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New Suitable Bus Station Site Selection Using Multi-Criteria Evaluation and Gis Technique In Case of Tepi Town, Ethiopia

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Abstract

Site selection for bus station site is an important issue for town planning and development in fast-growing world relation to protection of our environment. Because of the complexity of land management systems and the selection of the appropriate new bus station site requires consideration of multiple criteria and evaluation methods. Different Geographic data have been used to study the conditions of land use land cover by considering the study area. Criteria's affecting the environment are considered and including physical environment with economic factors. Distance and value criteria factors and calculated criteria weights are applied using the Multi-criteria evaluation (MCE). All these procedures have led to build a hierarchy model to solve the bus station site-selection problem in the study area. A geographic information system (GIS) was used to manipulate and process spatial data. Suitability index maps were graded from lowest to highest suitability using spatial information technologies. The candidate sites were determined by aggregation based on the Multi-Criteria Evaluation and criteria weights methods. The candidate sites were divided by 'very low suitable', 'low suitable', 'suitable', 'high suitable' and 'very high suitable' bus station sites. Very high suitable areas represent best suitable sites. This thesis work result suggests a sitting methodology and provides essential support for decision-makers in the assessment of a new suitable bus station site selection in the study.

***Keyword**: Multi-Criteria Evaluation, Geographic Information System and new bus station*

1. INTRODUCTION

A bus station is a infrastructure structure where city or intercity buses stop to pick up and drop off passengers. It is larger than a bus stop, which is usually simply a place on the sidewalk, where buses can stop. It may be intended as a terminal station for a number of routes, or as a transfer station where the routes continue. Elements of bus station are route of buses, bus stop, catchment area, topography, real time Information, safety and security, amount of money payed, vehicles, passengers, and service. This element will affect the quantity and quality of bus service in any city.

Mobility enables us to separate home from work and visit friends and family, do institution work through town and city, as well as to allow us to do business across a country, wider region and globally. It has the ability to provide some powerful benefits to narrow people and wider society. The most important benefit of good public transportation is that it reduces the need and desire for private vehicle ownership to some extent and thus can massively reduce the amount of motorized travel (Barter, 2000). In addition to support specialization, transportation provides us with the sort of mobility and accessibility we need to live our lives in the way anyone wants to live. So for this purpose the well-known bus station is important and needed. A well-known bus station has fixed bus lines, variable in combination with a dynamic passenger's information system. There is a problem of traffic congestion, a mix of different slow and fast moving vehicle, encroachment on the street by people, luck of sidewalk around road in town, enough facility of pedestrian (abad, 2006). All these are adding up to make the transport system unsound and unsaved. Most public transport runs to a scheduled timetable with the most frequent Services running to headway. Share taxi offers on-demand services in many parts of the world and some services will wait until the vehicle is full before it starts and waste the time of passenger. Para transit is sometimes used in areas of low-demand and for people who need a Door-to-door service in world, the public transportation such us bus is a one of a good transportation that is use as a second transport. Terminal operational efficiency decides the whole efficiency of city transit system (ZHOU XUEMEI, 2001) due to that, POE is expected to identify issues in bus terminals based on users perception in order to satisfy their needs, service improvements, encourage the public transportation and cost effective with good quality of life in the city.

The research about the bus services and passenger demand is made to solve and improve the problem Public transport is a shared passenger transportation service which is available for use by the general public. Share taxi offers on-demand services in many parts of the world and some services will wait until the vehicle is full before it starts. A passenger being very sensitive to conditions while they are waiting for bus (LITMAN, 2007), may influence their transportation decisions.

