Development of Goverment Schools Based on GIS: A Case Study of Orangi Town, Karachi

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Abstract
The primary school system in Pakistan needs improvement in order to provide the basic right of education to all. Government schools are not enough to cater the needs of increasing population of the country. The main goal of this study was to present a methodology for the development of government schools based on geographical information system (GIS) through a case study of Orangi Town in Karachi. In this study, first the adequacy of government schools in the study area was evaluated and then the need for additional schools with their suitable locations were identified. Data regarding school locations and students enrollments were collected from Sindh Basic Education Program of a non-profit NGO iMMAP. School building footprints were digitized from 2001 and 2013 Google Earth archived images. Population in 2013 was estimated by projecting 1998 census data downloadable from the website of the Census Bureau of Pakistan. An educated assumption of 20 % of the total population of Orangi Town was used to calculate number of primary school-aged children. Study results showed that schools existed in 2013 were not sufficient to serve all these children. This study also revealed that new schools were built during this time period, but the population growth rate was much higher than the growth rate of schools that created a big supply-demand gap. The most progressive Union Council (UC) of Orangi Town was Haryana Colony where 17 new schools were constructed between 2001 and 2013 though the required number of schools still fall short. New sites for schools were also proposed to optimally serve Orangi Town’s residents using GIS proximity analysis.

Keywords: Education, GIS, Proximity Analysis, Schools, Temporal Analysis

1. Introduction
Education is the basic human right that should be available to all people belonging to any socio-economic class. It is not only the requirement of an individual but the successful human societies around the world have high literacy rates. Pakistan is a developing country with high population growth rate and the reported literacy rate of Pakistan is 57.7 % (Rehman et al., 2016). The people belonging to the lower and lower middle classes can only afford government schools for their children because of their minimal tuition fees. The population growth rates in these two classes is higher than the growth rate of government schools accessible to them. Before the situation gets further worse, there is an urgent need to improve the education facilities and make it possible for every child in the country to avail this opportunity.

Every good governance is expected to take up the responsibility of facilitating its peoples in acquiring quality education. In Pakistan, there are two types of school systems: the government schools where education is almost free, and the private schools that charge extraordinarily high fees for providing education. The existence of parallel educational systems in Pakistan and their limited accessibility to the majority of the population is even a bigger dilemma. The underprivileged children can only study at government schools and most of these schools not only have an insufficient number of teachers and limited educational facilities but lack proper curriculum to compete with the private schools’ standards (Alderman et al., 2001). Parents, who may afford higher tuition fees, send their children to private schools. The medium of teaching is also different in both private and public school systems. This disparity is not only promoting a class difference between the masses and the elites of our society, but it is also causing restlessness among people who are deprived of their basic education right. Gender imbalance at school level is also evident from the prevailing ratio of 10 boys to 4 girls (Qureshi, 2012). One of the reasons for this unfortunate situation is the low allocation of funds in the education sector coupled with unsuitable sites selection for schools. In 2014 national budget, financial allocation for education is around 1.5 % to 2 % of the total national Gross Domestic Product (GDP) which is way too low compared with the global standard of 4 % (Ministry of Finance, n.d.). Poverty and its consequence in the form of child labour are also some major factors that
prohibit parents to send their children to schools (Ray, 2000). These problems contribute to low literacy rate in the country which in turn causes economic crises in terms of increasing number of unemployed people.

Taking all these factors into account, it was felt necessary to evaluate government schools and their growth in the past decade taking Orangi Town as a test case (Taki and Lubis, 2017). Although one of the five programs run by the renowned Orangi Pilot Project since 1980 in the same area was education which has upgraded and improved the academic standards of the private schools in Orangi Town (Hasan Arif, 2006). However, the need for upgradation of government schools still exists.

In this study, a geodatabase of the existing schools in the study area was built that was further utilized to derive valuable information regarding the adequacy of the current school system serving Orangi Town residents. It is an agreed upon fact that planning and development in any sector including education can be done more efficiently if these are managed through geodatabases. In this study, sites for building new government schools were also proposed in areas where the existing system failed to cater the educational needs of the people. Emerging technologies of Geographical Information System (GIS) and Remote Sensing (RS) were utilized for this purpose (Audet and Paris, 1997)(Agrawal and Gupta, 2017)(Huang and Jiang, 2017).

