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Assessment of Schools Spatial Distribution and Identifying Suitable Areas by Using GIS Technology: In Case of Debre Markos Town North Western Ethiopia

Tagele Mossie Aschale
Department of Geography and Environmental Studies, Debre Markos University
Po. Box 269, Debre Markos, Ethiopia

Abstract
Schools need be located on safe places; these safe locations should also be optimal and economical to the public in terms of accountability. Location of these schools has always been done without use of any scientific methods and has led to sprouting of schools located in unsuitable locations. To enhance an academic excellence and identify better school site this study applied GIS technology in Debre Markos Town, Ethiopia. In Debre Markos many schools characterized concentrate in centres, vulnerable for natural risk like flooding, near to noise areas, markets and rivers. The aim of this study was to assess the spatial distribution pattern, conformity of both national and international standards and indicate the future suitable areas of new school sites based on national and international standards of public primary and secondary schools in Debre Markos Town. Debre Markos Town lcated in the North-Western Part of Ethiopia. In Debre Markos Town populated more than 95,000 residents and 18 public primary and secondary schools. This study used both primary and secondary GIS data including filed survey, quick bird images, population and high-resolution satellite images from google earth. These data took form EMA (Ethiopian Mapping Agency, Debre Markos Town Municipality. Arcgis 10.4.1, DNGarmin and Google Earth used as a software packages for different geo-processing application and data calibration. The method totally used national and international standards to assess distribution, conformity and identify the suitable new school sites. The result revealed that 89% schools are located less than two kilometres far away than other schools and 11% are schools far away more than two kilometres than other schools. Around 11 or 61% schools located with 450 meters distance of road facilities the remaining 7 s or 39% schools are located far more than 450 meters from road facilities. Endemata Primary School is the most unsuitable schools compare with to other schools. It was near to market centre, Wuseta River and noise area. For the future, not only schools but also other public facilities should apply national and international standard before the construction of schools and other public facilities. Foo the establishment and implementation of new school sites GIS ha a vital role. Therefore, the government and urban planners should apply GIS technology to identify the suitable school site.

School facilities and distribution
Education is one of the most important tool of economic and social expansion and household livelihoods and food security status. Some quantitative studies indicated that investment on education strengthens the productivity in all the sectors of the economy much more than other levels of public sector, and that economic returns to investment on education are greater than those arising from other levels public sector investments (Irshad, 2016)

To make such human capital development, needs full investment to build standard academic institution from primary to tertiary and research institutions. These academic institutions including schools need good environmental areas for better work and learning system. Thus, schools need be located on suitable location; these suitable locations should also be optimal and economical to the public in terms of accessibility. Location of these schools has always been done without use of any scientific methods and has led to sprouting of schools located in unsuitable locations (Bukhari. et al, 2010).

GIS is a most recent and reliable tool and inevitably of great use in this modern world and the fast-changing technology and need be embraced. Indeed, geospatial mapping of development projects is a way of managing and monitoring fair and safe site selection locations and suitability of school's sites. GIS technology is cost effective, efficient, and accurate and eliminates human bias in location of new schools (Osman K.et al., 2010)

GIS technology can collect, store, integrating, analysing spatial referenced data. It enables that to implement, establish integrate, structured and good manner location placement of schools in the urban areas. This technology support to select the suitable and the appropriate location of infrastructure by integrating and considering both national and international selection site standards (Irshad, 2016).

GIS is used to identify candidate sites for new schools. The procedure followed under a GIS framework rejects the unacceptable sites considering pre-determined factors exclusively, contained in the form of multiple layers of attribute information to select the candidate sites (Umar.etal, 2015). It also requires some framework like minimum and maximum distance between schools, roads, rivers, towns or factories if any and capacity

versus land size of existing schools. In this application, GIS is a screening tool in a site selection process to narrow the number of candidate sites, subsequently leading to one or more suitable sites for a school development projects are often located by undefined means sometimes just because money or space is available and continuity is not obvious since projects are not mapped on regular interval to easily visualize the spatial distribution and expansion (Osman K.et al., 2010).

Planned location of schools, health centres, urban park areas, petrol stations, hospitals, drinking water lines, telecom lines are vital to enhance the living standard of the urban dwellers. In Ethiopia, most of these facilities are established without considering both national and international standards of school's placement like UNSECO and Amhara National Regional State of Education Bauru. It is also common in Debre Markos Town mismatch location of these facilities.

There are many schools around on noise areas and vulnerable to traffic accidents on the adjacent of main roads. Some schools are also located on steep slope and rigid areas. Some schools also concentrate only in the centre of the town while others are far from the residence places of students.

By considering these problems, this study used GIS technology to assess the distribution, conformity and identify recommended suitable location of these facilities in Debere Markos Town. It enables that to indorse the suitable sites for the location of schools. It will also provide information on the distribution and the relevance of the location of schools in this town.

1.2 Study Area

Debre Markos Town found in Amhara Regional State, East Gojjam Zone as a capital city (centre) of East Gojam Administrative Zone. It far from Addis Ababa (capital city of Ethiopia) 299 Kilometres in North West of Addis Ababa. Debre Markos town lies in rigid mountains area of north western high lands. Astronomically, the town is located between 10^{o} 16.9` to $10^{o}$22.5`North Latitude and 37^{o} 41.4` to $37^{o}$46.2`East Longitude. Area of the town is expected to be 1214.9 sq. Km and 65.82 km/square density.

In Debre markos town, both public and private schools there are 17 KG, 23 primary schools, 3 high schools, 2 preparatory schools, 15 adult education schools, 11 different colleges and one University. Educational service buildings composed of all primary, secondary and a preparatory school owned by the city administrations is inventoried. A total of **179** old and new school buildings are registered covering a total area of **33,608.36** square meter of land.

In public, there are 18 school both in primary and secondary schools and covered around 32047.78-meter square of area.

