See the 2010 factor structure as an example shown in Table 2. The variables are reordered so that the first six have their largest loadings on Factor 1, the next three on Factor 2 and the final two on Factor 3. The three factors account for a majority (58.1%) of the total variance contained in the 11 original variables. This is acceptable, but admittedly subpar since a significant portion (41.9%) of information unaccounted for.

Adding to the challenges is interpretability of the results particularly the meaning of each factor. Even after numerous experiments of various combinations of variables and different methods of polarizing the factor loadings, the factor structure in Table 2 is far from a clear picture. Perhaps for lack of better terms, we label Factors 1-3 as “socioeconomic disadvantages”, “rurality”, and “linguistic-cultural barriers”, respectively. As an example, Figure 5 maps the spatial pattern of socioeconomic disadvantages in 2010. Analyses for all years showed consistency in revealing three similar significant social groups. For limited space, other factor scores in 2010 or factor scores in other years are not shown. The struggle to meet basic physiological needs was a strong identifier of socioeconomic disadvantaged social groups. Physiological needs relate to variables such as household below poverty or lack of kitchen facilities. Satz (2012) stressed that physiological challenges could impact the educational attainment of students. Analysis of Table 1 shows that such challenges may be more difficult to overcome today than in the past due to the loss of schools that service highly vulnerable populations. In Table 1, schools are grouped according to their major correspondence with one of the three factors. In addition to the issues discussed above, the complex web between original variables and composite factor scores also limit the value of the factor analysis in this case. Our analysis of interaction between aspatial variables and spatial accessibility below is based on the original variables.

Based on Table 3, the relationship between accessibility and physiological variables has become neutral, which means these disadvantaged populations have experienced little improvement in terms of accessible schools over twenty years. The relationship of race with access is also identified as significant. The negative correlation signifies that as access to high schools increased as the nonwhite population declined. This finding raises questions about the quality of high school education found in predominately Black communities and also reflects the aforementioned vulnerability of poor predominately Black populations captured in the socioeconomic disadvantage population of this study. Figures 6 and 7 exhibit how accessibility growth corresponds to levels of student population by race across 29 high schools in the study area. Accessibility is shown to increase with raised levels of White students, while accessibility decline is connected to larger Black student populations.

5. Association with School Accountability

Both spatial accessibility and aspatial factors may influence student academic performance in school. The former is determined by "where you are", and the latter is by "who you are" (Wang, 2012: 1105-1107). The two also interact as discussed in the previous section. This section uses a simple correlation analysis to examine the relationship between accessibility (accessibility scores), social groups (aspatial factor scores), and school accountability (school performance score or SPS) for 2010. This analysis is conducted based on a randomly selected 50% sample size of 2010 BRMSA public high schools based at the school-level data. The ecological nature of this analysis is both limited by our data source (only aggregate school-level SPS data available) and the exploratory purpose of our work (for generating hypotheses for future multilevel inferential studies based on a combination individual student and school-level data).

Table 4 shows that accountability (SPS) has a statistically significant association to both accessibility and the linguistic-cultural barriers factor, but not the other two composite factors. The positive correlation between linguistic-cultural barriers and SPS is somehow surprising, and the lack of relationship of SPS with either socioeconomic disadvantages or rurality is also puzzling. Given the complex web in individual socio-demographic variables and composite factor scores, the interpretation could benefit from professional perspectives by educational experts, and we hope to explore more in future in-depth analysis.

Most noticeably, the correlation coefficient between accessibility and SPS is as high as 0.752 (i.e., R^2 = 0.566), as shown in Figure 8. This should heighten concern about the sustainability of various contemporary education policies. If accessibility continues to be downplayed in policymaking, these new structures of schools may be destined to succumb to similar challenges of their public school predecessors. The accessibility score defined by the 2SFCA method reflects both the faculty-to-students ratio and the spatial impedance (distance) between student residence and school. In other words, either understaffing in a school or excessive travel by students may contribute to its underperforming. The former is widely acknowledged by the public and education policymakers as demonstrated in various initiatives in driving down class size. The latter receives less attention and calls for more recognition. A school's remoteness implies that longer travel time on trips make wearier students, and perhaps it makes more challenging for active parents participation in school affairs. This linkage also suggests likely diminishing returns or diseconomies of scale in the contemporary trend of mega high schools since fewer schools imply longer distance on average.