1.1 Study Area

Orangi Town is a densely populated town in the northwestern part of Karachi covering an area of 60 sq.km. It shares borders with New Karachi Town in the north, Gulberg Town in the east, Liaquatabad Town in the south, and SITE Town in the west (Fig. 1). Orangi Town has 13 Union Councils (UCs) with a total population of 919,995 people out of which 183,999 are children of 4-5 years age group. The town consists of 86 informal settlements or katchi abadis which account for over 70% of its population. It has 10,4917 houses in 7,256 lanes which make on average around 9 people per house (Hasan Arif, 2000).

Several ethnic groups are residing in Orangi Town including Muhajirs, Punjabis, Sindhis, Kashmiris, Seraiiks, Pakhtuns, Balochis, Memon, Bohras, Ismailis, and others. Orangi Town was selected for this study because of its critical condition with respect to population, economic status, urban sprawl, and an insufficient number of government schools.

Orangi residents merely get enough money to make both ends meet, so it is quite hard for them to send their children to private schools of the area where tuition fees are higher than what they can afford.

Fig 1. Study Area

Government schools are not only insufficient in number, but their defective and inadequate infrastructure, larger class sizes, and unstable enrollments are making these systems less efficient and unattractive for the residents of Orangi Town.

2. Methodology

This study has three major objectives as described below.

1. To report temporal changes in number of schools over a span of 12 years from 2001 to 2013 using Google Earth archive images to evaluate their growth in Orangi Town.

2. To calculate the ratio between primary school aged children and number of schools to access the adequacy of existing schools in the study area.

3. To analyze the proximity of schools from the population being served and suggest new school locations for Orangi Town children with easy access to serving schools.

2.1 Data Collection

For mapping of schools, it was necessary to collect school location data. The existing school data used in this study were acquired from USAID non-profit organization IMMAP Pakistan (Broda and Baxter, 2003). The IMMAP had earlier conducted a survey with the objectives to reconstruct and rehabilitate schools in five (5) towns of Karachi. Other data and their sources are listed below.

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1 Administrative units at city level.
1. Union Council map of Orangi Town of Karachi Metropolitan Corporations.
2. Google Earth archive maps to find out the temporal changes in the number of schools over the span of 12 years (Al-hanbali et al., 2003).
3. Union Council (UC) wise population data of Orangi Town from the Census Bureau of Pakistan (Mahmood, 2011).

2.2 Data Processing
Several data processing steps were performed to achieve the objectives of the study. The following are the sequence of these steps including GIS and remote sensing techniques. Fig. 2 shows the methodological framework of the study.

1. Geo-referencing: Maps of Orangi Town, acquired from Karachi Metropolitan Corporation (KMC), were scanned and geo-referenced using ground control points identified at Google Earth images.

2. Digitization: Digitization of UC level maps and school location data were done to prepare geodatabase and GIS maps.

3. Data Manipulation: Information from raw data was derived. Details of data analysis are discussed in ‘Data Analysis and Results’ section.

4. Estimation of Future Population: The available population Figs. when this study was conducted, were from 1998 census. Population growth model (Eq. 1) was used to estimate the population of Orangi Town in 2013 (P) using 2 % population growth rate (r) described in the Current Account Balance of Pakistan

\[ P = P_0 e^{rt} \]  

Eq.1

Where;

\[ P_0 = \text{population in 1998 (723,694 people); } r = 0.02; \text{ time span for estimation which was 15 years in this study.} \]

Population of 2013 was calculated as;

\[ P_{(2013)} = 723,694 e^{0.02*15} = 976,884 \text{ people} \]

3. Data Analysis and Results
3.1. Temporal Change in Number of Schools from 2001 to 2013

As discussed earlier, the primary education in a country should be the responsibility of its government. To assess the initiatives taken by the city government of Karachi in its highly populated town of Orangi, the number of government schools, their growth to cater increasing population of the town, and their serving capacities to address the need of the residents were analyzed. It was believed that with an increase in population there should be a corresponding increase in the number of schools. Using iMMA data and Google Earth archive maps, schools that existed in 2001 were digitized first. Similarly, the schools footprints in 2013 were digitized. The difference between 2013 and 2001 schools was the change in number of schools in Orangi Town over the span of 12 years. Few pieces of evidence were drawn from the following maps and tables (1-2) that are discussed in this section.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Azad Nagar</td>
<td>1</td>
<td>6</td>
<td>14</td>
<td>8</td>
</tr>
<tr>
<td>Haryana colony</td>
<td>2</td>
<td>0</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>Hanfiabad</td>
<td>3</td>
<td>4</td>
<td>11</td>
<td>7</td>
</tr>
<tr>
<td>Muhammad Nagar</td>
<td>4</td>
<td>8</td>
<td>13</td>
<td>5</td>
</tr>
<tr>
<td>Madina colony</td>
<td>5</td>
<td>1</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Ghaziabad</td>
<td>6</td>
<td>2</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Chushti Nagar</td>
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<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Bilal Colony</td>
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<td>3</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Islam Chowk</td>
<td>9</td>
<td>4</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Gabol Colony</td>
<td>10</td>
<td>3</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Data Nagar</td>
<td>11</td>
<td>9</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>Mujahidabad</td>
<td>12</td>
<td>2</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>Baloch Goth</td>
<td>13</td>
<td>8</td>
<td>8</td>
<td>0</td>
</tr>
</tbody>
</table>