Figure 1 Location of Debre Markos Town

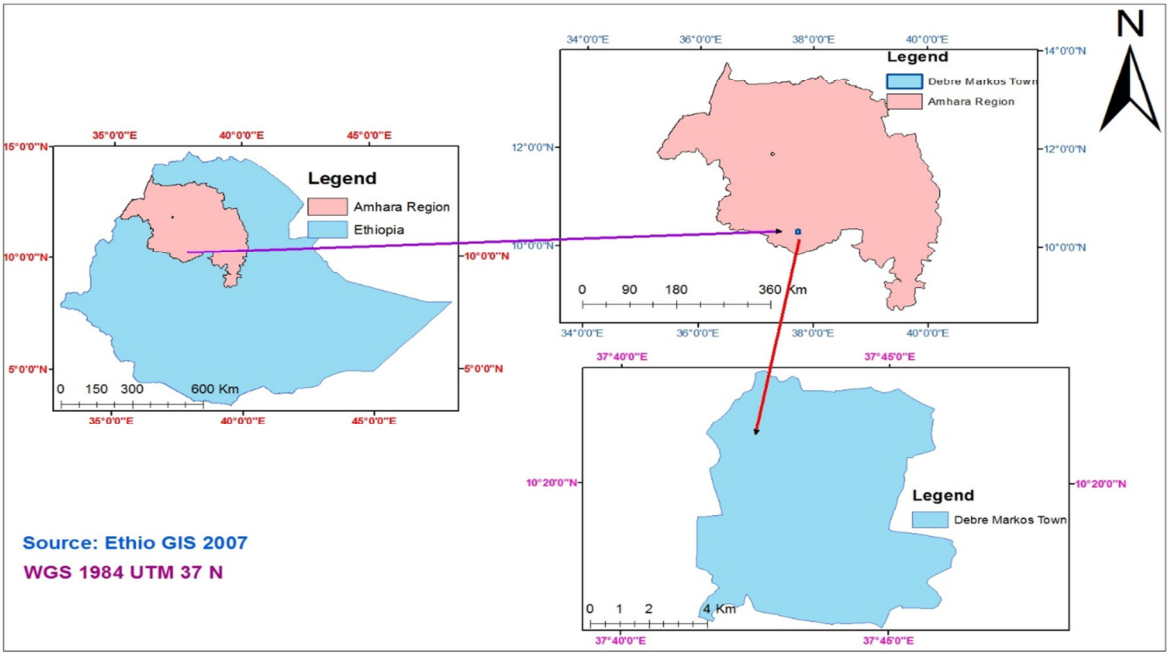


Table 1 Public primary and secondary students in Debre Markos Town

School	Location	School_Id	No_Blocks	Area (m2)
Nigus Tekel Haimanot Primary School	Kebele 04	SC_01	15	4509.03
Addis Hiwot Primary School	Kebele 05	SC_02	6	740.11
Yemeka Primary School	Kebele 04	SC_03	3	258.40
Debza Primary School	Kebele 03	SC_04	13	1954.28
Biruh Tesfa Primary School	Kebele 03	SC_05	7	697.85
Ede Tibeb Primary School	Kebele 06	SC_06	11	1897.58
Tsehay Gibat Primary School	Kebele 07	SC_07	7	792.46
Chemoga Primary School	Kebele 07	SC_08	2	189.43
Abma Primary School	Kebele 03	SC_09	15	3285.45
Yene Primary School	Kebele 03	SC_10	8	1100.79
Endemata Primary School	Kebele 02	SC_11	10	1560.58
Deil BeTegil Primary School	Kebele 05	SC_13	13	1635.70
Hidase Primary School	Kebele 05	SC_14	5	657.93
Muaket Primary School	Kebele 05	SC_15	3	315.69
Debre Markos Preparatory School	Kebele 03	SC_16	19	4642.89
Debre Markos Attekalay Secondary School	Kebele 04	SC_17	11	3483.69
Menkorer Secondary School	Kebele 06	SC_18	14	1773.56
Ethio Japan Secondary & Preparatory School	Kebele 03	SC_19	14	3841.54
Total	18		176	32047.78

Data and Softwares

Both primary and secondary data were used to assess the distribution and suitability analysis of selected infrastructures in case of Debre Markos Town, which were obtained from field survey, Debre Markos Town Land Management Team, Ethiopian Mapping Agency (EMA) and Google Earth. The data and materials used include satellite imagery, population data and GPS data

Table 2 Types of Data and their characteristics

No	Data Name	Data Source	Specification/format of Data	Data Type	Date of Data produced
1	Quickbird Image	Google Earth	High resolution	Secondary	2016
2	Population Data	Debre Markos Municipality	Excel	Secondary	2013 projected data
4	Street Map Data	Debre Markos Municipality	shapefile	Secondary	2015
5	GPS data	Field Survey	GPS 60 Model	Primary	2016
7	Ethio GIS Data	EMA	Vector and raster	Secondary	20016

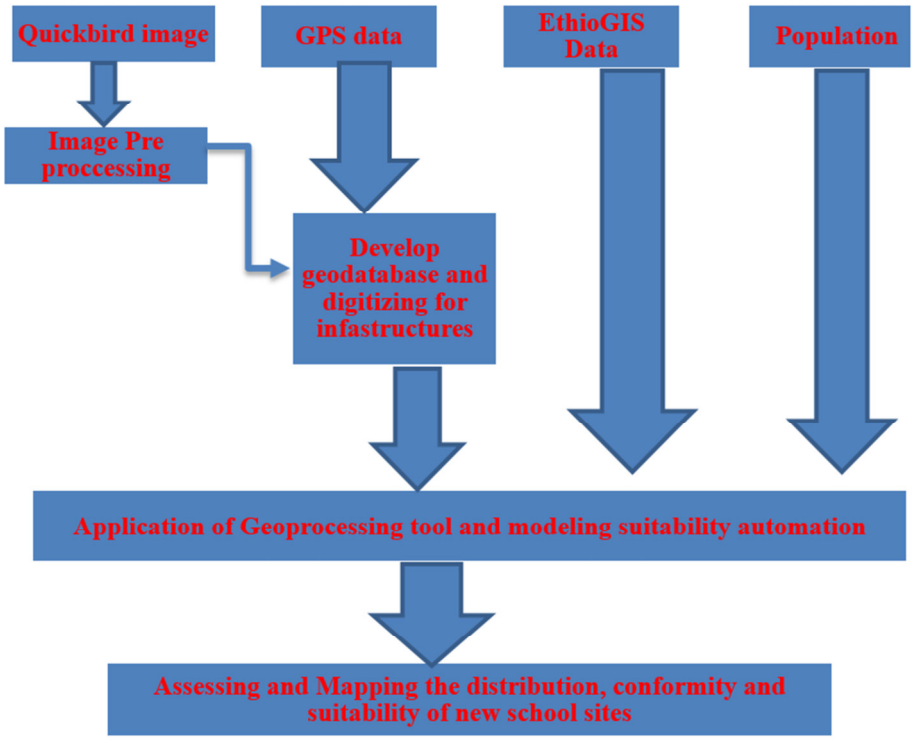
Table 3. Type of softwares and their functions

Number	Software Name	Function of Softwares
1	Arc Map 10.4.1	To applied different geo-processing tools, Digitizing
2	DNRGarmin	Record or register the collected GPS data
3	Google Earth	Download and Crosschecking of data

Methodology

The study collected data by using GPS receiver, data conversion (raster to vector) data extraction, digitizing, query functions, join and relate function, geo-referencing data, spatial analysis, geo-statistics analysis, and different geo-processing tools. To produced suitability areas for new school site selection, the research applied suitability modelling automation. This modelling automation enabled and analysed that spatial data with to attribute data by calibrating different geo-processing tools.

