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Planning and Analysis of Educational Facilities using GIS: A Case Study of Busia County, Kenya

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ABSTRACT:

The educational sector in Kenya as in many other third world countries is faced with numerous challenges such as lack of infrastructural and human resources, poor accessibility, imbalance between demand and supply, among others. A spatial analysis on the situation of the sector for a better understanding is essential at various geographical levels in order to evaluate the extent of these challenges. The purpose of this study was to illustrate how GIS can be used in addressing the educational planning problems through a case study of educational facilities in Busia County. The study involved inventory mapping of all the educational facilities in the County in the backdrop of existing road networks, analysis of the regional distribution of educational facilities, and evaluation of spatial accessibility to the facilities. Demographic data were used in demand analysis for various educational services within the county. Using the demand ratios such as school age population to primary schools, Secondary schools to primary schools, teacher to student ratio and student to toilet facility ratios demand maps and graphs were generated in GIS environment that clearly illustrates the challenges facing parents and other stakeholders as well the disparities in provision of quality education within the County. In addressing the spatial distribution challenges especially in the imbalance in demand and supply, Centres of Excellence are proposed, and suitable public primary schools are identified for expansion to secondary schools, based on certain criteria such as number of facilities, land size the school is located, and topography.

1 Introduction

1.1 Background and problem statement

Education is the process of learning and acquiring information. It can be classified into two: formal learning through an institution such as a school, and self-taught learning or what is often termed as life experience. In recognizing that quality education is a prerequisite to socioeconomic development, the Kenya government has committed itself to the improvement of the educational facilities in the entire country since independence. However challenges still exist in ensuring access to quality education for all school age children especially in the rural areas. Despite the government's efforts in expansion and delivery of educational facilities since independence, it is widely recognized that increasing population and demand for quality education far outstrip the ability of the Government to provide effective quality educational services in Kenya.

With the promulgation of a new constitution in 2010, the management of the country's resources and infrastructure will drastically change; revolving at two levels of governance: the Central government and the County government. This, it is presumed, will address issues of distribution of the country's resources equitably. The central government still retain most of the roles such as policy formulation, coordination and implementation as well as management of educational facilities, while the county governments will oversee the supervision and management of the facilities. It is therefore of essence for each county government to understand and enumerate its resources in order to better its service delivery to the people.

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Busia County, located in the western region of the country, was taken as a case study in this research. According to the 2009 census, the County had a population of 736, 942, rising at the rate of 34% from that of 549,644 ten years earlier. Despite the rising population, the county's educational facilities have remained unchanged, with statistics from the Ministry of Education showing that it has 417 primary schools, 92 secondary schools, 2 middle level colleges and 3 University Colleges. The situation on the ground generally reveals disparity in the distribution of these educational facilities, especially at the primary school level where some children walk quite long distances to access educational facilities and others walk quite short distances. Nonetheless, there exists no study to document either the spatial characteristic or accessibility to these facilities. This paper presents an effort of a geographical analysis on Busia County's education facilities. In specific, the study sought to map all educational facilities of the county in the backdrop of population distribution, topography, and the transportation network; elucidate on the capacities for the education facilities, as well as suggest ways of improving on equitable spatial distribution of the education facilities within the county.

1.2 The Study Area

Busia County is located in the Western Region of Kenya. It is border by the republic of Uganda in the north, and Siaya, Kakamega, and Bungoma Counties in the south, east, and north-east respectively. It is comprised of ten administrative divisions namely: Bundalangi, Funyula, Butula, Matayos, Township, Chakol, Amukura, Nambale, Amagoro and Angurai(Figure 1). The County covers an area of approximately 1,683 square kilometres and is located between latitudes 00° 01' and 00° 47' north of equator and longitudes 33° 57' and 34° 26' east of Greenwich meridian.

The county has moderate climatic conditions with temperatures ranging between 20 to 28° C. The main economic activities include agriculture at both small and large scale, fishing especially along the areas bordering Lake Victoria in Bunyala district, and dairy and livestock farming at small scale. Land in this county is privately owned, with individuals mainly having absolute rights as recognised by existing registration systems. The County has a quite a heterogeneous landscape that varies from flat and flood-prone lowlands of Bundalangi and Funyula to the hilly and steep Amagoro and Angurai divisions on the slopes of Mt. Elgon. The county is traversed by an expansive road network that links the administrative divisions as well as the county with its neighbours. It has also a varying population distribution, with Township division having the highest density, and Bundalangi and Funyula divisions that border Lake Victoria having the lowest.

