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Improving Walkability to Schools: A GIS Approach with Reference to the Gaza Strip

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Abstract

Planning for walkability is a main component of sustainable urban planning. Good planning for walkability improves community wellbeing, and offers more energy savings in transportation sector. This paper investigates this issue with reference to the school buildings located in Gaza city, Palestine. The potential to improve walkability to schools has been investigated through a review of the factors that encourage students to walk to their schools. More focus is given to walking distance as a main factor, which has been examined using GIS. This aims to analyse the current distribution of school buildings and whether or not it is adequate to enhance students' walkability. The study found that students' walking environment in Gaza requires substantial improvement including the proper planning and upgrading of sidewalks and footpaths. Several urban areas within the city are not served by schools considering a maximum walking distance of 600 m. This means that those areas should be given a priority in the urban plans concerning new schools construction.

Keywords: sustainable planning, school buildings, walkability, GIS, Gaza

1. Introduction

Sustainable urban planning and design is a main field of implementing sustainability in our built environment. Sustainable urban planning aims to implement sustainable development principles in our urban areas considering their comprehensive scope. This includes the environmental, social, and economic aspects. This also includes promoting sustainable land use considering the issues of green spaces provision, sustainable water resources management, walking suitability, i.e. walkability, and connectivity, and promoting a strong sense of place (Sustainable Cities Institute, 2013). Promotion of walkability in the built environment is an integral principle of sustainable urban planning. From an environmental point of view, it helps reducing reliance on vehicles, which consume fuel and pollute the environment. Considering the social dimension, it is believed that face-to-face human interaction is extremely relevant for supporting liveability, participation, social wellness, and safety in the built environment (Singh, 2016). Finally, it is a vital principle from an economic point of view, since walking ensures better physical and psychological health status of the society.

Urban planners and designers are required to make the neighbourhoods they plan suitable for the practice of walking and cycling. Encouraging walking to schools takes us back to the Neighbourhood Unit concept introduced by Perry in the last century (Patricios, 2001). Perry based his planning of the neighbourhood on the centralization of the neighbourhood basic school with a maximum walking distance of a half mile (800 m). However, some studies showed that walking to schools as a daily practice has decreased. For example, McMillan (2007) mentioned that between 1969 and 2001, walking to school in the U.S. decreased from 40.7% to 12.9% among students. This increases transportation economic and the associated environmental costs. Studies also found that physical activity of children nowadays declines starting from the school entry age. This leads to the increasing childhood obesity, and increases the risk of diabetes and other diseases. It even reduces children's ability to learn (WHO, 2016). Unfortunately, this is coupled with the spread of electronic games that increase children's sedentary behaviours.

All of that make walking to school a valid issue. Thus, it is required to encourage walking to schools through offering pedestrian-friendly urban environment. The general guidelines recommended for an effective pedestrian movement in urban areas are also recommended here. Firstly, urban designers should understand how students observe and interact with the urban environment in order to plan the required footpath layouts properly.

Designers should plan students' movement to lead and encourage them on. Their movement should be in logical sequences without obstacles (GLC, 1978). In this regard, residential density is a main factor that encourages students to walk to their schools. This is because urban canyons are perceived as three-dimensional images, which encourages students to move on and explore more. Thus, urban design could be employed to encourage students' walkability through changing dense housing forms, diversity of land uses, and well-connected streets (Gallimore *et al.*, 2011). Another important factor here is the elimination of the possible hazards. It is required in this regard to interconnect students' movement with the schools, and to separate it from cars circulation. Two options are available here: to use sidewalks combined with the streets, or to fully separate students' movement system from the roadway (Untermann & Small, 1977). Sidewalks should be properly designed through ensuring sufficient width, proper buffering from cars lanes, adequate paving, and through elimination of obstacles. Figure 1 shows some common problems in the Gaza Strip in this regard. This includes the mixed pedestrian and auto circulation and the absence of proper sidewalks.