6. Discussion and Concluding Comments

This research poses several important questions about the policies of public education in Louisiana. The overarching theme of the paper has been that policies have to account for the accessibility of students and communities to public high schools. However, given the rise in development of other forms of schooling being introduced into Louisiana, this researcher argues that accessibility should also be of equal importance for all schools and social groups. Hamnett and Butler's (2010) study found private schools of London consistently rejected students from distant "failing" school locations and preferred those in close proximity. If such a strong association of accessibility and accountability were to exist in Louisiana, then destination schools would eventually jeopardize their accountability ratings by admitting students from distant locations. Under this scenario, students located in isolated communities would potentially endure the most significant access restrictions. As referenced in the Hamnett and Butler study, positive discrimination on these social groups could prove beneficial in the ensuring that development of schooling options improve upon existing shortcomings and focus on the core geographic concepts of people, place, and access.

Many of the potential setbacks endured at various points of this experience proved to only be temporary. However, there are a few significant limitations that were encountered over the course of this study or are important to reinforce at the concluding stage of this analysis:

1. Due to privacy concerns and data availability, this study used block group or census tract centroids rather than student household or address data to represent and interpret student

locations. The lack of individual student SPS data also limits our work to an ecological study at aggregate units.

2. Major changes to high school such as consolidations or closures that occurred during the peripheral years of this study's time frame were infused into the study to gather a more complete analysis of regional changes.
3. Euclidean distances were utilized rather than network distances. This was a result of the void of personal address data and historical road networks.
4. The 5-mile catchment area was used to examine accessibility for schools in both urban and rural settings. An adaptation was implemented for the 2010 analysis as approximated attendance zone boundaries were used instead.