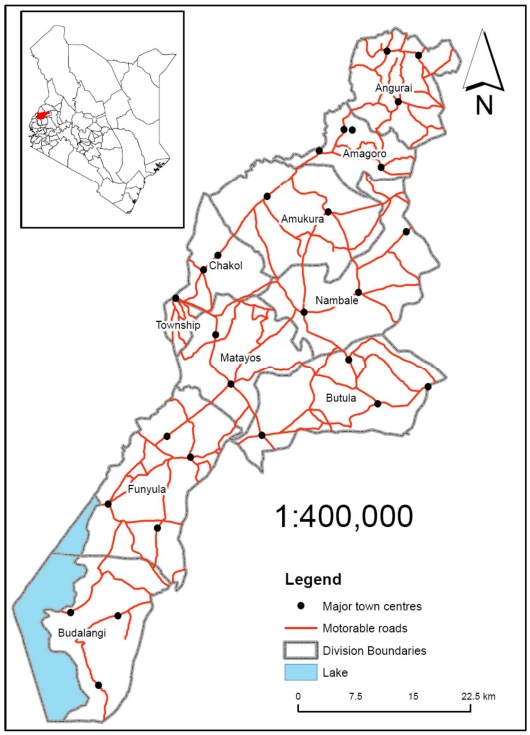

Figure 1: The study area: Busia County

1.3 Use of GIS in education planning

School mapping originated in France in 1963 (Caillods 1983; Da Graca, 1998; Galabawa et al. 2002; Govinda, 1999 as cited in Hite, 2008). School Mapping is a normative approach to the micro-planning of school locations and is also used to investigate and ensure the efficient and equitable distribution of resources within and between school systems especially when large-scale reforms or significant expansion of an educational system takes place (Calillods, 1983). Such reforms could be in form of government policies, such as the policy for free and compulsory primary education in Kenya that was introduction in 2003.

An educational system is inclusive of all supportive facilities, teaching staff, and an environment that is conducive for learning. Access to educational does not only mean attending school but also the proximity to the transportation network such as roads, sufficient number of teaching staff, adequate classrooms, good playing facilities etc. Access to quality educational facilities is therefore a critical determinant of the economic status of the populace. It is concerned with the ability of a population to obtain reasonably specified quality educational services. In general, access to quality education is an important concern for developing countries as is a significant factor that contributes to the economy of a given country. With its spatial analytic capabilities, GIS provides a good platform for a deeper geographical analysis of education accessibility.

To improve access to educational facilities, it is crucial to monitor how access varies across geography and sub-populations. Maps can be used to explore issues such as utilization and location of educational services and the difference levels of facilities. However the issue of access to educational facilities is in many respects a geographical one and thus spatial display of data is, in many ways, essential. The results are intended to empower researchers, policy makers, decision makers, practitioners, and donors to develop educational-related policies that achieve the highest benefits. GIS systems are therefore well suited to measuring spatial accessibility to educational facilities as they contain the core components needed for analysis such as data capture, storage, management and manipulation tools for both spatial and attribute data, core analysis algorithms such as buffering, overlay, suitability, proximity analysis, shortest path and raster cost-distance analysis, programming environments to customize and extend existing algorithms and create new analysis tools and mapping and visualization tools to communicate the results of analysis (Bazemore et al, 2003).

GIS can still be used in educational sector in many other ways such as conducting market studies and documenting educational needs of a community and to manage materials, supplies, human resources, and logistics, to forecast future enrolments and to predict future school requirements and appropriate locations so as to enhance accessibility to quality education and in the end improve the quality of life among many other areas (Attfield et al. 2002).