Figure 1. The problem of mixed pedestrian and auto circulation is common in the Gaza Strip (CNN, 2016)

2. Walkability to Schools in Gaza

This study is done with reference to the Gaza Strip in general and Gaza city in particular (Figure 2). Gaza city is the main city in the Gaza Strip, which forms the southern governorates of the Palestinian Territories. Its population is about 600,000 people and its area is 56 km^2 (Municipality of Gaza, 2016). Number of schools in the Gaza Strip is 712 schools, 265 of which are located in Gaza city. This figure is distributed over three categories: 170 governmental schools, 63 UNRWA schools for Palestinian refugees, and 32 private schools. Majority of these schools are basic ones, which account for 205 schools, i.e. 77.3% (PCBS, 2015). In general, urban planning in Gaza takes two forms. The first one is the expansion and filling of the current residential zones. This usually takes the form of vertical expansion, where additional floors are added to the existing housing blocks. Less frequently, empty land parcels are utilised for new constructions. The second form is establishment of new urban settlements in the empty areas of the Gaza Strip. Planning for schools in the second case is more straightforward, where the required infrastructure could be secured and planned to consider the future expansion. However, planning for schools in the first case faces great challenges considering the different urban problems that exist in the current urban environment, especially those related to the pedestrian movement.

Taking walkability to schools as a main focus, several good points could be clearly noticed in the Gaza Strip. A main point is that walking to schools is a common practice that could be noticed on streets. Although no specific statistics could be found in this regard, it is essentially required to support this practice through diagnosing and solving walkability problems. Using participatory observation, the study diagnosed several common problems in this regard. These problems could be categorised as follows:

- Lack of proper pedestrian safety measures is common in Gaza streets. This includes absence of sidewalks, stop signs, and painting of crosswalks in several areas. In this case, students are forced to walk on street, and to cross streets without a proper control.
- Existence of permanent and temporary walkability obstacles. This includes using sidewalks for commercial uses, which reduces their effective width. It also includes obstacles on the existing sidewalks such as tiling problems and improper treatment of slopes, which could cause serious injuries.

- Student with disability experience difficult times on their way to their schools. For example, it is a common phenomenon that sidewalks at crossings are not provided with curb ramps (curb cuts).
- Improper treatment of trash bins, which is hazardous to students' health.
- Students walk through inactive walking environments. Active walking environments encourage students on, and are achievable through providing streets with several elements such as seats for rest, trees for shading, and street lighting (Antariksa & Surjono, 2016).
- Some areas are characterised with long school walking distance. This point has been particularly investigated in this study.

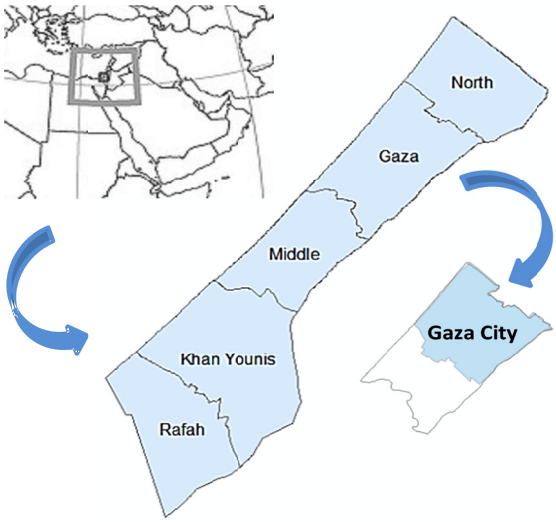

Figure 2. The five governorates of the Gaza Strip showing Gaza Governorate and Gaza City

The above-mentioned observed problems could be used to deduce the factors that are expected to improve walkability to schools in the Gaza Strip. In order to validate and prioritise these factors, ten local urban planning experts were consulted. These experts have been asked to rank the importance of ten suggested walkability enhancement factors using three-degree Likert scale (low, medium, and high). Frequencies have been estimated and then used to calculate the Relative Importance Index (RII) of each factor. RII could be calculated using the following equation:

$$RII = \sum P*U/(N*n) \quad (1)$$

Where P is respondent's rating of the factor importance, U is the weight given on Likert scale (from 1 to 3), N is the highest weight on the scale, and n is the total number of respondents. Table 1 shows the obtained results. It is clear from the relatively high values of RII that respondents see all the suggested factors as important ones. This indicates that there is a lot to be done to improve the environment of pedestrian movement in Gaza. It is clear also from Table 1 that respondents see the proposed safety measures at top of the agenda. This is due to the importance of this factor in addition to the great deficiency that could be observed in this respect. The following factors that come next are proper walking distance, and careful design of sidewalks. The least relative importance value was observed in the factor of careful design of street furniture, which is not deemed by the respondents as an urgent issue. From the three top-ranked factors, walking distance has been selected for further investigation using GIS as discussed in the following section.