Bus station and its service in Tepi Town

The old bus station in Tepi town was established in1972 E.C with only few numbers of buses. When this bus station was established there are no more road networks which link or move things and person from one place to another place for the purpose of trade or others. The road network is very important things during transfer or movement of person and things. As blood vessels used in our body, road networks also used in one country on the world. Therefore this road networks must have fixed station which used bus rest and at this station people find bus simple used it to go from one place to another for different purpose. Depending on this old or existing bus station the study established the new bus station in Tepi town. Using modern technology instrument to solve different problems come out with this old bus station. This new bus station should have shelter for bus, safety and security shelter for passengers, enough location to stop bus, enough information for passengers which shows where buses are going with in a fixed time and price, having enough toilet, light in general giving enough direction for user at all. To select new bus station in Tepi Town different factors were taken under consideration those factors are land use, health center, distance from educational place, slope, population density, distance from main road, distance from residential area, marketing area, existing bus station and others. Bus station should be located on a level section of road to maximize accessibility and safety for mobility impaired passengers in general enough security. In general it should be selected to maximize safety and security for bus Passengers, residents, and road users.

2. LITERATURE REVIEW

2.1. Historical development of bus station

Northern Ireland: The Regional Transportation Strategy established a new approach to transportation planning in Northern Ireland. The implementation of the initiatives contained in this strategy will, over the strategy period, make a significant contribution towards the achievement of the "vision "for transportation contained in the Regional Development Strategy for Northern Ireland 2025 (Shaping our Future).This is to "have a modern, sustainable, safe transportation system which benefits society, the economy and the environment and which actively contributes to

social inclusion and everyone's quality of life."(An Accessible Transport Strategy for Northern Ireland, Department for Regional Development, 23 April 2005.)

Researches on public transportation is show the behaviour in Kula Lumpur suggested the need of enhance efficient public transportation to attract more car owners all over the country, (ABDULLAH NURDEEN1, 2007) and (Zakaria et al., 2010) Bus terminal acts as core provide transit services support the economic and social development of surrounding area. According to (PROGRAM-TCRP19, 1996) defined that spacing, location and operation of bus terminal significantly influences transit system performance and customer satisfaction.

South Africa: This literature review study on public transport and mobility in South African cities takes place at a crucial point in the trajectory of South African passenger Transportation development. Since emergence from apartheid, South Africa as a Nation has been locked in a process focused on overcoming the spatial and socio-economic inequalities inherited during the apartheid regime. From a transport Perspective, there has been much progress made in transport policy reform which begun in the mid-1990s with the development of the White Paper on National

2.2 urban Transportation

Urban form comprises of different elements that determine its character and no going activities which is characterized by the integrated land use pattern and it's inter connection, established by the transportation links. Consequently there is a wide variety of urban forms, spatial structures and associated urban transportation systems. Urban transport is organized in three broad categories of collective, individuals and freight transport (Rodrigue, 2006). In several instances, they are complementary one another, but sometimes they may be competing for the usage of available land/transport infrastructures.

3. DESCRIPTION OF THE STUDY AREA

3.1 Geographical locations

Tepi town is located in Southern part of Ethiopia in SNNPR State, Sheka- Zone, and Yeki wereda at a distance of 611 km from Addis Ababa. Its astronomical location of the town has a latitude and

longitude of 7°12′N &35°27′E and 7.20°N35.45°E with a mean elevation of 1,097 meters above sea level (Tepi municipality, 2008).