Similarly, the school’s footprints in 2013 were digitized. The difference between 2013 and 2001 schools was the change in number of schools in Orangi Town over the span of 12 years. Few pieces of evidence were drawn from the following maps and tables (1-2) that are discussed in this section.
In 2013, the highest densities of schools were found in Baloch Goth and Mujahidabad, and high densities in Haryana Colony, Hanifabad and Muhammad Nagar (Fig. 6).

Fig. 6. 2013 Schools Density Map

Fig. 7. UC-wise Increase in Schools (2001-2013)

Fig. 7 shows the temporal changes in number of schools in each UC. Haryana Colony had the maximum increase of 17 schools during the study.
period. Gabol Colony and Hanfiabad also had new schools built during this time period. This information helped in deducing government initiatives and it was concluded that government had paid some, although not sufficient, attention to the education system of Orangi Town. To improve education standards in the town, the government ought to plan more schools in the union councils that have unserved population of school-aged children.

3.2. Population to School Ratio

Population to school ratio in each UC was calculated by dividing the UC population with the number of schools in that UC. The purpose of this analysis was to ascertain, on average, the population being served by a single school. Fig. 8 and 9 show population to school ratios at UC level in 2001 and 2013 respectively. In these Figs, the darker regions illustrate the severity level of these union councils bearing dense population with the scarcity of schools.

![Population and School Ratio 2001](image)

![Population and School Ratio 2013](image)

3.2.1. Ratio between 5-9 years age group population and schools

According to the estimated population of Sindh-Pakistan, 15.47% are 5-9 years age group children (Distribution of population, 2012). The same percentage was used to calculate population between 5-9 years in each UC.

Table 3. UC-wise Population of 5-9 years Age Group

<table>
<thead>
<tr>
<th>Name</th>
<th>UC No</th>
<th>Pop 1998</th>
<th>Estimate Pop 2013</th>
<th>Population between 5-9 years of age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Azad Nagar</td>
<td>1</td>
<td>56,160</td>
<td>75,808</td>
<td>11,727</td>
</tr>
<tr>
<td>Haryana colony</td>
<td>2</td>
<td>64,570</td>
<td>87,160</td>
<td>13,484</td>
</tr>
<tr>
<td>Hanfiabad</td>
<td>3</td>
<td>54,372</td>
<td>73,394</td>
<td>11,354</td>
</tr>
<tr>
<td>Muhammad Nagar</td>
<td>4</td>
<td>63,753</td>
<td>86,057</td>
<td>13,313</td>
</tr>
<tr>
<td>Madina colony</td>
<td>5</td>
<td>49,998</td>
<td>67,490</td>
<td>10,441</td>
</tr>
<tr>
<td>Ghaziabad</td>
<td>6</td>
<td>59,402</td>
<td>80,184</td>
<td>12,404</td>
</tr>
<tr>
<td>Chishti Nagar</td>
<td>7</td>
<td>58,582</td>
<td>79,077</td>
<td>12,233</td>
</tr>
<tr>
<td>Bilal Colony</td>
<td>8</td>
<td>64,776</td>
<td>87,438</td>
<td>13,527</td>
</tr>
<tr>
<td>Islam Chowk</td>
<td>9</td>
<td>62,248</td>
<td>84,026</td>
<td>12,404</td>
</tr>
<tr>
<td>Gabol Colony</td>
<td>10</td>
<td>56,121</td>
<td>75,755</td>
<td>11,719</td>
</tr>
<tr>
<td>Dada Nagar</td>
<td>11</td>
<td>56,964</td>
<td>76,893</td>
<td>11,895</td>
</tr>
<tr>
<td>Mujahidabad</td>
<td>12</td>
<td>51,866</td>
<td>70,011</td>
<td>10,831</td>
</tr>
<tr>
<td>Baloch Goth</td>
<td>13</td>
<td>24,882</td>
<td>33,587</td>
<td>5,196</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>114</td>
<td>723,694</td>
<td>976,884</td>
<td>151,124</td>
</tr>
</tbody>
</table>