3. GIS Investigation of School Walking Distance

ESRI ArcGIS is used as a main research tool here. ArcGIS was initially developed by the Environmental Systems Research Institute (ESRI) at the end of the last century. It is used for several applications including creation of maps and analysis of mapped information (ESRI, 2013). It is an effective research tool in urban studies, where it works effectively with databases. GIS is a valid approach to examine walkability in residential areas (Moura *et al.*, 2017; James *et al.*, 2015). For example, Gupta *et al.* (2016) carried out a GIS-based analysis to assess the accessibility at hierarchical levels of urban green spaces. Such spaces promote social interaction and physical activity in the community. The study used GIS network analysis to assess the accessibility of urban green spaces at hierarchical levels. This was done through applying different network distance to each hierarchy

in a developing region. Azmia and Ahmad (2015) carried out a GIS analysis to examine the effect of residential density, land use mix, and street connectivity on walkability between two precincts in Malaysia. The study carried out buffering analysis on different produced thematic maps. The analysis confirmed the relationship between the above-mentioned three factors and walkability in the examined urban area.

Table 1. Prioritising walkability factors in the case of Gaza as recommended by local urban planning experts

No.	Walkability Factor	Explanation	RII	Rank
1.	Visual Interest	Planning walking paths in a way that exposes students to variety of views and land uses.	0.67	5
2.	Proper Walking Distance	Schools should be located within a reasonable walking distance from home	0.90	2
3.	Cleanliness of Walking Paths	Proper treatment of trash bins and other hazards to students' health	0.80	3
4.	Elimination of Obstacles	Obstacles such as illegal use of sidewalks, tiling problems, and improper treatment of slopes should be treated	0.80	3
5.	Continuity	Walking paths should be continuous without any interruption	0.73	4
6.	Safety Measures	Provision of safety measures such as stop signs and painted crosswalks.	0.97	1
7.	Supporting the Disabled	The right of walking should be secured for student with disability through provision of required measures such as curb ramps.	0.67	5
8.	Careful Design of Sidewalks	Sidewalks should be designed with sufficient width and proper protection from adjacent cars.	0.90	2
9.	Careful Design of Street Furniture	Designing an active walking network to encourage walkability using street furniture such as seats and street lighting	0.57	6
10.	Integration with Nature	Designing an active walking network to encourage walkability using trees for shading and integrated natural amenities	0.73	4

In the current study, the Spatial Analyst extension in ArcGIS is used to carry out an analysis of a set of vector maps and data grouped in a database. This is intended to assess students walking distance towards their basic schools. This is done with reference to Gaza city using ArcMap program to create a spatial analysis model. The main components of this model are: geoprocessing tools, variables that hold values, and finally connectors that connect values to the tools. To build the required model, the following data are required:

- A map of the Gaza Strip with a defined coordinate system.
- A map of the municipal borders of the different cities including Gaza city.
- A map of the Gaza public buildings including schools. It is required to get some attributes of the schools such as location and types.

It is possible then to build up the model using the following steps:

- To create a new model within a toolbox located in the above-mentioned database.
- To import the required geoprocessing commands to the model, which are:
  - *Select* command from Extract tool set in the ArcToolbox: to select the schools located in Gaza. To do so, the integrated query builder has been used depending on the following SQL expression: "TYPE" = 'school' AND "LOCAL" = 'Gaza'.
  - *Select* command again to select Gaza city from the Gaza Strip map. This could be done using the predefined attributes of the Gaza city map.
  - *Buffer* command from Proximity tool set in the ArcToolbox: to create the desired buffer around each single school depending on a predefined walking distance. Distance here is provided as a linear value. Assumed values are 800, 600, and 400 m.

- *Erase* command: to erase the resulting buffer layer using two input layers: the resulting Gaza city layer, and the resulting buffer zone layer. This is useful to expose areas that are not served with schools within the three examined buffer distances, i.e. 800, 600, and 400 m.