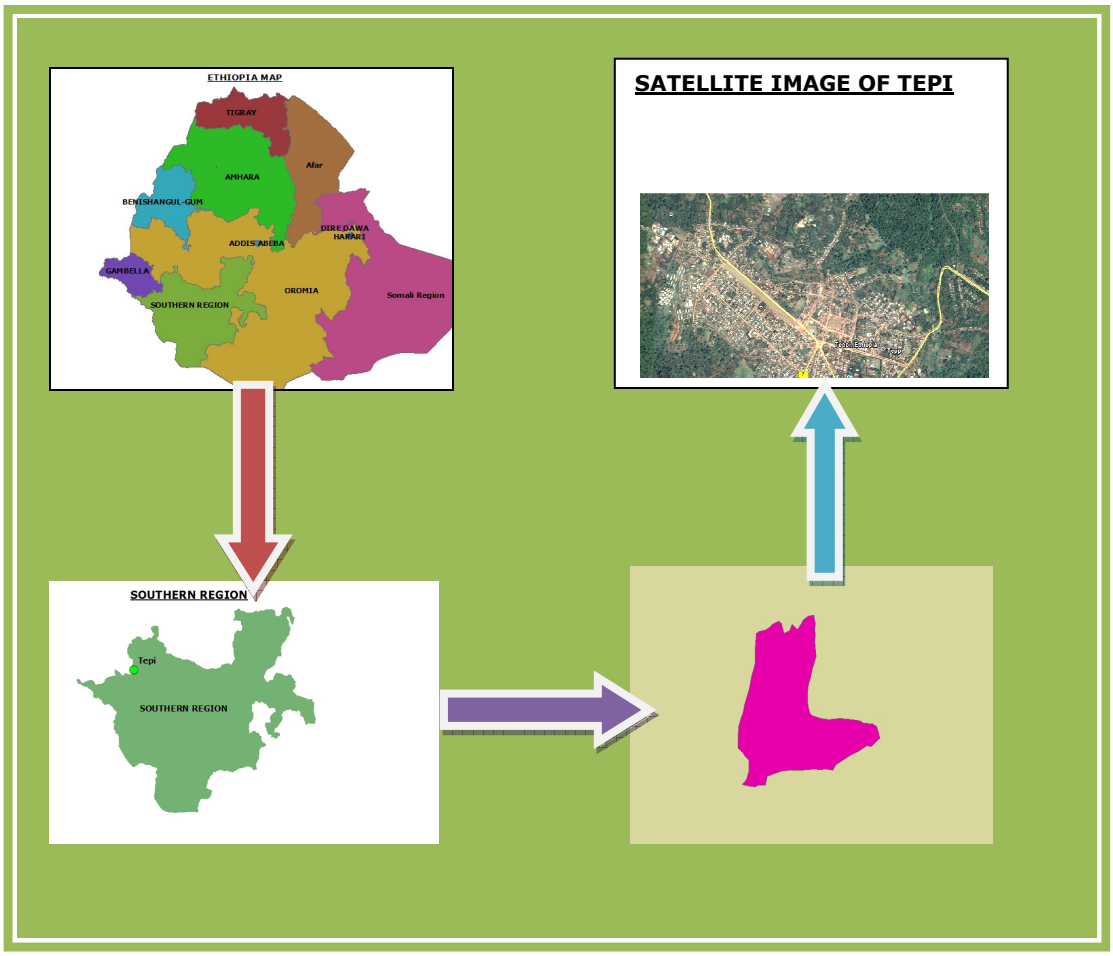

Figure 3.1: Location of Tepi Town

3.6 Road net work

Transportation plays very large role in everyday lives. Each of person and things travels somewhere almost every day, whether it is to get to work or school, to go shopping, or for entertainment purposes. In addition, almost everything consumes or use has been transported at

some point. The project area has different main roads like millennium road and other networks connected .

3.8 Land Use and Land Cover

The land use of the project area is coffee plantation, garden, and plantations of fruits such as banana, avocado, mango, papaya, cereals grasses. And also the area is covered by long trees which are very big and causes difficulties in study the area practically.

4. METHODOLOGY OF STUDY

4.1 Data Collection

Data collection is a term used to describe a process of preparing and collecting data. The purpose of data collection is to obtain information to keep on record, to make decisions about important issues, to pass information on to others. The information presented here has been collected through the use of both primary and secondary data sources.

4.1. 1. Primary data collection

Primary data collection is the method in which the data is gathered directly using GPS instrument. The data collected are coordinates points (Easting, Northing and Elevation points). Direct observation constituted a major data collection tool both at the reconnaissance stage and during actual survey. To facilitate rapid interpretation of observed features, observations and data collection were aided by field survey and master plan of our project area. This brings for the mental map of our project area to prepare neatly by taking consideration of the land use map of Tepi Town.

