

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

Sumaira Zafar^{1*}, Maha Qaisar¹, Zainab Sohail¹, Arjumand Zaidi²

^{1,2} Department of Remote Sensing and GISc, Institute of Space Technology (IST)-Karachi, ² USAID Advance Center for Water Studies, Mehran University of Engineering and Technology-Jamshoro

* Corresponding author : sumaira.zafar_ncrg05@ist.edu.pk

Tel.: +92-21-34650765 Ext 2296

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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 downloaded 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 Councils¹ (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 104,917 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*, *Seraikis*, *Pakhtuns*, *Balochis*, *Memons*, *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.

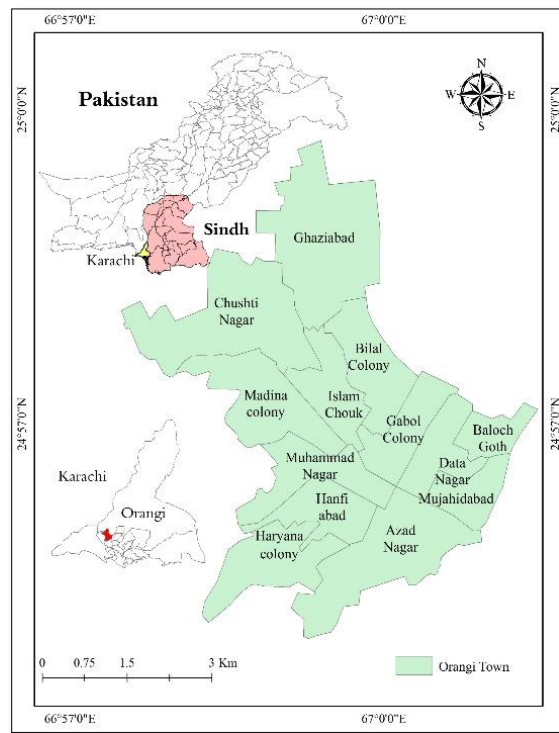


Fig 1. Study Area

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.

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).

$$P = P_0 e^{rt} \quad \text{Eq.1}$$

Where;

P_0 = population in 1998 (723,694 people); $r = 0.02$; t = time span for estimation which was 15 years in this study.

Population of 2013 was calculated as;

$$P_{(2013)} = 723,694 e^{0.02 \times 15} = 976,884 \text{ people}$$

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.

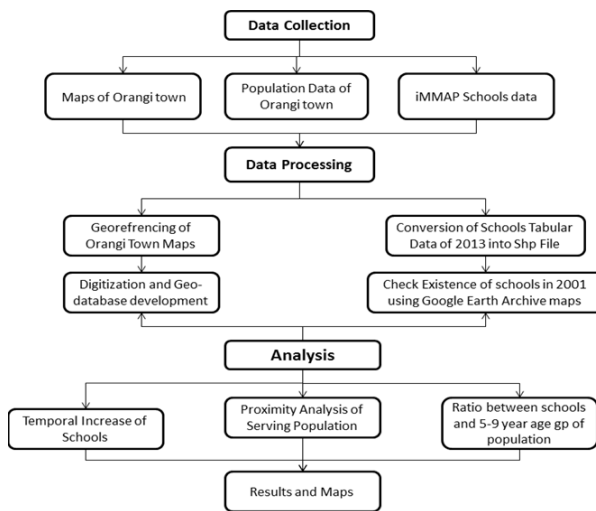


Fig. 2. Methodological Framework

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 Fig.s, 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*.

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 iMMAP data and Google Earth archive maps, schools that existed in 2001 were digitized first.

Table 1. Number of Schools in 2001 and 2013

Name	UC. No.	School (2001)	School (2013)	New School In 12 Years
Azad Nagar	1	6	14	8
Haryana colony	2	0	17	17
Hanfiabad	3	4	11	7
Muhammad Nagar	4	8	13	5
Madina colony	5	1	5	4
Ghaziabad	6	2	4	2
Chushti Nagar	7	0	5	5
Bilal Colony	8	3	3	0
Islam Chowk	9	4	4	0
Gabol Colony	10	3	5	2
Data Nagar	11	9	9	0
Mujahidabad	12	2	12	10
Baloch Goth	13	8	8	0

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.