• Finally, it is required to validate the model in order to fix any problem, and to run it from within ModelBuilder. The result is shown in Figure 3, which shows the actual model (up), and the parametric one (bottom). The parametric version of the model offers the ability to use the same method in other geographic places in order to resolve similar planning problems.

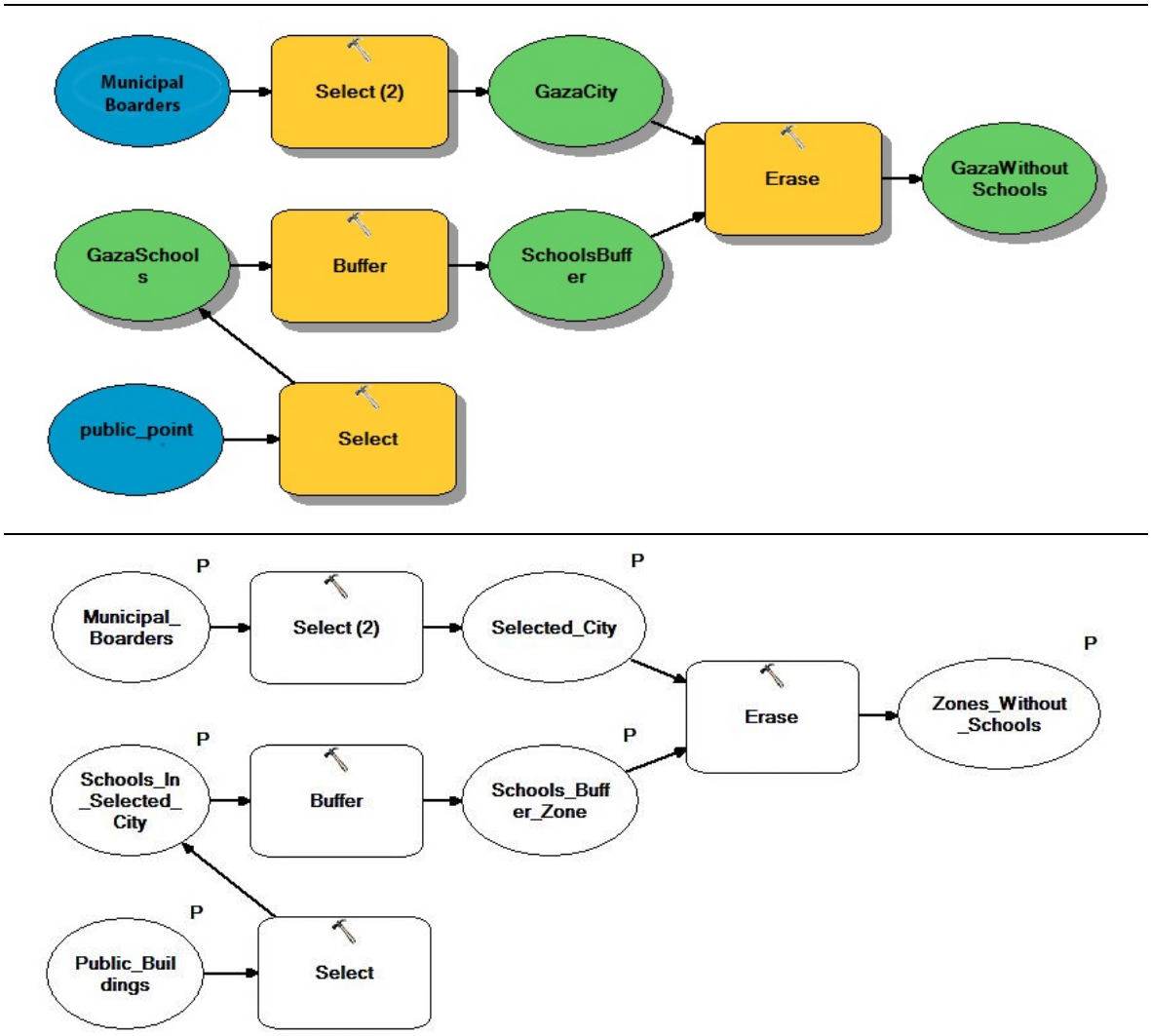

Figure 3. The actual (up) and parametric (bottom) GIS spatial analysis model that is used to find out the areas that are not served by schools in Gaza city