4.1.2 Secondary data collection

The secondary data is mainly obtained from published or unpublished books, laws and regulation, strategic plan and satellite image of the study area. A variety of collected data sources dealing with different data types including topographic maps, land Information, social and economic data, statistical records, satellite data/aerial photograph have been used in thesis research.

Table 4.1: Data type, source and description

No.	Item	Specification	Source	Description/purpose
1	Boundary map	Coordinate (x,y,z)	Field survey	To determine the location of the study area
2	Land use land cover	Coordinate (x,y,z)	Field survey	Classification of land use land cover and determine the sites and assign the Most suitable land use for the new bus station
3	Location of existing bus station	Coordinate (x,y,z)	Field survey	To locate the existing bus station
4	Road network	Coordinate (x,y,z)	Field survey	Locate the accessibility of bus station
5	Topographic map	DEM_raster data format	Field survey	Evaluate the terrain type (analyses the slope)
6	Population	Population Number (2007)	Tepi municipality	Determining the population density of the area

Spatial data: the information about the location shapes of geographical features and the relationship between them. For instance, the spatial data are: shape files created on arc catalog and exported to arc map; such as road, point and etc.

Non spatial data: it is tabular or textual data describing the geographic characteristics of features. Collected socio- economic data is filled to the attribute table using option- add field.

4.2 Downloading

The term downloading is distinguished from the related concept of streaming, which indicates the receiving of data that is used nearly immediately as it is received, while the transmission is still in progress and which may not be stored long-term, whereas in a process described using the term downloading, this would imply that the data is only usable when it has been received in its entirety. The data collected in the site (field) was down loaded using Window mobile center software by the help of communication cable.

4.3 Importing

The import and export of data is the automated or semi-automated input and output of data sets between different software applications. Before connecting of all points in GIS environment, import has been used to transfer excel data to GIs software by using the conversion tools.

- Creating Contours Using Arc GIS

Tin Contour uses an input TIN to calculate contours that are written to an output feature class. The output is a 2-D poly line feature class with contour heights assigned as attributes. The contour interval specifies the distance between contour poly lines. The z-factor is the number of ground x, y units in one surface z unit. The input surface values are multiplied by the specified z-factor to adjust the input surface z units to another measurement unit.

- Creating TIN using Arc GIS 3D analyst

A 3D surface model is a digital representation of features, either real or hypothetical, in three-dimensional space. Arc GIS can create and store three types of surface model raster, tin, and Terrain.

- Generating TIN slope by using the Arc GIS Spatial Analyst toolbar

From the Arc GIS Spatial Analyst toolbar, create a slope raster for an entire area, enabling you to get an impression of the steepness of the terrain, and use the output for further analysis. Spatial Analyst dropdown arrow, point to Surface Analysis Slope.

- Determining aspect in 3D Analyst

The compass direction that a topographic slope faces, usually measured in degrees from north. Aspect can be generated from continuous elevation surfaces. Aspect identifies the steepest down

slope direction from each cell to its neighbors. It can be thought of as slope direction or the compass direction a hill faces. It is measured clockwise in degrees from 0 (due north) to 360, (again due north, coming full circle). The value of each cell in an aspect dataset indicates the direction the cell's slope faces. Flat areas having no down slope direction are given a value of -1. Tin aspect can be drawn by two methods which are drawing tin by aspect and drawing tin aspect using the arc GIS spatial analyst toolbar. The TIN faces are rendered with colors to indicate the direction that they face.

Table 4.3: sample of data imported

Northing	Easting	Elevation	Code
796587.4	765879.4	1259.133	B1c1
796574.5	765876.3	1258.82	B1c2
796600	765869.8	1259.905	B1c3
796713.8	765987	1263.477	b1c4
796847.1	766106.8	1263.146	b2c2
796847.9	766113.9	1264.795	b3c1
796922.9	766181.1	1265.806	b3c2
796933	766190.6	1265.136	Airportc1
796985	766231.6	1262.188	Airportc2
796993.5	766219.2	1263.348	B4c2
796802.9	766329.9	1259.836	b3c4
796797.2	766336.5	1259.322	b4c3
796720.7	766254.8	1259.296	b3c4

4.4 Methods

According to their importance, contribution towards selecting suitable new bus station site, the developed factors were weighted using weight module in Idrisi software environment.