Table 2. UC-wise Population of Orangi Town

Name	UC No.	Population 1998	Estimated Population 2013
Azad Nagar	1	56,160	75,808
Haryana Colony	2	64,570	87,160
Hanfi abad Muhammad Nagar	3	54,372	73,394
Madina colony	4	63,753	86,057
Ghaziabad	5	49,998	67,490
Chushti Nagar	6	59,402	80,184
Bilal Colony	7	58,582	79,077
Islam Chowk	8	64,776	87,438
Gabol Colony	9	62,248	84,026
Data Nagar	10	56,121	75,755
Mujahidabad	11	56,964	76,893
Baloch Goth	12	51,866	70,011
Baloch Goth	13	24,882	33,587
Total		723,694	976,884

Figs 3 and 4 illustrate the number of schools in UCs of Orangi Town in 2001 and 2013 respectively. Fig. 5 is a density map for 2001 developed by dividing the number of schools in each UC by its area in sq.km. The density of schools was more in regions with darker shades in the map. Baloch Goth had 11 schools, Data Nagar 6 to 10 and Muhammad Naqar had 4 to 5 schools per sq.km.

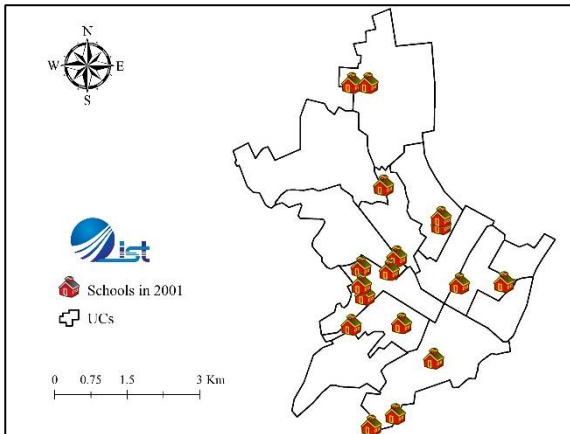


Fig. 3. Schools in 2001

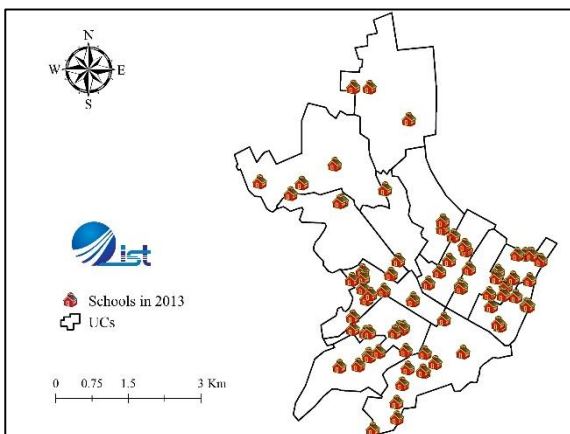


Fig. 4. Schools in 2013

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).