Results are shown in Figure 4. It shows the results of the carried out buffer analysis on Gaza city. It also shows the areas left of the city after erasing the buffer zones. These areas practically are not within a walking distance from any nearby school. Three walking distances have been investigated in this regard: 400, 600, and 800 m. The latter one (a half mile) was the initial recommendation of Perry when he introduced the Neighbourhood Unit concept in the last century (Patricios, 2001). Considering the current decrease in the practice of walking to schools among students (McMillan, 2007), the author suggests considering shorter distances. Considering a walking distance of 800 m, area that is not served by schools is 10.8 km^2. The city looks well-served by schools with the exception of the eastern areas. These areas are boarder one which are hazardous in situation of military conflicts. Reducing the walking distance to 600 m increased the unserved areas to 16.9 km^2, which means an increase of 56%. These areas could be noticed in the eastern and southern zones. A further reduction to 400 m increased the unserved areas to 25.5 km^2, which means a substantial increase of 136% in all zones of the city.

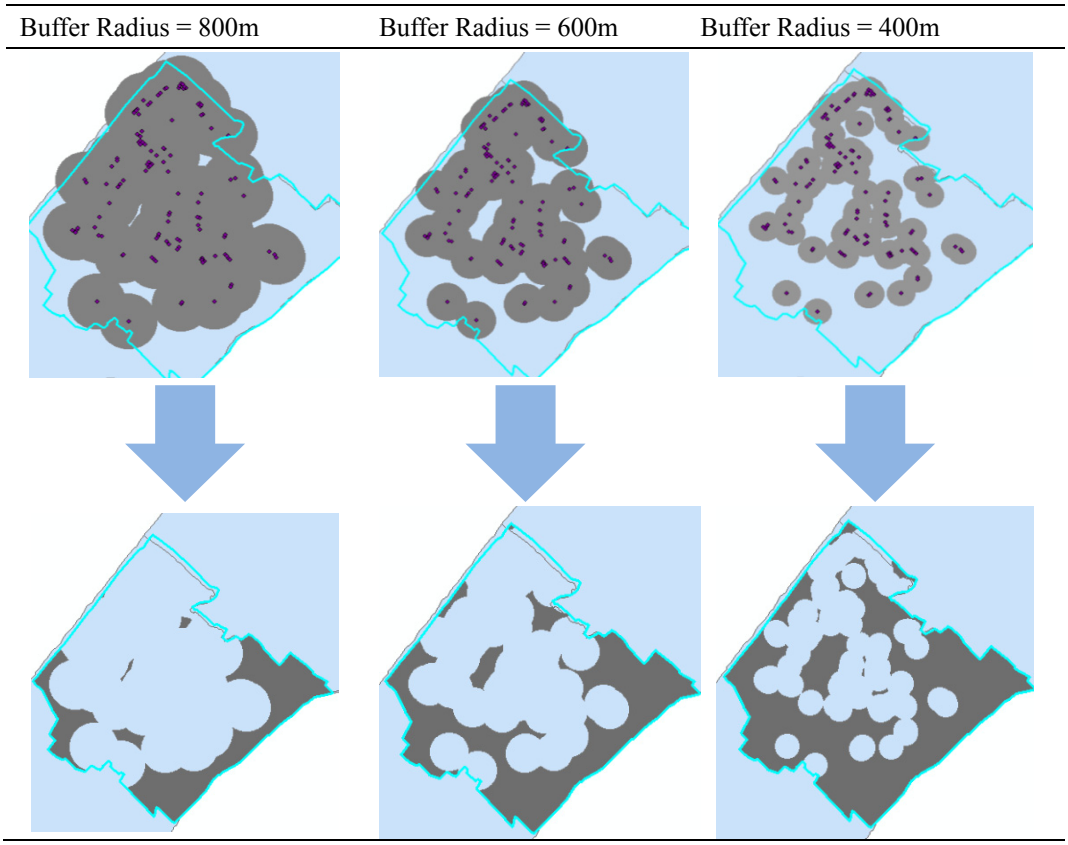

Figure 4. Schools buffers (up) and the resulting area not served by schools (bottom) in Gaza city assuming different values of maximum straight-line walking distance to school