The following diagram assessed, mapped and identified the suitability school site selection in Debre Markos Town. This includes detail geoprocessing tools and modelling automations. It summarized spatial and attribute data integration, classification, digitizing, overlay analysis, proximity analysis, symbology and spatial statistics analysis.



Criteria Used for Selecting the Best Location for the Facilities

The researcher used different criteria to assess the conformity and suitability of selected infrastructures in Debre Markos Town. These criterions are set by Amhara Regional State Education Beauru, and International scholars criterions. The researcher applied priority to assess the conformity and suitability of facilities by regional, national continental and global scale standards within respectively.

Schools: For this facility, the researcher uses Amhara National Regional State Education Bureau (ANRSEB) , Talam&Ngigi, 2011 (worked in Kenya it is preferable and appropriate with to our country context and convenient for the researcher)

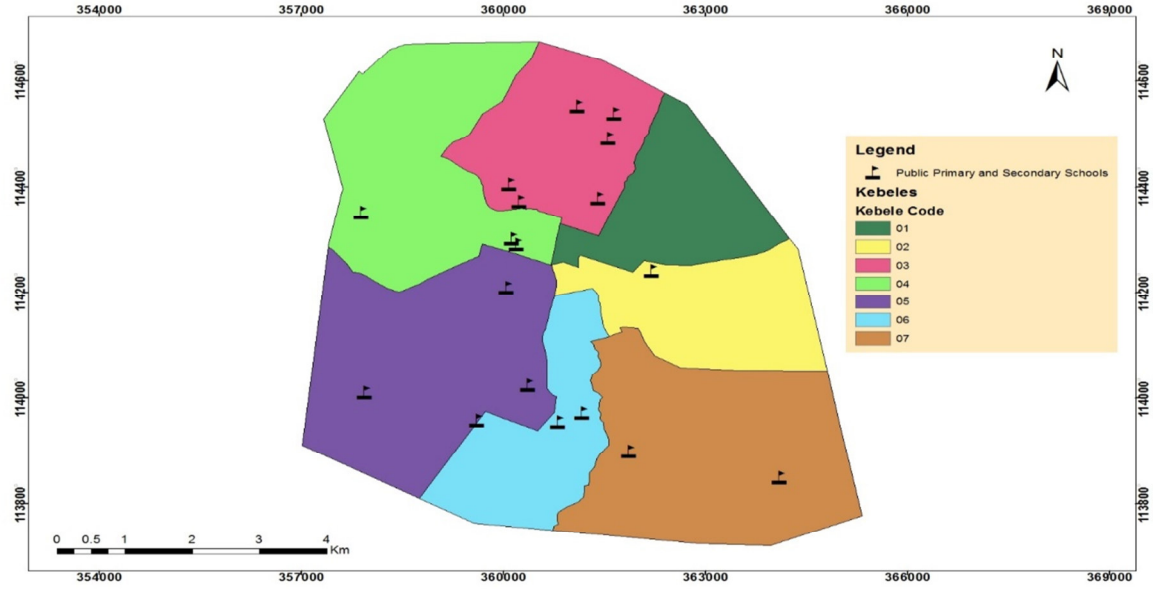
- Schools don't far from above 2kms from the resident of the students (ANRSEB)
- Schools should be located at a minimum distance of 2Km from each other to minimize competition and encroaching in to each other's catchment areas (Talam&Ngigi, 2011).
- Schools locate distance from road and streams distances greater than 450m are most suitable (Talam&Ngigi, 2011).
- Slope gradient school sites should be less than 15 degrees most suitable (Talam&Ngigi, 2011).

Results and Discussion

Schools distribution in Debre Markos Town

In this study, 18 public primary and secondary schools were selected. These schools located in different part of the towns but they weren't distributed evenly. The following map indicates that the spatial distribution of public primary and secondary schools in Debre Markos Town.

Figure 2 Map of Primary and secondary Public schools in Debre Markos Town.