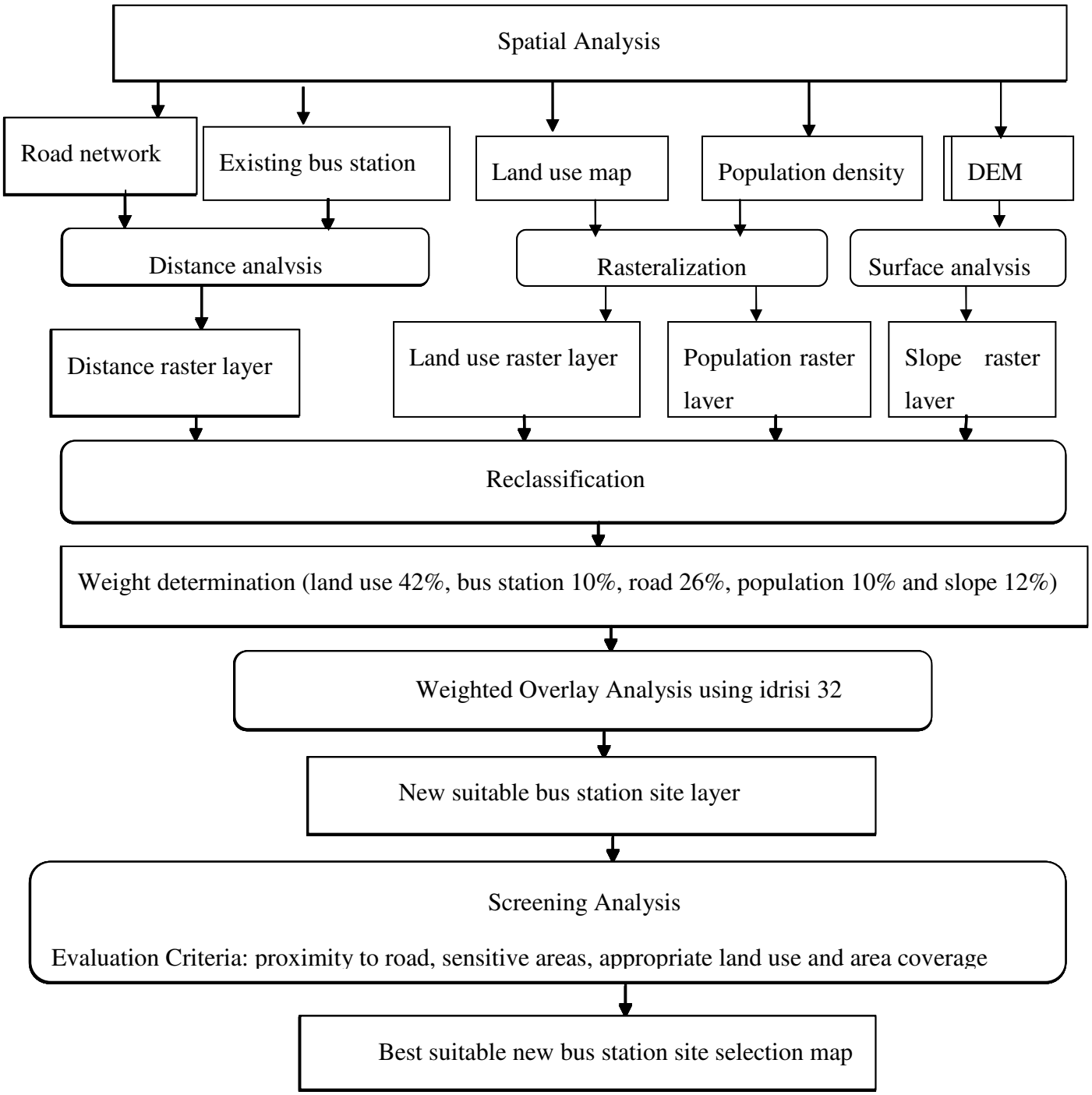

Figure 4.1: work flow the study

5. DATA ANALYSIS, RESULTS AND DISCUSSION

5.1. Analysis Specification

In this study the following factors (slope, population density, road network, land use and existing bus station) are used to determine the suitable sites for new bus station location. These data layers were converted into raster layers and reclassification. The study was conducted on 30m and the boundary of tepi town as the cell size and analysis mask respectively. The suitability rescaling option indicate 1-5 (1-indicate very low, 2-low, 3-suitable, 4-high and 5-very high suitability) and the important pairwise comparison values.

5.1.2 Road Factor

One of the purposes of road networks is to transfer passengers and things from one place to another place within a short pried of time. Therefore the location of the bus station site close to a road network would help to reduce the costs related to transportation and used their time properly. To locate the bus station site, determine the buffer distance from the road network which is determining the factors.