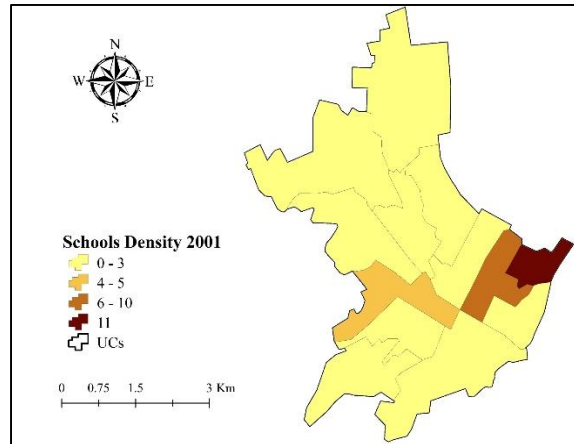


Fig. 5. 2001 Schools Density Map

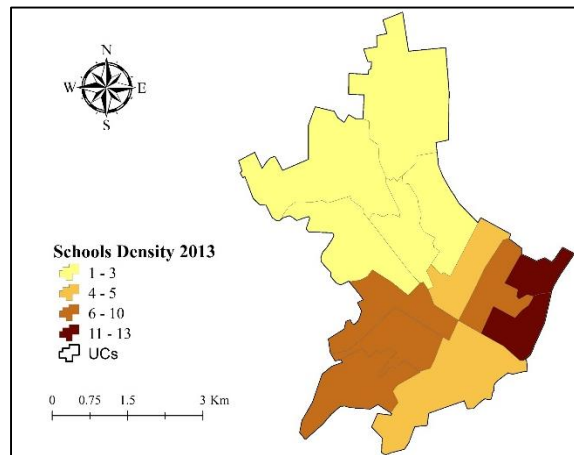


Fig. 6. 2013 Schools Density Map

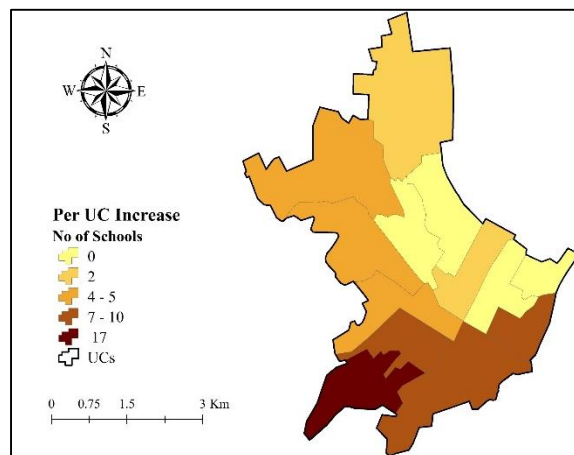


Fig. 7. UC-wise Increase in Schools (2001-2013)

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.

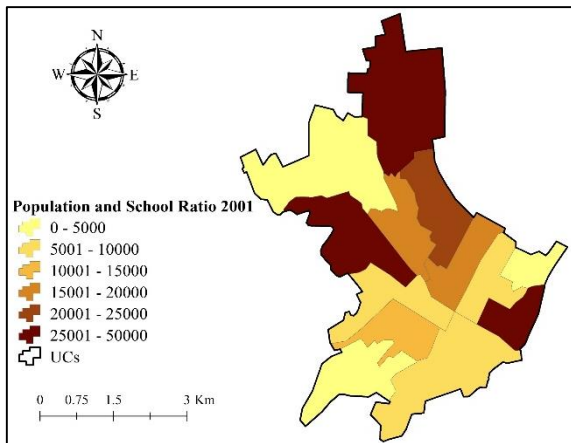


Fig. 8. Population and School Ratio (2001)

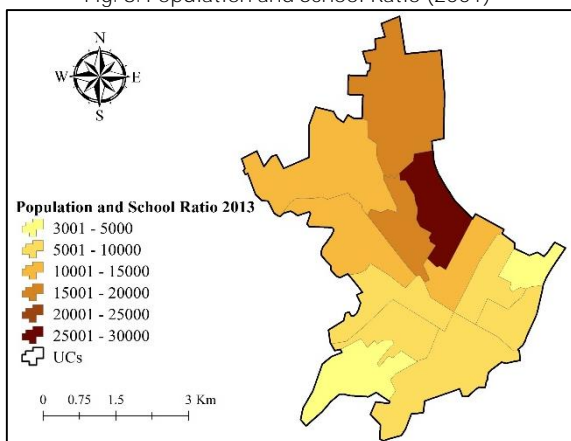


Fig. 9. Population and School Ratio (2013)

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

Name	UC No	Pop 1998	Estimate d Pop 2013	Population between 5-9 years of age
Azad Nagar	1	56,160	75,808	11,727
Haryana colony	2	64,570	87,160	13,484
Hanfiabad	3	54,372	73,394	11,354
Muhammad Nagar	4	63,753	86,057	13,313
Madina colony	5	49,998	67,490	10,441
Ghaziabad	6	59,402	80,184	12,404
Chishti Nagar	7	58,582	79,077	12,233
Bilal Colony	8	64,776	87,438	13,527
Islam Chowk	9	62,248	84,026	12,999
Gabol Colony	10	56,121	75,755	11,719
Dada Nagar	11	56,964	76,893	11,895
Mujahidabad	12	51,866	70,011	10,831
Baloch Goth	13	24,882	33,587	5,196
Total		723,694	976,884	151,124

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.