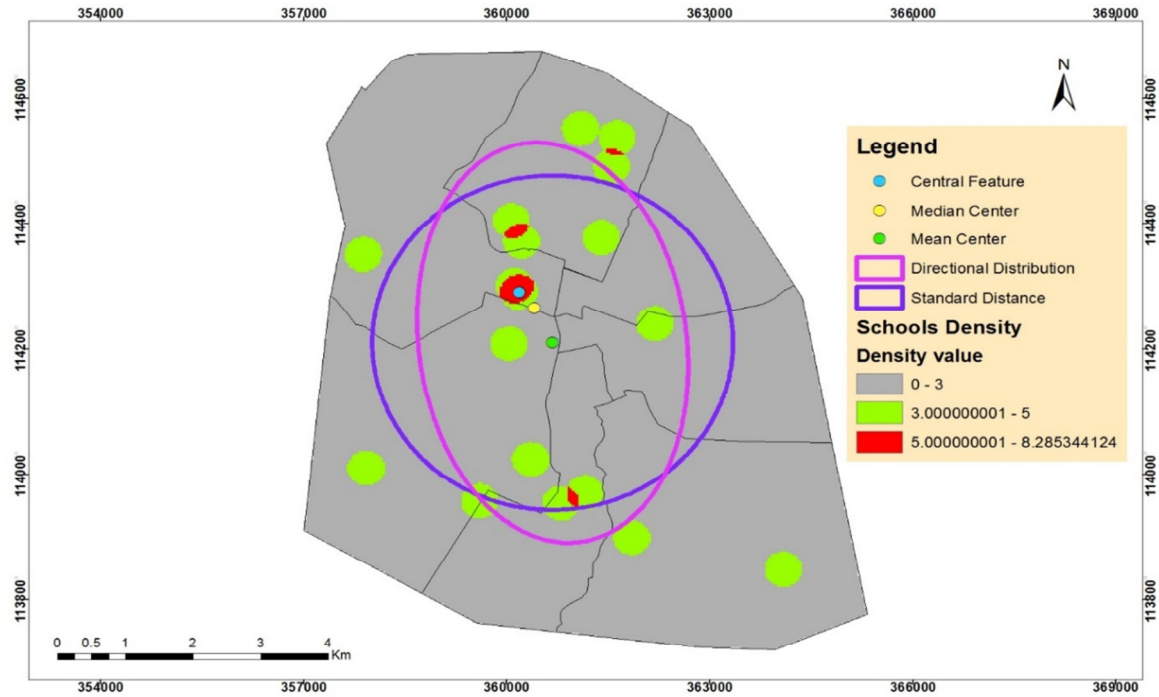


This indicate that in Kebele 03 more public schools are located compared with to other kebeles. In this kebele there are 6 schools or around 33 % while in kebele 01 there is no any public schools. In kebele 05, 4 schools, kebele 06, 2 schools kebele 07, 2 schools, kebele 02, 1 school and kebele 04, 3 schools are located. This condition will controversy with the principle of "fair and equity education for all" ministry of education. This will also discourage student who live far away the schools, especially, primary students and young students.

Schools Distribution Pattern

To analysed the spatial distribution of schools the study applied spatial statistical analysis tools. This enabled that to produce point density, mean location, central feature, median location, mean location and directional distribution of schools in Debre Mrakos Town. The following map summarized and illustrated these spatial statistics tools application and geographical distribution features of schools in Debre Markos Town.

Figure 3 Map of the distribution pattern characterises of schools in the town



The result revealed that the central location of these school is located kebele 04 between Debre Markos Attekalay Secondary School and Nigus Tekle Haimanot Primary School. The central feature location tool used to indicate the central location school with compared with to other schools. Median center also enabled that to the location that minimizes overall Euclidean distance to the features in a dataset. The median center of Debre Markos Town Public schools located around in the center of the city. Point density also calculated the density of point features around each output raster cell. Conceptually, a neighbourhood is defined around each raster cell center, and the number of points that fall within the neighbourhood is totalled and divided by the area of the neighbourhood.

This result classified and revealed that on three areas of the town high density of schools and the other schools are moderate and sparsely distributed along the town.

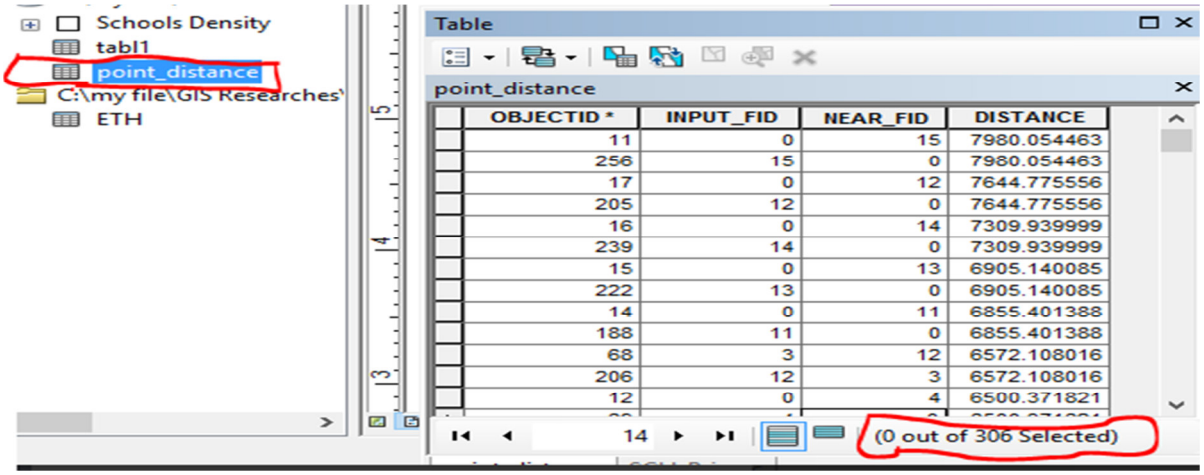
This study also tried to measure the geographical distribution of schools in Debre Markos Town by applied directional distribution and standard distance tools. These tools summarized the spatial characteristics of geographic features like central tendency, dispersion, and directional trends and measured the degree to which features are concentrated or dispersed around the geometric mean center respectively.

Schools distribution along with different infrastructures

A. Schools should be located at a minimum distance of 2Km from each other to minimize competition and encroaching in to each other's catchment areas (Talam&Ngigi, 2011):

Based on this standard schools in Debre Markos town the distance between each other is various. To solve this problem, point distance tool on proximity tool set is a typical tool. This tool determines the distances from input point features to all points in the near features within a specified search radius. It creates a table with distances between two sets of points. if the default search radius is used, distances from all input points to all near points are calculated. The output table can be quite large. For example, on these 18 schools each school compute the distance between all other 17 schools, the result is 306 records in point distance table (18*17=306).

Table 4 the distance between schools



The lowest distance between each other is 126.223381 meters between Nigus Tekle Haimanot Primary School and Debre Markos Attekalay Secondary School. The second closet schools are also Debre Markos Preparatory School and Debza Primary School around 362.657746 meters. In contrast to this, the maximum distance between is 7980.054463 meters between Chemoga Primary School and Yemeka Primary School. The second maximum distance between Biruh Tesfa Primary School and Chemoga Primary School around 7644.775556 meters. This indicated that there is high variation distance between schools. For instance, Chemoga Primary School is far away from all public schools.

The location of schools with the central place is Nigus Tekle Haimanot Primary School. This produced by using near analysis tool. This produced by using the central feature output and determine the centrality of schools. The most decentralise schools is Chemoga Primary School, it far way 5897.323345 meters away the central school.

Table 5 Most isolated schools from other schools

SCH_Pri_sec

NEAR_DIST	SC_Name
2071.078567	Endemata Primary School
2376.649755	Yemeka Primary School
2426.269355	Yene Primary School
2669.760539	Deil BeTegil Primary School
2765.687753	Biruh Tesfa Primary School
2860.970789	Ethio Japan Secondary & Prepar
3342.783632	Ede Tibeb Primary School
3378.801745	Hidase Primary School
3422.90706	Menkorer Secondary School
3596.750133	Muaket Primary School
4255.705898	Tsehay Gibat Primary School
5897.323345	Chemoga Primary School

18 (0 out of 18 Selected)

The distance between each school should be more than 2 kilometres. But table 4.3 show that around 16 schools are their nearest school is located less than two kilometres. The remaining Yemeka Primary School and Chemoga Primary School far away more than two kilometres from other schools.