Fig. 10 represents the population of primary school going children in 5-9 years age group in 2013. Each union council had more than 5,000 children between 5-9 years of age. Map regions with intense shades represent the UCs having more children of this age as compared to the UCs with lighter shades. In Fig. 10, it is also evident that number of students enrolled in the government schools of Haryana Colony was maximum among all other UCs. The number of enrollments in this UC was 2,600, whereas, the school-aged children of this UC were around 16,000 in 2013. This implies that majority of the school-aged children were not getting school education.
Fig. 10. Population of 5-9 Years Age Group (2013)

Fig. 11. 5-9 Years Age Group and Schools Ratio (2013)

Fig. 13. Proximity from Existing Schools

Fig. 14. Easily Accessible Proposed School Sites

3.3. Proximity of School to Serving Population

Orangi Town comprises of low-income group residents that can barely afford educational expenses of their children. It is presumed that people living far from schools will hesitate to send their children with an additional conveyance cost. GIS proximity tool based on Euclidean Distance was used to visualize the distances of current schools from the settlements of the Orangi Town (Lisa Aultman-Hall et al., 1997) (Falb et al., 2007). For proximity analysis, a maximum threshold of 500 meters was considered as a convenient walking distance for children living nearby. Proximity analysis was done to evaluate if these schools were within this convenient distance from the population being served? New schools were proposed where people were living far from schools at a distance more than 500 m.

In Fig. 13, the served areas are presented by the innermost circles (in yellow colour) with 500 meters radius around each school. Fig. 13 also illustrates the distance of each school from adjoining population. From this Fig., an urgent need can be highlighted for establishing new schools in the areas with deep orange shade representing areas farther than 500 m from any serving school in Orangi Town. The GIS tools can be used to suggest new school sites based on an easily accessible distance between schools and people being served by these schools. Following this approach, Fig. 14 represents proposed new schools sites in Ghaziabad, Bilal Colony, Medina Colony, Chisti Nagar, Islam Chowk, Gabol Colony, Azad Nagar, and Haryana Colony.

4. Conclusions

In this study school data of 2013 were compared with the school footprints on 2001 archive Google Earth image to analyze schools growth during study period in a heavily populated town of Karachi named Orangi Town. The school growth was also compared with the population growth of Orangi Town within that time frame. As expected, the population growth was much higher than the increase in number of schools. The existing schools were found to be insufficient in number to cater the
educational needs of the area. This situation is very alarming and many social issues such as unemployment, crime, poverty, and others can emerge due to increase in illiterate population.

The school going population in each UC was divided by the number of schools present in that UC to find out the number of children that could be served by a single school. Few UCs that were densely populated had very high children to school ratio which indicated that the existing schools in 2013 were not enough and more schools were needed in these areas.

In this study, the proximity of schools from the population to be served was also analyzed considering a maximum threshold of 500 meters as an acceptable walking distance for children living nearby. This proximity analysis revealed that there were some unserved settlements in the northern parts of Orangi Town. The GIS proximity analysis also helped in identifying sites for the construction of new school buildings in unserved areas of Ghaziabad, Bilal Colony, Medina Colony, Chisti Nagar, Islam Chowk, Gabol Colony, Azad Nagar and Haryana Colony.

This is also important to mention here that this study was based on quantitative assessment of primary school systems in Orangi Town that, is not a sufficient indicator to evaluate an overall adequacy of any education system. Not only the construction of school buildings should be the prime concern but maintaining it further is essential for the sustainability of the educational system. Therefore, it is proposed as a future research task, to evaluate the quality of school system in Orangi Town to augment the finding of this study. Till then, the results of this study can help the government to step forward and strengthen educational system through establishing new schools in areas that are still unserved. Only then the limited education budget can be optimally utilized and people at Orangi Town may get primary education within walking distances from their homes and at an affordable cost.

References
Al-hanbali, N., Al-kharouf, R., Bilal, M., 2003. INTEGRATION OF GEO IMAGERY AND VECTOR DATA INTO SCHOOL MAPPING GIS DATA-MODEL FOR EDUCATIONAL DECISION SUPPORT SYSTEM IN JORDAN.

Distribution of population, 2012.