Figure 5 shows the areas that are not served by schools and required number of future basic schools assuming different maximum walking distances. It shows that as maximum walking distance to schools decreases, the required number of future basic school nodes exponentially increases. The Figure shows that number of future basic school nodes for the three examined walking distances of 800, 600, 400 m are 6, 16, and 51 nodes, respectively. However, school size should be reduced as walking distance decrease, as schools in this case will serve smaller urban zones. This is in fact a rough estimation considering that data available for schools do not include school level, i.e. basic or secondary. However, it gives acceptable indication since majority of schools in Gaza city are basic ones (205 out of 265). They also do not include school type, i.e. governmental or UNRWA schools. The latter type is only available for Palestinian refugees. This makes school planning in the Gaza Strip challenging, where identifying interrelation between these two types and the city population is essentially required. One way to do so is to plan schools within the city in clusters, where both types could be planned together. There is also some sort of uncertainty here, since the maximum acceptable walking distance to the school in Gaza is not clear. Although the distance of 400 m looks impractical, the study recommends carrying out a further field study to investigate residents' attitude towards this issue.

In addition to the walking distance, improving walkability to schools considering the rest of factors requires a field survey. This is required for each street segment and intersection. Main problems related to security, obstacles, disability support, and cleanliness and amenity should be identified. This should facilitate the required interventions. These data could be linked with Gaza maps to facilitate a further GIS analysis. This could be used to identify locations of the most urgent interventions depending on methods such as Maps Algebra. Results obtained in Table 1 regarding prioritising walkability enhancement factors could be used to give each factor its weight in this recommended GIS analysis.

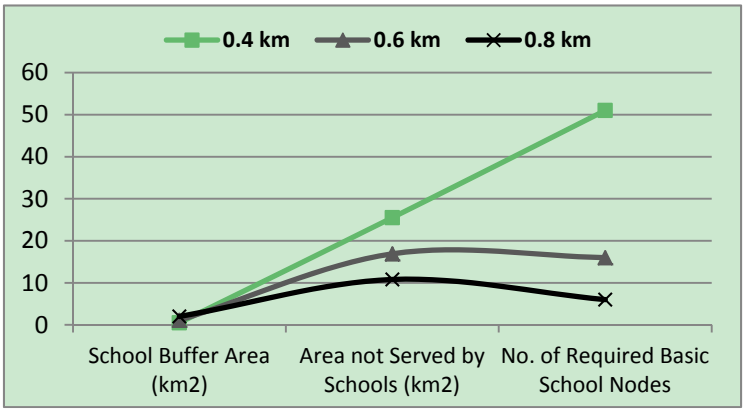

Figure 5. The effect of maximum walking distance to schools on the required future basic school nodes

4. Conclusion

Urban planning is a main field of implementing sustainable development principles. This aims to create healthy communities considering several environmental, social, and economic factors. Considering walkability as a main focus of this study, it is believed that communities in general should be pedestrian-oriented. In this regard, encouraging students to go to their schools on foot is a recommended practice that reduces our reliance on transportation, and promotes social wellbeing in our communities. To achieve this aim, a pleasant walking environment within a proper walking distance should be secured. Taking Gaza Strip as an example, there is a lot that could be done in this regard. However, the following interventions are at top of the agenda as recommended by the local urban planning experts:

- Ensuring students' safety through the provision of safety measures such as stop signs and painted crosswalks.
- Schools should be located within a reasonable walking distance from home.
- Careful design of sidewalks, which should be designed with sufficient width and proper protection from adjacent cars.

The study then investigated the effect of students' walking distance to their schools on the distribution of these schools in Gaza city. This was done using ESRI ArcGIS package. The study carried out a spatial analysis using a database of vector maps associated with a set of data regarding Gaza schools and municipal boarders. A parametric model was produced in this regard using the toolbox component in ArcMap. Three walking distances were examined: 400, 600, and 800 m. The analysis found that as maximum walking distance to schools decreases, the required number of future basic school nodes exponentially increases. Considering the current decrease in walking practice to schools among students, the study recommends replacing the traditionally recommended value of a half mile (800 m) by a shorter distance. Although the distance of 400 m looks impractical, the study recommends carrying out a further field study to investigate residents' attitude towards this issue. Reducing students' walking distance to their schools necessitates improving schools distribution through increasing their number and reducing their size.

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