2 Methods and Materials

2.1 Overview and Materials

The problems that are experienced by the education sector in Busia County are mainly related to the spatial distribution of educational facilities and lack of balance between demand and supply in the provision of education to school age population. This study attempts to address these problems through inventory mapping of the education facilities, geographical analysis of demand-supply, facility analysis, staff-allocation analysis, and spatial accessibility and suitability analysis. Spatial accessibility in this research was based on straight line distances from the existing road networks. Demand analysis for the school facilities was carried out by computing the various indices such as, the ratio of school age population to existing facilities such as schools and classes, ratio of teachers to students, the ratio of secondary schools to primary schools, ratio of private schools to public schools, as well as ratio of number of facilities to the population density; all these were calculated and aggregated for analysis at the administrative division level.

Data used for this research work included scanned topographical maps, administrative boundary maps, demographic data of the county, school locations and related attributes. Data relating to the educational facilities was obtained from the Ministry of Education. The data comprised of the spatial location of the education facilities together with various attributes. The attributes of the data included facility classification. i.e. whether a primary , secondary or tertiary institution, total enrolment, number of teachers, school land area (acreage), number of toilet facilities for both boys and girls, number of laboratories, ownership of the school, whether the school was mixed. However, the dataset that was acquired had several missing values, necessitating only limited analysis to be undertaken, and forcing the analysis to be aggregated to the division level. This was particularly so for the primary schools data where the only analyses possible were on the spatial distribution per division in

the county, their ratio to that of secondary schools, accessibility, and for identifying suitable primary sections that could also allow expansion to accommodate secondary wing.

Additional spatial data for vocational training centres, middle level colleges, the three university colleges in the county, as well as important town centres, was collected using hand-held Global Positioning Systems (GPS) receivers. The GPS receivers were also used for verification of the spatial location data of the school data from the Ministry of Education and for the location of additional schools whose data had not been captured in the ministry database. All these were then assembled in a GIS geodatabase for further manipulation and analyses.

2.2 Methods

A total of nine topographical map sheets at a scale of 1:50,000 covering Busia County were used. All the topographical maps were scanned and then georeferenced in Arc 1960 datum. The georeferenced map sheets were then converted from Arc 1960 reference spheroid to the WGS 1984 for harmonization with the position data of the schools that was already pre-collected. From these scanned maps, information as such rivers, streams, contours, road networks and railways were extracted through on-screen digitizing and stored as feature classes. The feature classes were then edited and to remove the errors that occur during the digitizing such as dangles, overshoots and undershoots. These feature classes were then used as basemap elements of the County educational facility map and also in the analysis of accessibility to these facilities.

The roads were originally classified into three: tarmac roads, dry weather roads, and loose surface roads. The dry and loose surface roads formed the main access to the educational facilities, while the tarmac roads formed only a small percentage of road networks. In analyzing accessibility, the tarmac and dry weather roads were considered as motorable, and used in the selection of suitable public secondary schools that could be expanded to educational *Centres of Excellence* for each division. The schools selected for expansion were those which fell within a buffer of one kilometre from either the tarmac or dry weather roads (motorable roads). Further buffer analyses were undertaken by setting several 1km buffer bands in order to facilitate discussions on levels of accessibility from the roads.

Information from informal interviews from education officers and other administrators showed that it would be more expensive to bring equitability in education by building new secondary schools. Furthermore it would be quite a task to find any land on sale for such project, as the demand superseded supply due to high population. Therefore it was suggested that public primary schools that were located on large parcels of land could be expanded to have a secondary wing. Therefore, spatial selection based on attributes was done, and further those identified had to be within the 1km buffer zone of any road.

A digital elevation model (DEM) was created from contours digitized from scanned topographical maps. The DEM generated was used during the suitability analysis to locate public secondary schools, which had enough areas of land (more than 7 acres) and on suitable grounds that were neither very flat (as the area is prone to flooding) nor too steep, to be expanded to *Centres of Excellence,* and also in identifying primary schools which could be expanded to have a secondary school section.

3 Results and analysis

3.1 Spatial distribution of education facilities

Aggregating the obtained data at the division level revealed the spatial distribution of the various educational facilities of Busia County (Table and Figure 2). Funyula division has the highest number of public primary schools, followed by Butula while Township division has the least. However, Butula lead in the number of public secondary schools while Townships still had the least. Amagoro and Nambale Divisions, however, had the highest number of private schools.