Table 6 Schools which are far away more than 2 km each other

Table

SCH_Pri_sec

NEAR_DIST	SC_Name	No_Blocks	Fence_Foun	Fence_Fo_1	Fence_Wall	F
398.711889	Menkorer Secondary School	14	Timber	Moderate	Timber	Mc
398.711889	Ede Tibeb Primary School	11	Timber	Good	Timber+CIS	Gc
470.009224	Yene Primary School	8	Timber	Very Good	Barbed Wire	Ve
470.009224	Ethio Japan Secondary & Preparatory School	14				
563.195005	Biruh Tesfa Primary School	7	Timber	Moderate	Timber	Mc
831.073734	Deil BeTegil Primary School	13	Timber	Good	Wire	Ve
834.655668	Addis Hiwot Primary School	6				
995.792791	Tsehay Gibat Primary School	7	Timber	Moderate	Timber	Mc
1008.568999	Hidase Primary School	5				
1146.802201	Abma Primary School	15	Timber	Moderate	Timber	Mc
1580.836356	Endemata Primary School	10	Timber	Moderate	Timber	Mc
1751.655517	Muaket Primary School	3	Timber	Severe	Timber	Se
2254.458197	Yemeka Primary School	3	Timber	Moderate	Timber	Mc
2292.196538	Chemoga Primary School	2	Timber	Moderate	Timber	Mc

17 (0 out of 18 Selected)

SCH_Pri_sec

This indicates that around 89% of schools are located less than two kilometres distance between them and densely populated in the center of the town. The remaining two schools around 11% are located more than two kilometres far away any other schools.

B. Schools locate distance from road and streams distances greater than 450m are most suitable (Talam&Ngigi, 2011). Based on this principle the study assessed school's proximity analysis regarding to road and rivers.

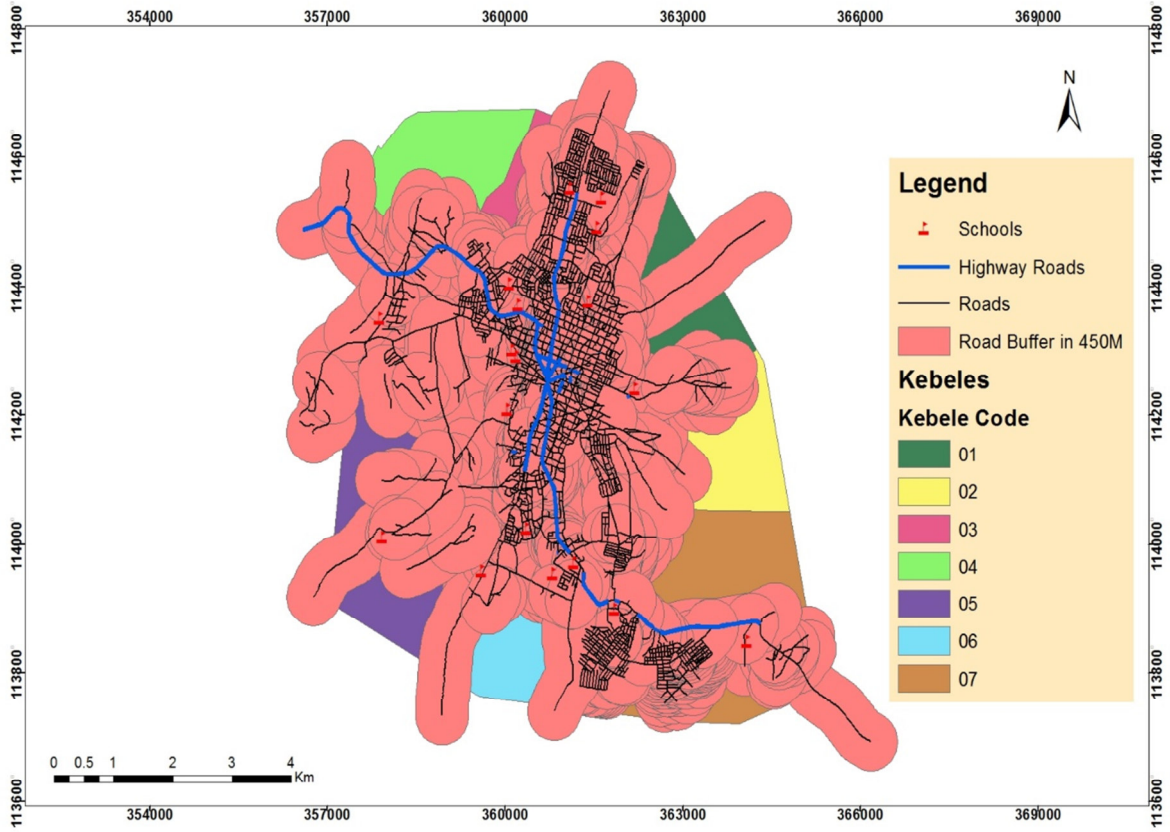


Figure 4 Map of Distribution of roads with to schools

This showed that all schools are located 450 meters' buffer zone of roads. This will a good environment for students access their schools easily. But on some schools located side of highways. These highways have high traffic and traffic accidents. This will another negative impact on the security of students. To solve this problem the study used Generate Near Table, it calculated distances and other proximity information between features in one or more feature class or layer that between schools and highways. The result indicated that Debre Markos preparatory School, Tsehay Gibat Primary School and Biruh Tesfa Primary School are near to the highways and expose to traffic accidents for students. While Muaket Primary School, Hidase Primary School and Yemeka Primary School are far away the highways. These are safe for highways traffic accidents.

As table 4.4 Indicate that around 11 or 61% schools located with 450 meters distance of road facilities the remaining 7 s or 39% schools are located far more than 450 meters from road facilities. The following table illustrated the connectivity of schools with to highways in Debre Markos Town.