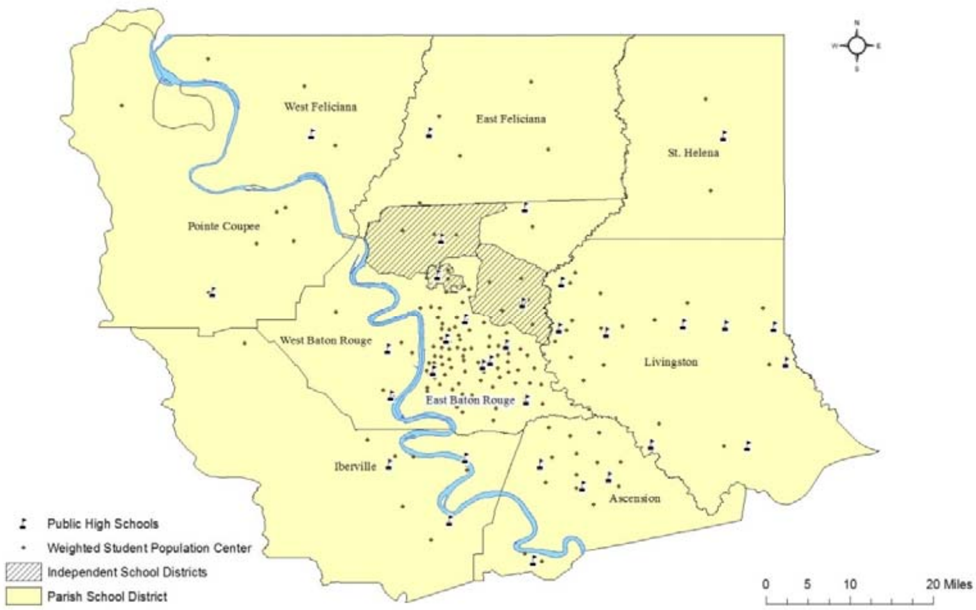

Figure 1. Census block group centers and public high schools in BRMSA

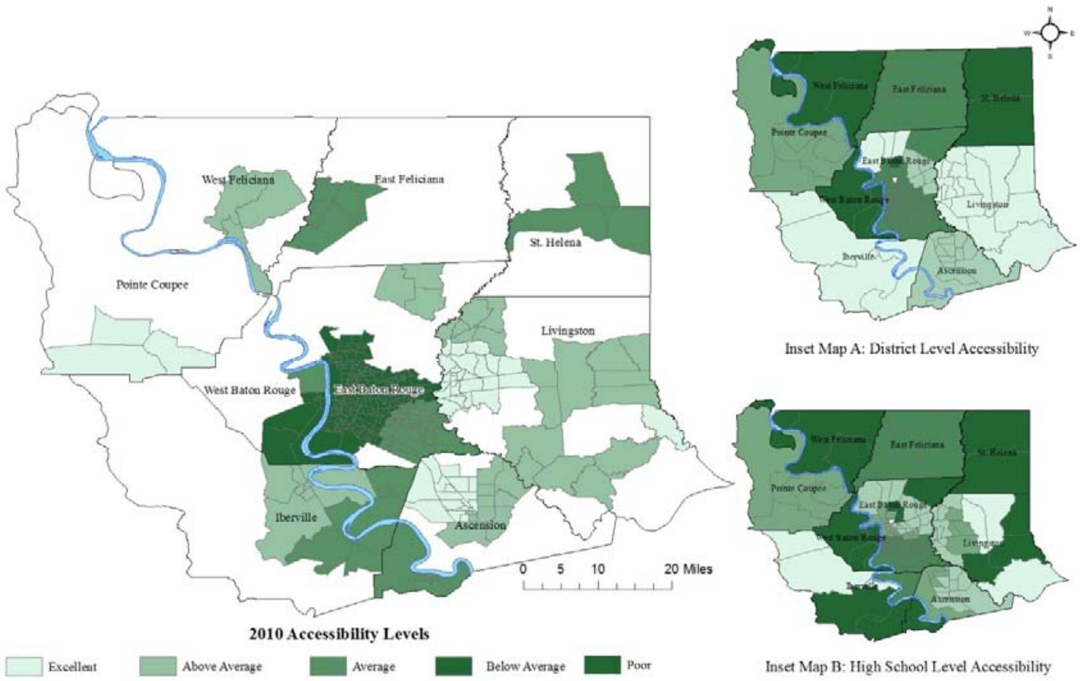

Figure 2. Spatial accessibility to high schools by block groups in BRMSA 2010

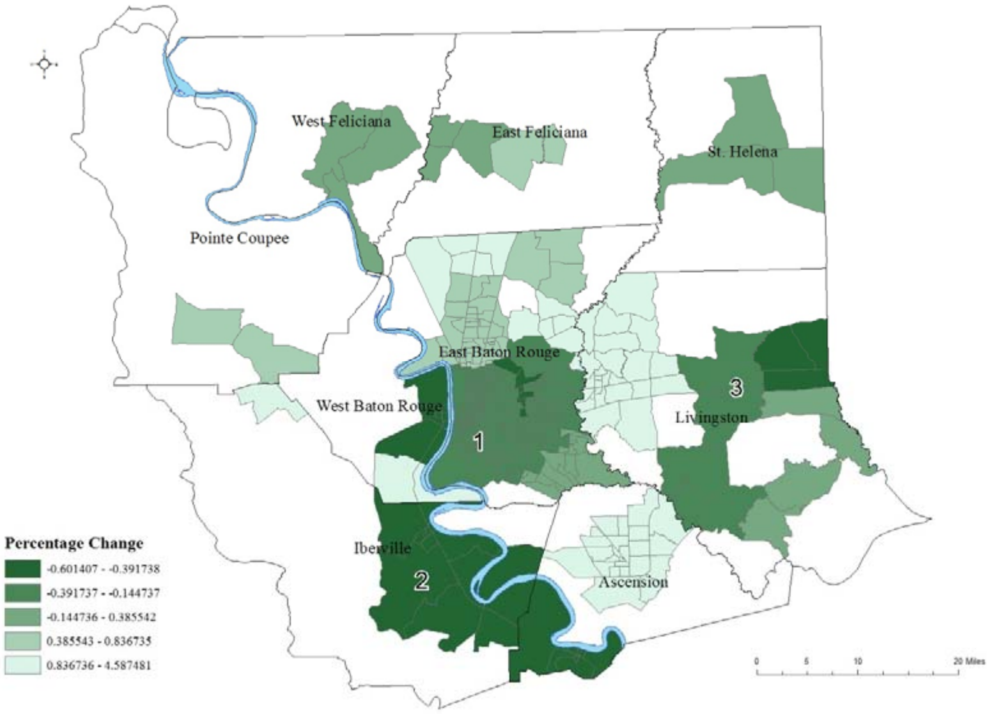

Figure 3 Change in accessibility scores from 1990 to 2000

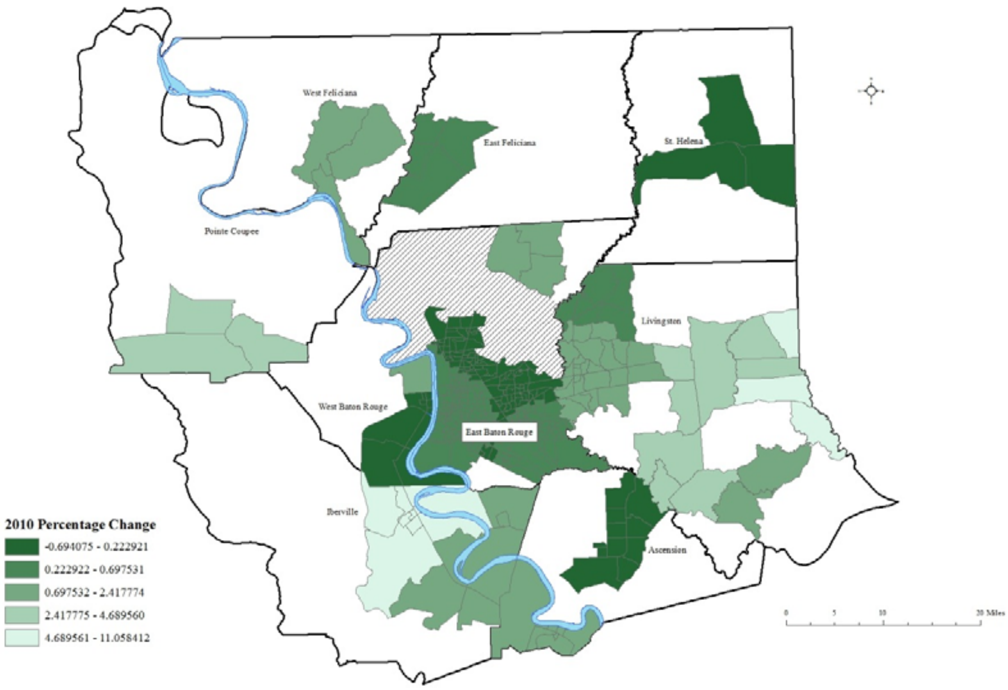

Figure 4 Change in accessibility scores from 2000 to 2010

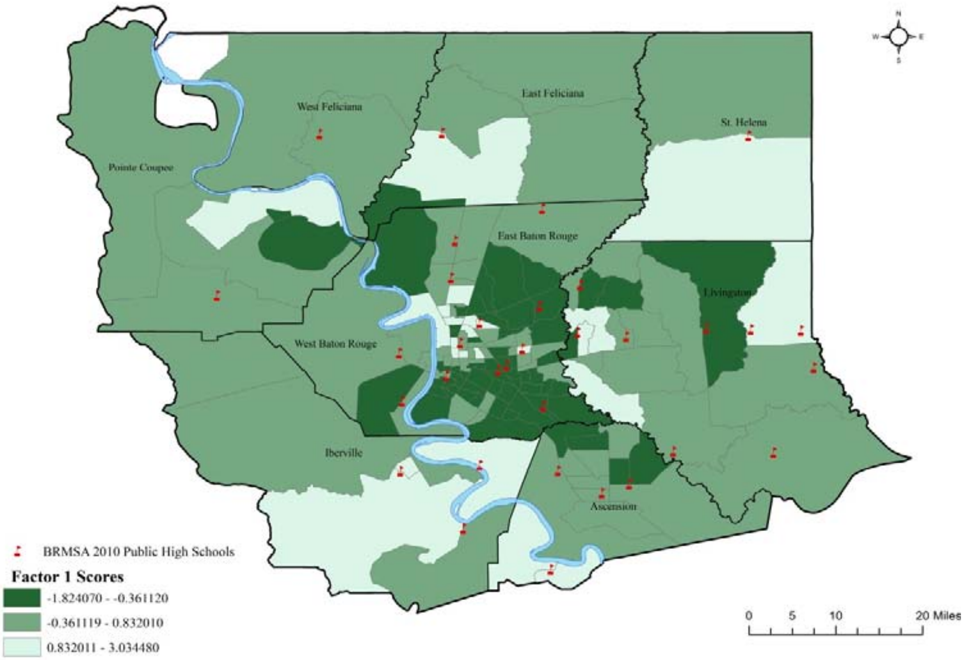

Figure 5. Socioeconomic disadvantages scores in 2010

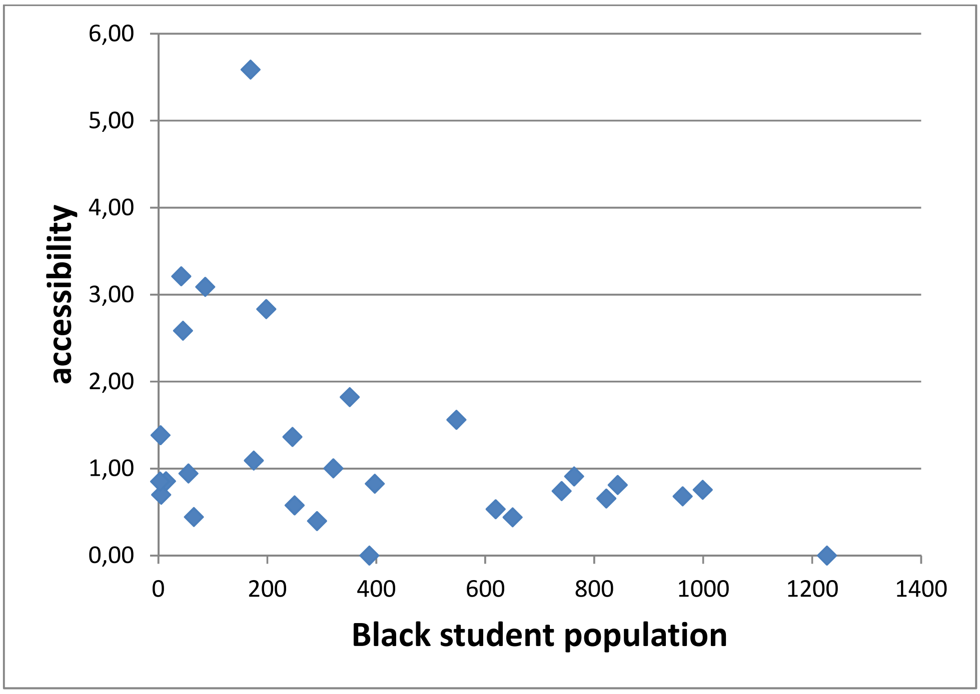

Figure 6. Accessibility vs. Black student population across high schools

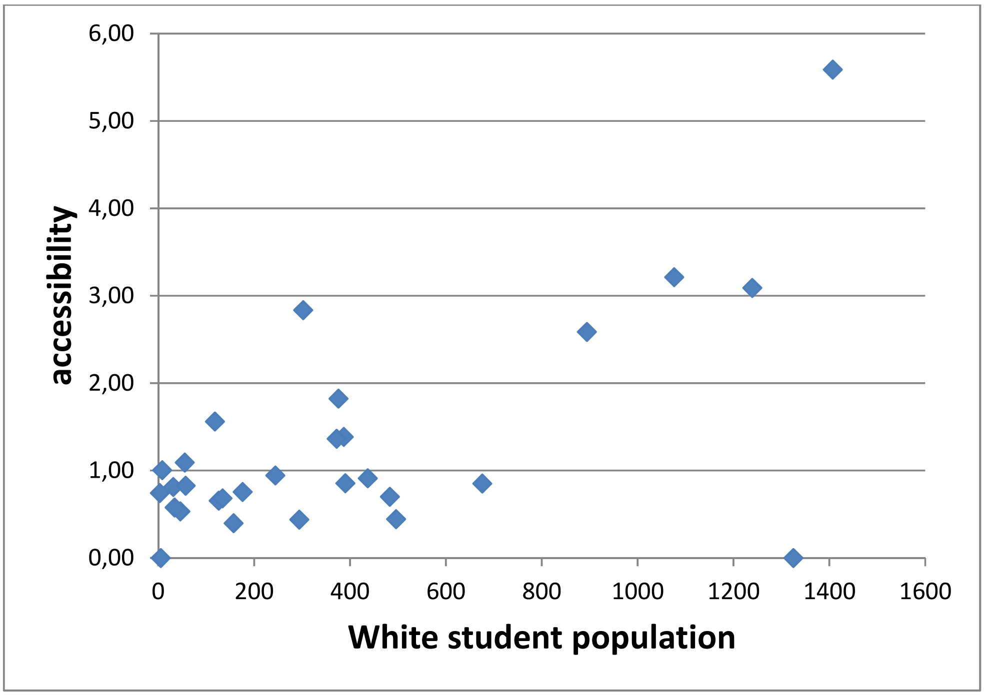

Figure 7. Accessibility vs. White student population across high schools