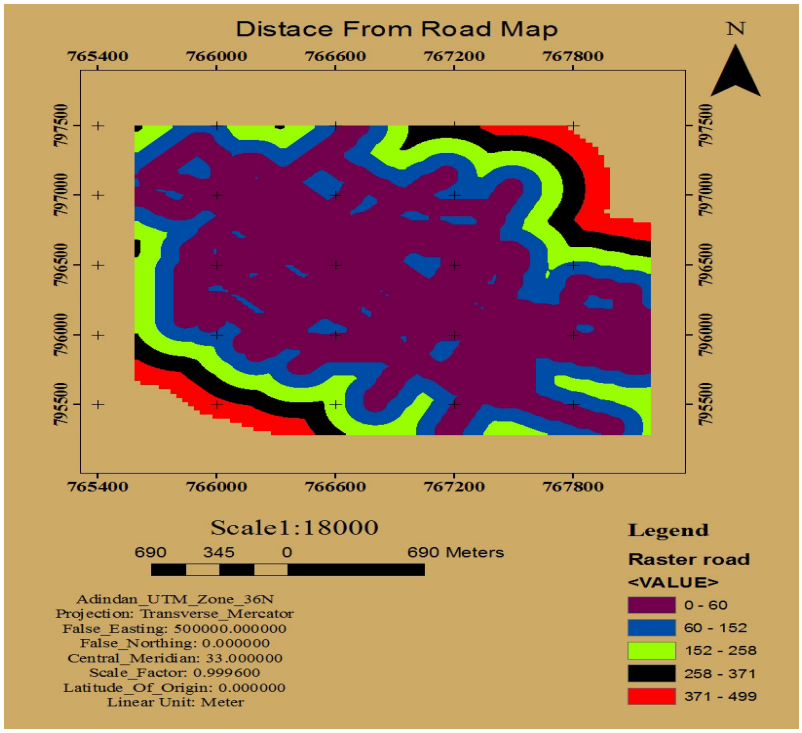

Figure 5.1: Raster Road network map of Tepi Town

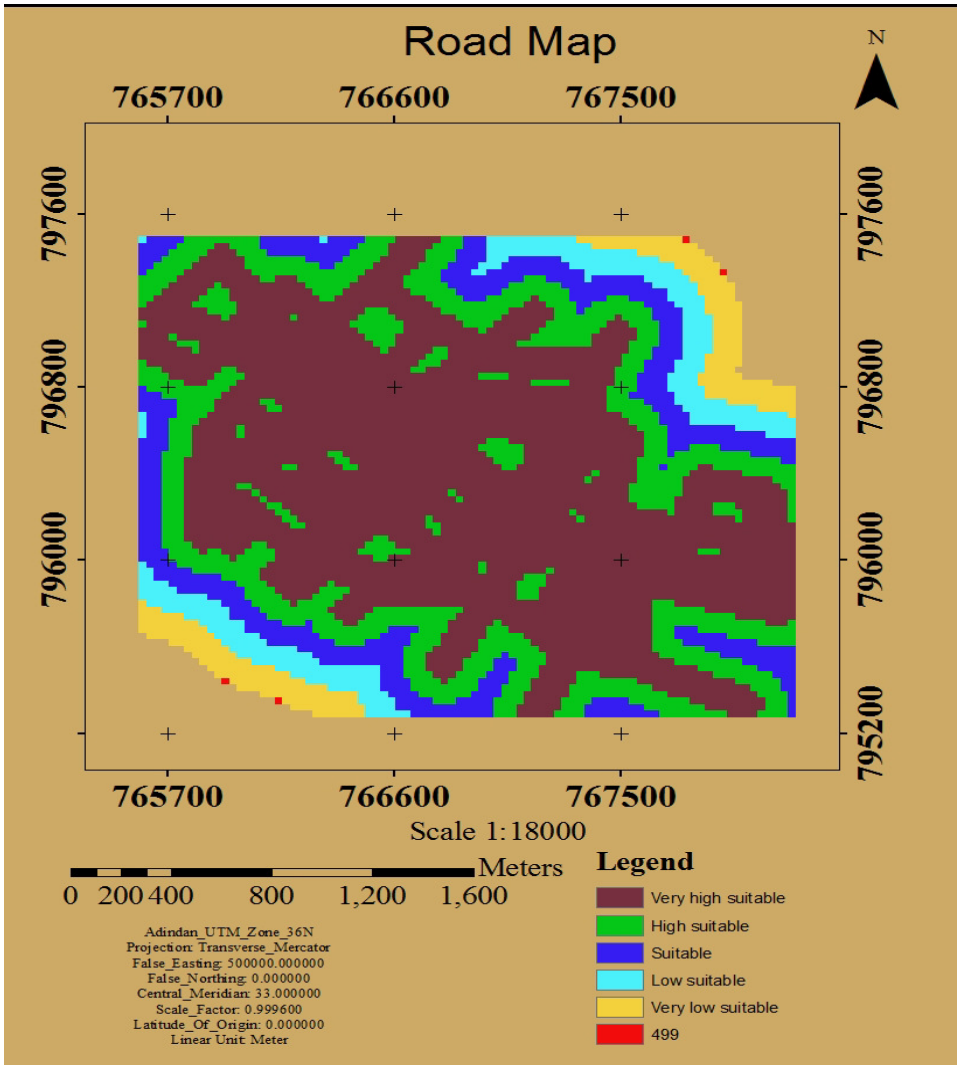

Figure 5.2: Reclassified distance from road

The factor was re-classified to make sure that which sites are more suitable according to section 5.1. Figure 5.2 is constructed in order to create the re-classified map of Tepi Town road network.

The above figure shows that the factor reclassified into five classes the first class is contained from 0-60m which is very high suitable, the second class is 60-153m, which is high suitable class, the third class is 153-258m which is suitable class, the fourth class is 258-371m which is low suitable and the fifth class is 371-499m which is very low suitable for site selection. Therefore, the distance from 0-60m is very high suitable for economic, safety and security reasons and suitable site location, to avoid transportation conflicts and mainly due to visual reasons. Generally the distance

greater than 499m from the main road is classified as unsuitable since it would not be economically feasible to site selection.

Table 5.1: Suitability score of reclassified road network

No	Road distance(m)	Suitability score	Suitability class	Area (ha) or percentage total (%)
1	0-60	5	Very high suitable	30.31or 17.73%
2	60-153	4	High suitable	11.67 or 6.83%
3	153-258	3	suitable	64.35 or 37.64%
4	258-371	2	Low suitable	35.82 or 20.95%
5	371-499	1	Very low suitable	28.8 or 16.85%

5.1.3 Land use/land covers Factor

The Land use and Land cover is used in order to determine which areas are more suitable for a bus station site. For this paper Land use type include such as residential area, institutional, commercial area, industrial area, bare land and recreational area would be considered and assigned an appropriate index of land use suitability.