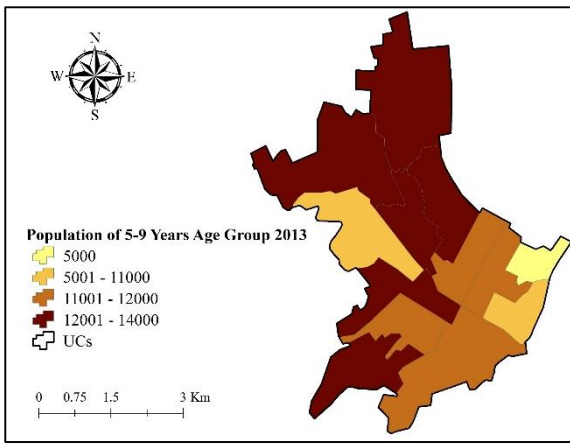


Fig. 10. Population of 5-9 Years Age Group (2013)

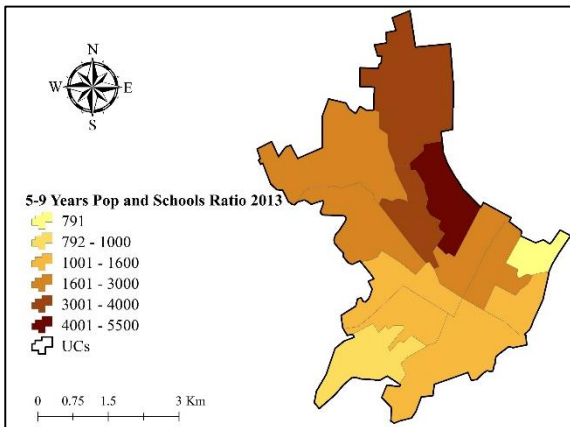


Fig. 11. 5-9 Years Age Group and Schools Ratio (2013)

Fig. 11 shows union councils with dark shades representing less number of schools for children between 5-9 years of age. As the shade goes lighter, the number of schools for the primary level going children increases.

In Fig. 12, it can be observed that a small number of students were enrolled in government schools in 2013. This can also indicate another problem of the area where not only the sufficient number of schools were not present to serve the population but the residents themselves were not aware of the importance of educating their children.

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.

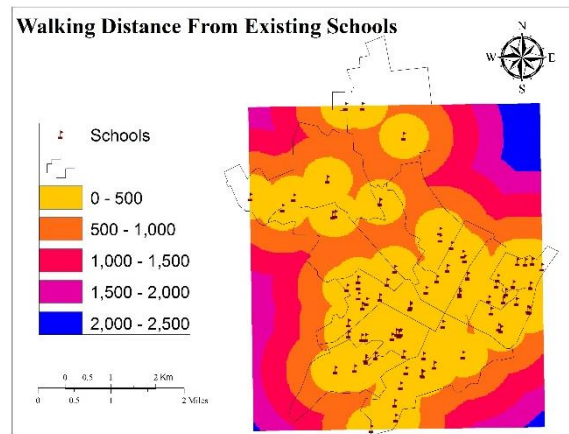


Fig. 13. Proximity from Existing Schools

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.

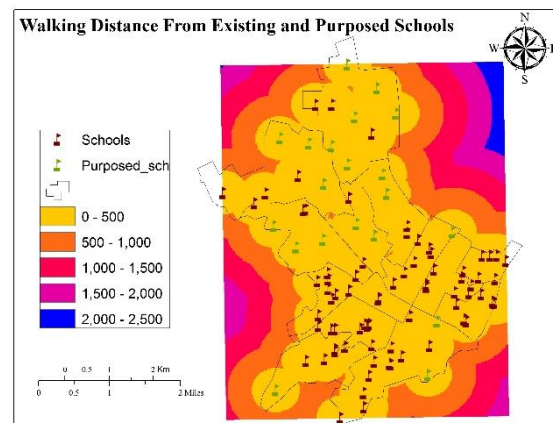


Fig. 14. Easily Accessible Proposed School Sites

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.

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