Table 1: Distribution characteristic of education facilities in Busia County

Division	Pop. Total	Area in Sq. km	Density	College	Public Sec.	Private Sec	Public Prim.	Private Prim	VTC	Total
Township	35,663	22.3	1,599	1	2	1	8	5	1	**18**

Matayos	75,682	173.9	435	0	13	0	38	6	1	**58**
Nambale	94,637	237.8	398	2	13	2	41	6	3	**67**
Butula	121,870	247.1	493	0	16	1	57	9	2	**85**
Angurai	59,740	146.9	407	0	9	1	38	2	1	**51**
Amagoro	58,207	114.1	510	0	3	1	19	11	0	**34**
Funyula	93,500	265.1	353	1	11	1	64	3	2	**82**
Budalangi	66,723	188.3	354	0	7	0	34	3	1	**45**
Amukura	61,536	159.0	387	0	6	0	43	1	1	**47**
Chakol	76,388	140.6	543	1	5	0	24	5	1	**36**
Total	**743,946**	**1695.1**		**5**	**85**	**7**	**366**	**51**	**13**	**527**

***Sec. – Secondary Schools; Prim.- Primary Schools; VTC – Vocational Training Colleges;**

3.2 Accessibility analysis

The use of buffer analysis showed that 84% of the primary schools and 89% of the secondary schools were within 1km travel distance from motorable roads. This means that majority of educational facilities could easily be accessed by educational administrators. Except for a single primary school in Chakol division, all the other remaining schools lay within 4 km from motorable roads.

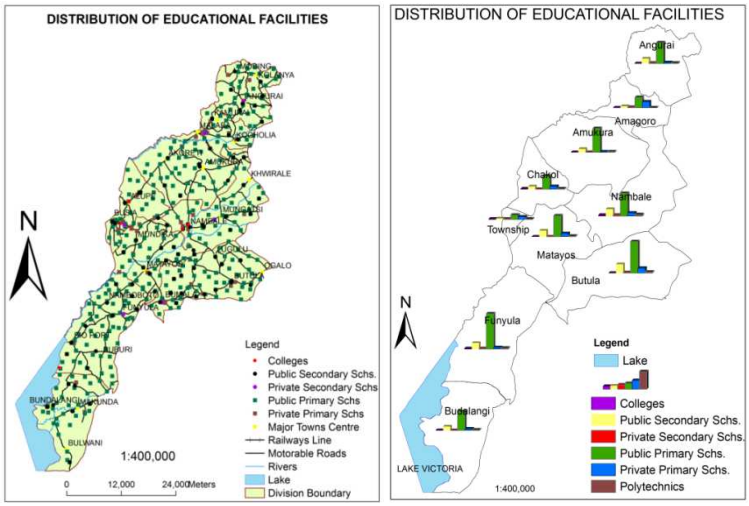

Figure 2: Spatial distribution of education facilities in Busia at the division level

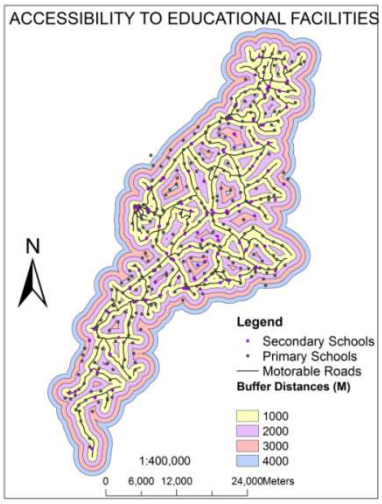

Figure 3: Schools distribution in relation to the road network.

3.3 Demand Analysis

The demand analysis was carried out at the division level. On the assumption that 65% of the population was school-age going, and that the secondary schools pupils was known from the collected data, several demand indices were calculated. With the primary school data, the indices were: school age population to number of primary schools, number of pupils per class, and the ratio of secondary schools to primary schools. Other geographical analyses carried out at the division level included: teacher-to-student-ratio for public primary schools, private-to-public schools, student-to-toilet ratio.