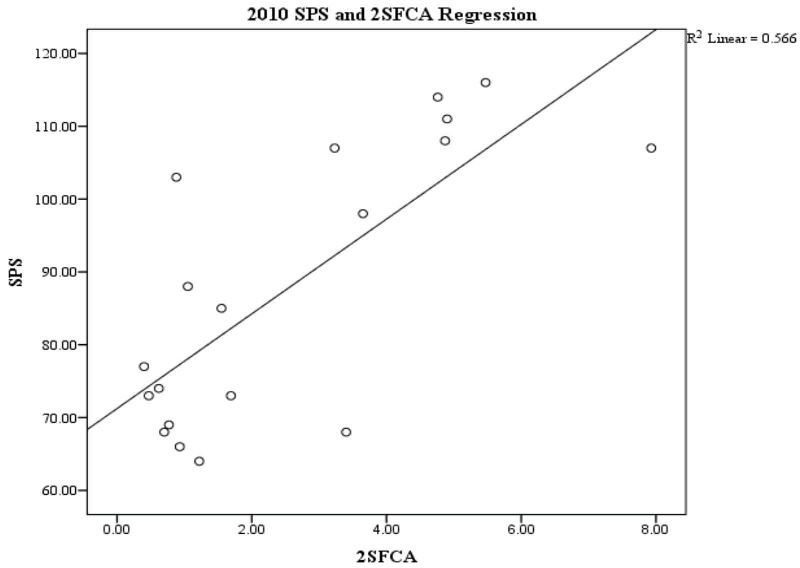

Figure 8. Association between spatial accessibility and school performance score

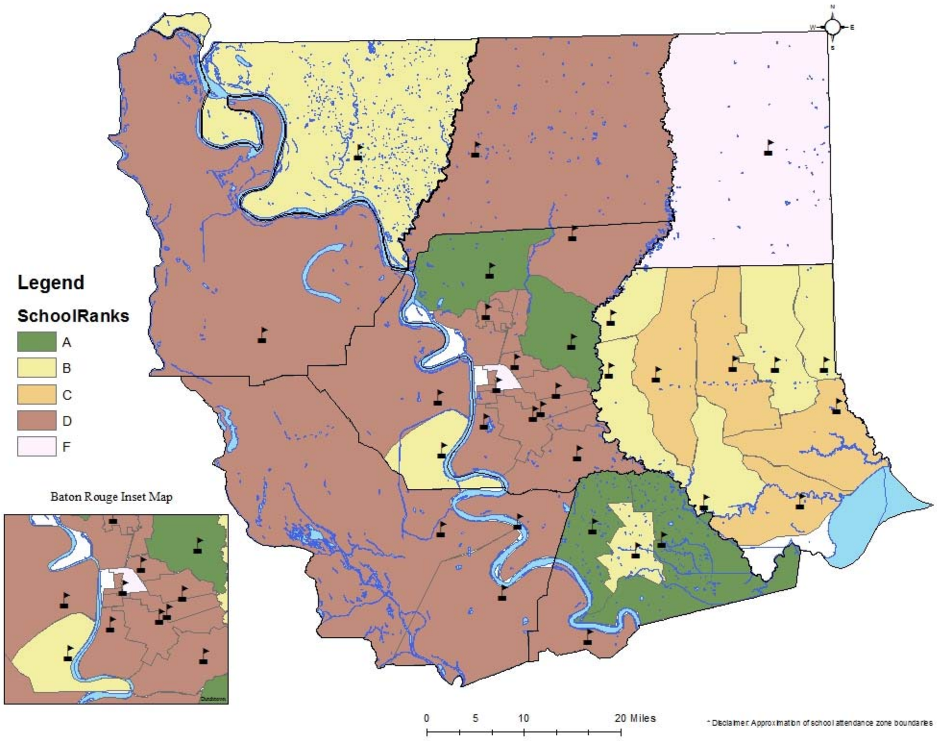

Figure 9. Social hierarchy based on SPS scores of 2010

Table 1 High school accessibility in BRMSA 1990-2010

	Schools	accessibility scores		
		1990	2000	2010
Socioeconomic Disadvantages	West Feliciana	1.89	1.36	3.23
	Clinton	1.68	1.51	Δ
	Shady Grove (Rosedale)	1.22	2.81*	●
	Jackson	0.96	1.09	Δ
	Rosenwald (New Roads)	0.61	Δ	n/a
	Plaquemines	0.59	0.44	0.47
	Donaldsonville	0.56	0.53	1.69
	McKinley	0.74	0.77	1.05
	Capitol	0.64	0.72	□
	Glen Oaks	0.80	0.74	0.77
	Istrouma	0.60	0.61	0.72
Rurality	Woodland	1.13	Δ	n/a
	Upper Pointe Coupee (Batchelor)	1.52	Δ	n/a
	Maurepas	1.59	1.38	3.29
	Rougon	1.32	Δ	n/a
	St. Helena	1.95	1	1.28