Table

Schools

NEAR_DIST	SC_Name
104.890642	Debre Markos Preparatory School
126.931713	Tsehay Gibat Primary School
141.893667	Biruh Tesfa Primary School
148.179228	Endemata Primary School
163.947021	Ede Tibeb Primary School
287.821932	Chemoga Primary School
320.706327	Menkorer Secondary School
329.805951	Nigus Tekle Haimanot Primary School
376.904651	Debre Markos Attekalay Secondary School
391.955357	Debza Primary School
425.017687	Ethio Japan Secondary & Preparatory School
468.196518	Yene Primary School
495.488738	Abma Primary School
507.220661	Addis Hiwot Primary School
510.992739	Deil BeTegil Primary School
700.430248	Yemeka Primary School
1303.885706	Hidase Primary School
2554.784057	Muaket Primary School

0 (0 out of 18 Selected)

Schools

Table 7 Nearest schools for road facility

The other determinant the location of school's streams and rivers. In Debre Markos there are around 3 main streams. Even though these rivers are seasonal streams on summer season they became flood. The following map revealed that around five schools are located in 450 meters buffer zone of rivers. This indicated that these schools are susceptible for summer flooding. These schools are Chemoga Primary School, Tsehay Gibat Primary School, Ede Tibeb Primary School, Endemata Primary School and Muaket Primary School.

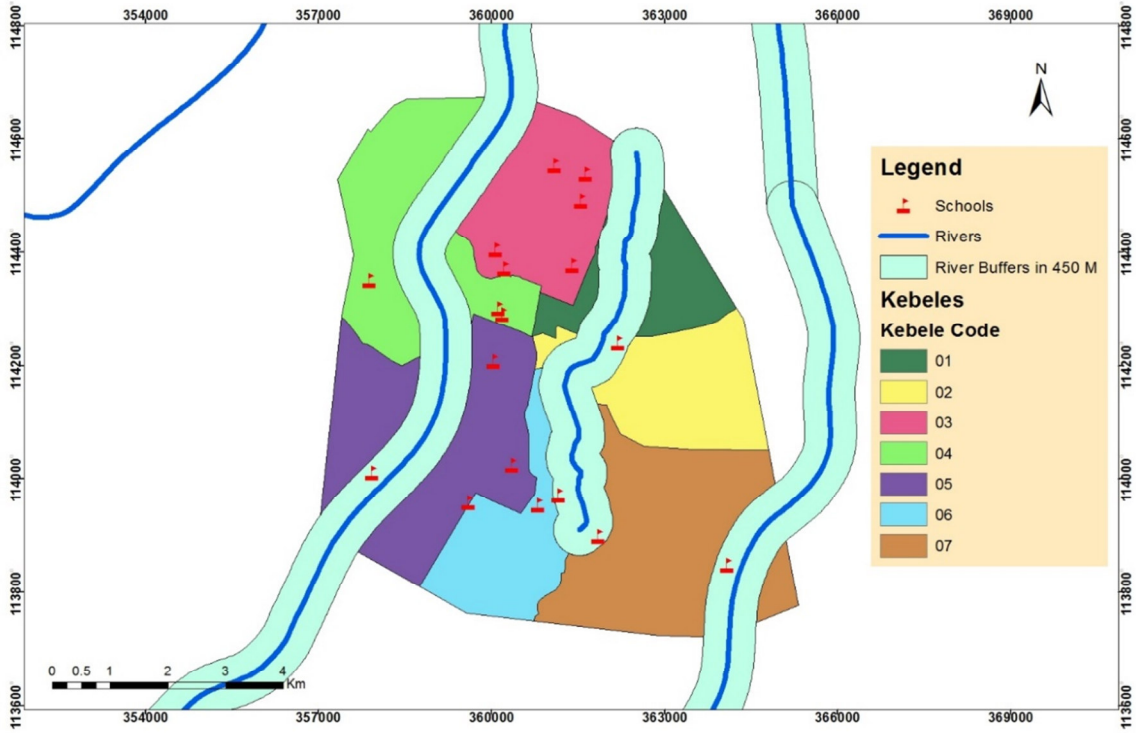


Figure 5 Map of 450 meters Buffer zone of streams over schools

C. Slope gradient school sites should be less than 15 degrees most suitable (Talam&Ngigi, 2011): Based on this guideline steep slope are not suitable for schools rather flat areas or gentle slope are comfortable for schools. The result showed that the sites greater than 15 degrees are not suitable, Chemoga Primary School located in steep slope are that greater than 15 degrees' slope inclination. The following map revealed that this slope value of school's areas.

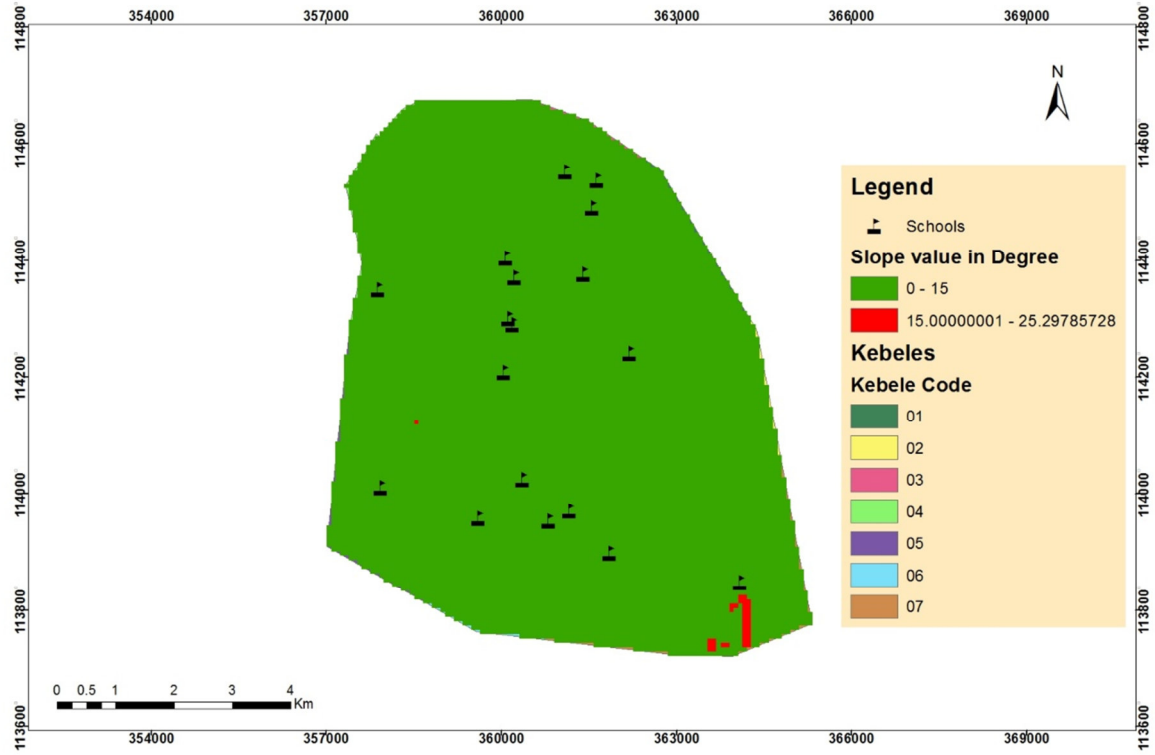


Figure 6 Classification of slope over school's distribution

D. Schools should far from above 1000 meters from the markets (ANRSEB):

This guideline reduced the noise congestion of school areas, Markets are congestion of population and noise pollution. This has negative impacts on schools on their calm environment. There are four market areas in Debre Markos Town. On these market areas, there some schools around there.