The results in general highlight the demand for and on education facilities at the division level. They reveal the spatial heterogeneity in demand as well as the disjoint in secondary to number of primary schools, ration of teachers to students, and also the number of pupils per toilet at the division level. Busia Township division and Amagoro have over 2,000 pupils in a primary school (see Table 3), and of the ten divisions of Busia County, only two had a demand of less than 1,000 pupils in a primary school. This shows that there is overpopulation in schools, calling for expansion of the primary school facilities or the creation of new schools. The analysis also show the ratio of secondary schools to primary schools being quite high, which indicates the necessity to have more secondary schools. The indices were mapped in the GIS environment in order to improve on the spatial analytic perspective.

Table 2: Education facility demand analysis

DIVISION	School age pop.-to-primary schools (n:1)	Secondary-to-primary schools (1:n)	Teachers-to-students (secondary) (1:n)	Students-to- Toilets (n:1)
Amagoro	2,042	8	37	44
Amukura	1,088	7	21	30
Angurai	952	4	18	28
Budalangi	1,204	5	19	39
Butula	1,313	7	35	37
Chakol	1,504	6	20	35
Funyula	895	6	34	31
Matayos	1,381	3	17	37
Nambale	1,297	3	18	34

Township	2,814	4	20	34

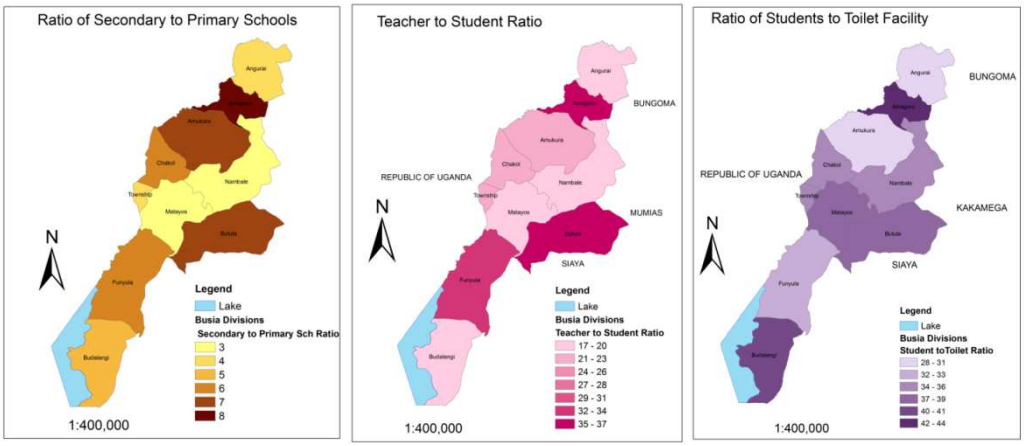

Figure 4: Spatial visualisation of the education facility demand analysis

3.4 Suitability analysis

3.4.1 Suitability analysis for primary schools for expansion

Further geographical analysis was undertaken to select the public primary schools which could be expanded to accommodate a secondary section, based on the demand analysis for form one places for each division. The assumption was that a division with a higher number of pupils in a given class will most likely have more pupils sitting form standard eight examination and hence a higher demand for secondary schools. Also the ratio of existing secondary schools to primary schools is considered in this analysis. The existing public schools were targeted because most of the land within the County is privately owned and not many people would be willing to sell their small portions. The factors considered in selection of suitable primary schools were: the selected schools should be located in divisions where the ratio of school age population is equal or greater than 1,300; the ratio of secondary schools to primary schools should be equal to or greater than four; the distance of the primary school from the existing public secondary school must be greater than or equal to 3.0 kilometres; the school must have area of land equal or greater than seven acres((2.8 hectares); and the location of the primary school must be in an area with a slope of between 2 and 20 degrees(so that hilly and very low-lying areas would be avoided).

The selection resulted in eight public primary schools for expansion located in the four divisions that had high demand for secondary school spaces; three schools were in Chakol division, Butula and Township had two schools each, while the remaining was found in Amagoro division (See Figure 5).