	Sunshine	1.22	●	n/a
Linguistic-cultural barriers	Live Oak	2.18	3.21	4.89
	Central	2.81	2.66	†
	East Ascension	4.09	3.57	5.32
	Denham Springs	3.96	3.09	7.93
	Dutchtown	-	-	6.88
	St. Amant	5.4	5.59	5.47
	Woodlawn	1.1	0.91	1.55
	Zachary	3.3	3.55	†

Δ School consolidation
● School closure
□ School taken over by state
† School formed independent district
* School name change

Table 2 2010 Rotated factor structure for aspatial variables

	Factor 1: socioeconomic disadvantages	Factor 2: Rurality	Factor 3: Linguistic-Cultural Barriers
Household below poverty level	.784	-.282	.215
Population 25+ without high school diploma	.781	.341	.102
Nonwhite population	.652	-.255	.003
Household lacking kitchen facilities	.492	.154	.129
Single parent household	-.401	-.129	.069
Population16-19 not enrolled in school	.399	.061	.259
Household lacking personal vehicle	.533	-.605	.082
Home ownership	.027	.599	.127
Population16+ in rural-oriented jobs	.168	.405	.075
Overcrowded household	.531	.041	.846
Little or no spoken English	-.031	.055	.252
Eigenvalue	*3.530*	*1.767*	*1.089*
Percent of variance	*32.1*	*16.1*	*9.9*

Extraction Method: Maximum Likelihood.
Rotation Method: Varimax with Kaiser Normalization.

Table 3 Correlation of socioeconomic variables and accessibility scores

Variable	Correlation coefficients		
	1990	2000	2010
Home ownership	.261**	.354**	.189*
Household lacking personal vehicle	-.116**	-.013	-.051
Household lacking kitchen facilities	-.058*	.071	.102
Overcrowded household	.011	.078	.074
Household below poverty level	-.050*	.027	-.002
Single parent household	-.024	.072	-.169*
Little or no spoken English	.051*	.09	.025
Population 25+ without high school diploma	.112**	.301**	-.171*
Population 16-19 not enrolled in school	.054*	.097*	-.039
Population16+ in rural-oriented jobs	.148**	.153**	-.046
Nonwhite population	-.145**	-.107*	-.132

** indicates significant at the 0.01 level (2-tailed);

* indicates significant at the 0.05 level (2-tailed).

Table 4. Correlation of accountability scores vs. spatial accessibility and composite factors

Vs. Spatial accessibility	.752**
Vs. Factor 1 (Socioeconomic disadvantages)	-.068
Vs. Factor 2 (Rurality)	-.094
Vs. Factor 3 (Linguistic-cultural barriers)	.514**

** indicates significant at the

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