Table

distance_market

OBJECTID *	INPUT_FID	NEAR_FID	DISTANCE
22	5	1	270.689024
47	11	2	441.118235
56	13	4	463.597425
19	4	2	619.039248
52	12	4	654.281122
60	14	4	743.14058
69	17	3	840.696268
39	9	2	1035.701687
44	10	4	1134.890982
35	8	2	1161.674464
13	3	3	1185.414579
5	1	3	1236.505538
48	11	4	1308.356143
42	10	1	1333.089588
20	4	4	1442.595241
9	2	3	1505.459872

Table 8 The nearest distance between market and schools

This data showed that seven schools found within 1000 meters' buffer zone of the market areas. These schools are Endemata Primary School, Debza Primary School, Yene Primary School, Debre Markos Preparatory

School, Biruh Tesfa Primary School, Ethio_Japan Secondary & Preparatory School and Ede Tibeb Primary School. The above table 4.5 indicates their distance variation on ascending order.

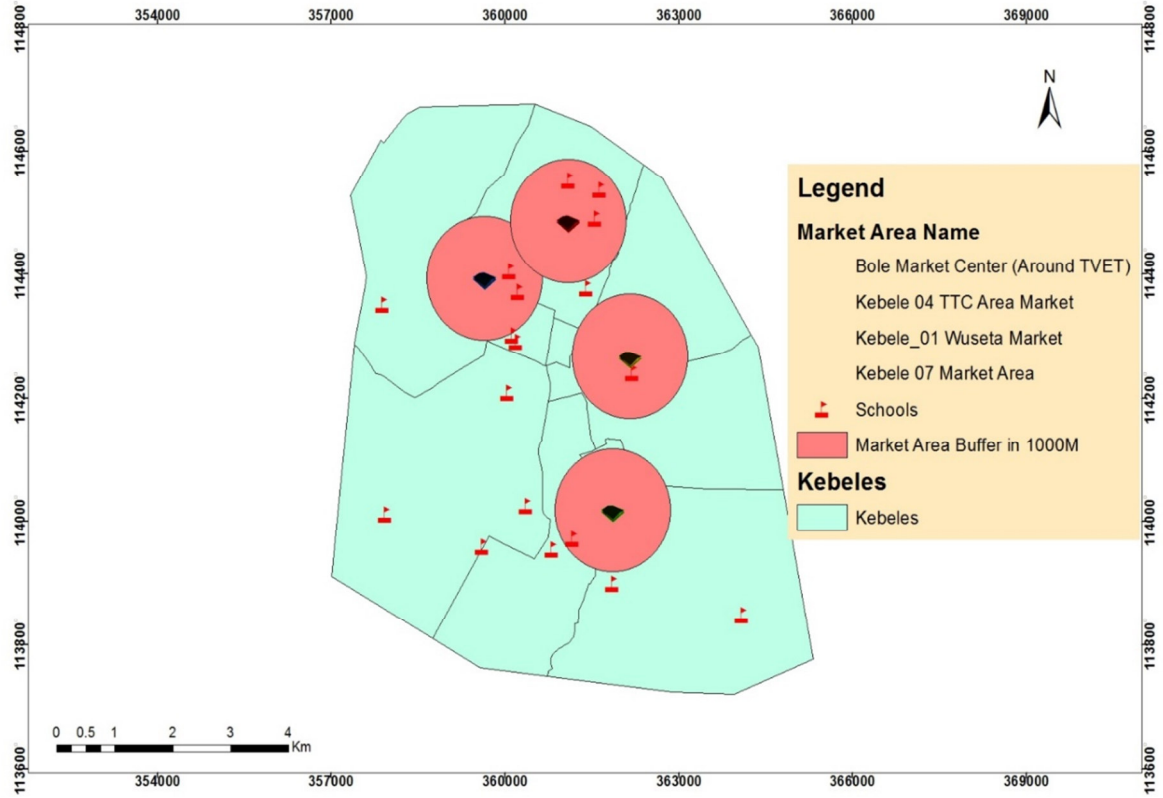


Figure 7 Market areas 1000meters buffer Zone over schools

Figure 4.6 showed that the schools in the buffer zone of market centres, they expose for noise pollution. This negative impact of claim environment is not good for students and schools learning environment.

4.1.4 Identify the Suitable Areas of School Based on Guidelines

The identification of suitable areas of schools need an integration of different geo-processing tools. This indicate that an automation and suitability modelling for school site selection based on the above criteria.