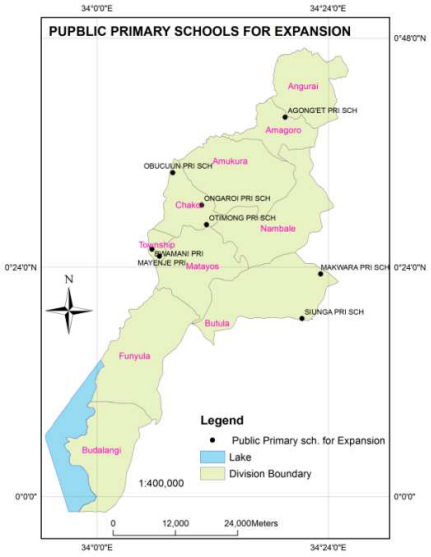

Figure 5: Public primary schools selected for expansion to include a secondary section

3.4.2 Suitability analysis to locate " *Centres of Excellence*"

The selection was based on divisions since the divisional boundaries separated small sub-tribes with conflicting interests especially when deciding on locality of important facilities like County headquarters or recently the location of national secondary schools where each sub-tribe demanded that the national school be located in their division. Therefore from the existing public secondary Schools in each division in the County, two schools were selected where possible so that the existing infrastructures could be improved and the schools expanded to become Centres of Excellence in education provision so as to improve quality and ensure equity.

The factors considered in selecting schools earmarked for expansion were: the school's total enrolment of students was set at greater than or equal to 350 students; the existing number of laboratories should be greater than or equal to two (at least 2 labs), the school must be located at a distance of less than or equal to one kilometre from motorable road, the school must have an area of land greater than or equal to fifteen acres (15 acres), and the school must be a boarding school of either boys or girls only respectively. Looking at the distribution of the schools that met the set criteria, one realizes that three divisions (Chakol, Amukura and Amagoro) have only one school each while Busia township division has none at all. The analysis of mixed schools in the four divisions that had deficit was then carried out but still none met the set criteria. It is therefore proposed that other criteria be set to identify one more school each in Chakol, Amukura and Amagoro divisions to be expanded.

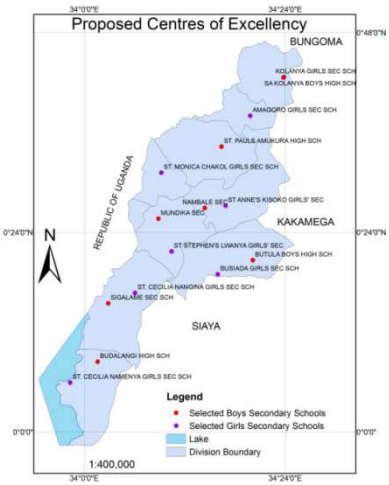

Figure 6: Secondary schools that met the criteria for expansion to Centres of Excellence.

4 Conclusions and Recommendations

The study demonstrated the use of GIS in analyzing positional related data and its enormous potential in solving educational planning problems. Using simple GIS tools like selection by attribute and location, it was seen that GIS can assist in addressing problems of disparity and lack of balance between demand and supply of educational facilities. Additionally, the visual display of the various demand maps and graphs availed in GIS, provides powerful support tools to aid decision making on what action to take. Parents can also make informed decisions when choosing schools for their children using these demand maps, charts, graphs and the database management system.

The results on accessibility analysis of the educational facilities show that most of Busia county education institutions to be well-accessible. However, mapping of the roads in different surface categories reveal that bitumen-covered roads to be quite few, calling for an upgrade of most of the roads. Prioritizing the roads to be improved to bitumen standards can be decided upon by spatial queries of facilities and centres that the road serves in combination with other spatial factors such as topography.

The proposal to expand some primary schools to have a secondary school section, and also the expansion of the proposed public secondary schools to Centres of Excellence in education provision will not only ensure quality, equity and gender balance but also promote harmonious co-existence amongst the sub-tribes in the county. Unfair competition for form one places, among the divisions with high demands and high enrolments rates will also have been addressed. Further analysis of facilities such as toilets, laboratories, and staffing, provides an opportunity to understand not only the spatial distribution characteristic of the education facilities across the county, but also on the quality of these facilities, and ability to address education needs.

As the study utilised projected data from the national and housing census of 2009, a more detailed study within actual survey data within the county is so that the actual situation on the ground can be well represented. Other non spatial factors like literacy, age, sex, religion, economic status and ethnicity could also be incorporated to check their influence on education sector.

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