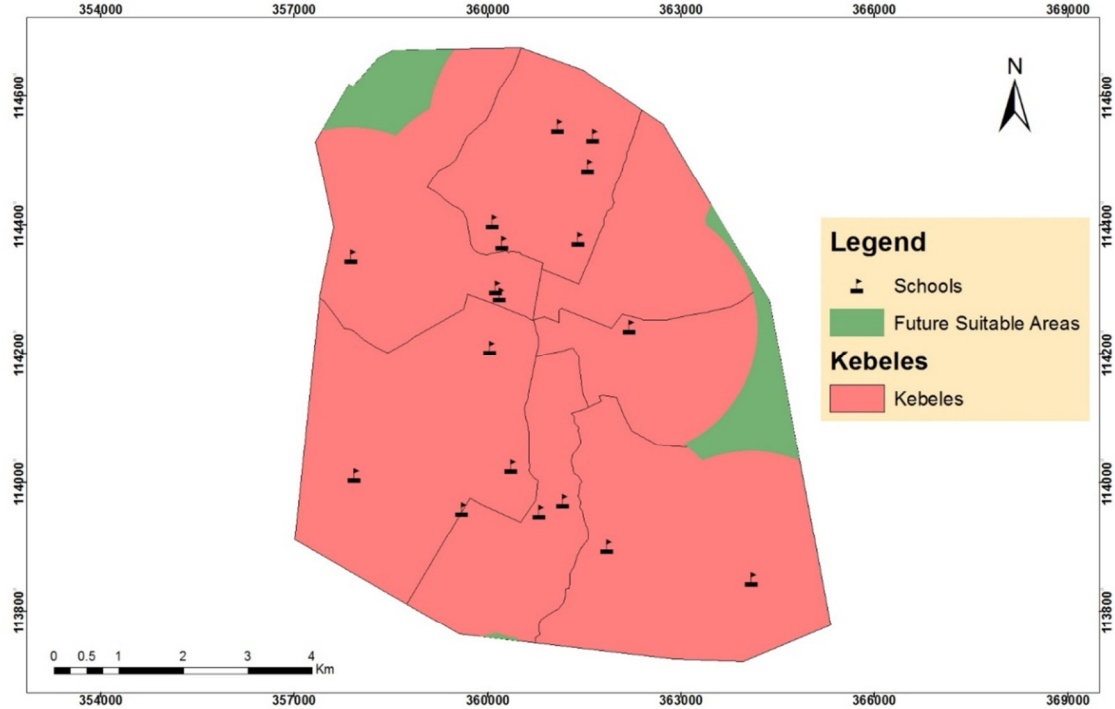


Figure 8 Map of future suitable area for school sites

Figure 4.7 indicated that most of school concentrated on the center. But on the peripheral areas there is no

enough schools in the town. Future sites recommend that to build on the north and eastern isolated areas of the town. The identification of these future suitable areas for school sites are used modelling automation. It enabled that to consider the criteria and generate the areas which are full fill the criteria.

The following diagram showed that the integration of different tools. The model automation used buffering to zone the layers and erase to remove the layers which are out of the standards. Finally, it integrated all outputs by overlay analysis tool of intersect. It produced the areas which fulfilled the above criteria.

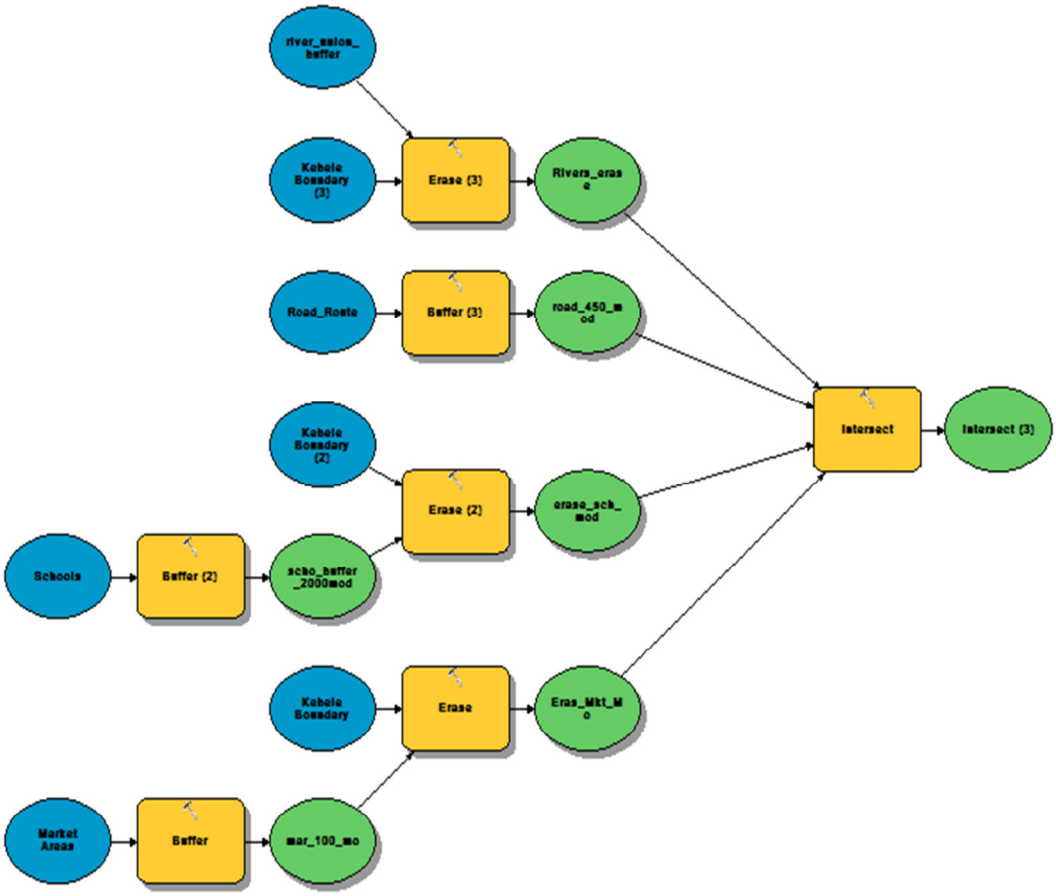


Figure 9 Suability automation model for suitable areas of school sites

Conclusion

The study clearly indicated that 89% schools are located less than two kilometres far away than other schools and 11% are schools far away more than two kilometres than other schools. Around 11 or 61% schools located with 450 meters distance of road facilities the remaining 7 s or 39% schools are located far more than 450 meters from road facilities.

Wuseta stream was the nearest river for Wuseta Primary school. Chemoga Primary School, Tsehay Gibat Primary School, Ede Tibeb Primary School, Endemata Primary School and Muaket Primary School are the other nearest rivers in ascending order distance from the river.

Seven or 39% schools are located with 1000 meters buffer zone from market centres 11 or 61% schools are located far 1 kilo meter from the market centres. The south-eastern edge areas were the steep slope area and not comfortable for new site selection. North and East edge part of the town is the suitable areas for new school site building areas.

Recommendation

Debre Markos Town Land management team and municipality, they should adopt and implement GIS technology for their day to day tasks. All areas of the town should register and implement good land management and administration system by using geo-spatial technologies. Debre Markos Town Land management team should always identify the suitable areas by using national and international standards and criteria.

In general, GIS technology and standards enable to enhance proper land management system in the town and effective and efficient implementation of school and other urban public facilities distribution in the town.

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