All are converted into raster layer used to get very suitable for bus station site. The raster layers were re-classified to develop factors. These factors used to select more suitable land use.

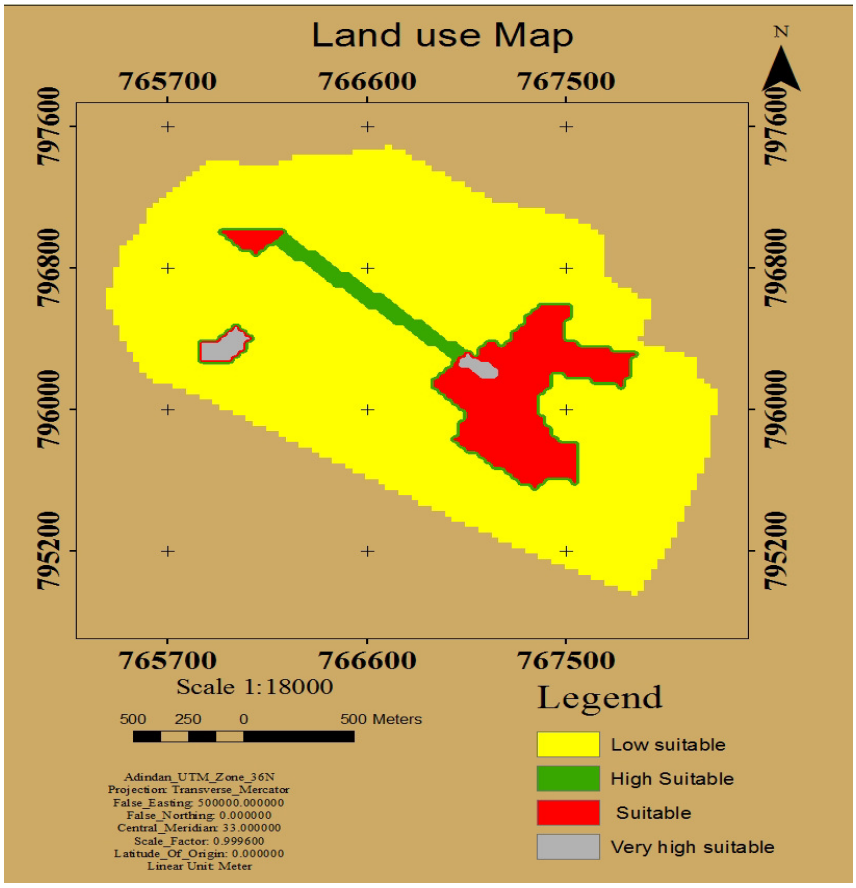

Figure 5.3: Reclassified the land use land cover map of tepi town

Table 5.2: Suitable score of land use land cover

No.	land use type	Value/score
1	bare land	5
2	Residential area	2
3	Commercial	3
4	Recreational and Parks	4
5	Institutional	1

The reclassified land use determined the suitable sites. To determine this site the bare land and recreational area land are more suitable. Green area is included in the barren lands and some reserved area. For this site selection the barren land is better for station site. The other land uses restricted site for new bus station. Figure 5.2 shows that 9.0ha or 9.43% out of the total area is high suitable, 45.63ha or 47.80% is suitable, 36.32ha or 38.05% is low suitable and 4.5ha or 4.71% is very high suitable for this factor.

5.1.4 Digital Elevation Model (DEM)

The slopes help to identify the maximum rate of change in surface value over a specific gradient and they are expressed in degrees or percentage. The slope map from the Digital Elevation Model (DEM) required for the final analysis, the spatial analysis tool in Arc Map 9.3 was used in the slope map calculation. Slope Calculation is one function in spatial analyst tool and this function was used to derive the slope map from DEM.

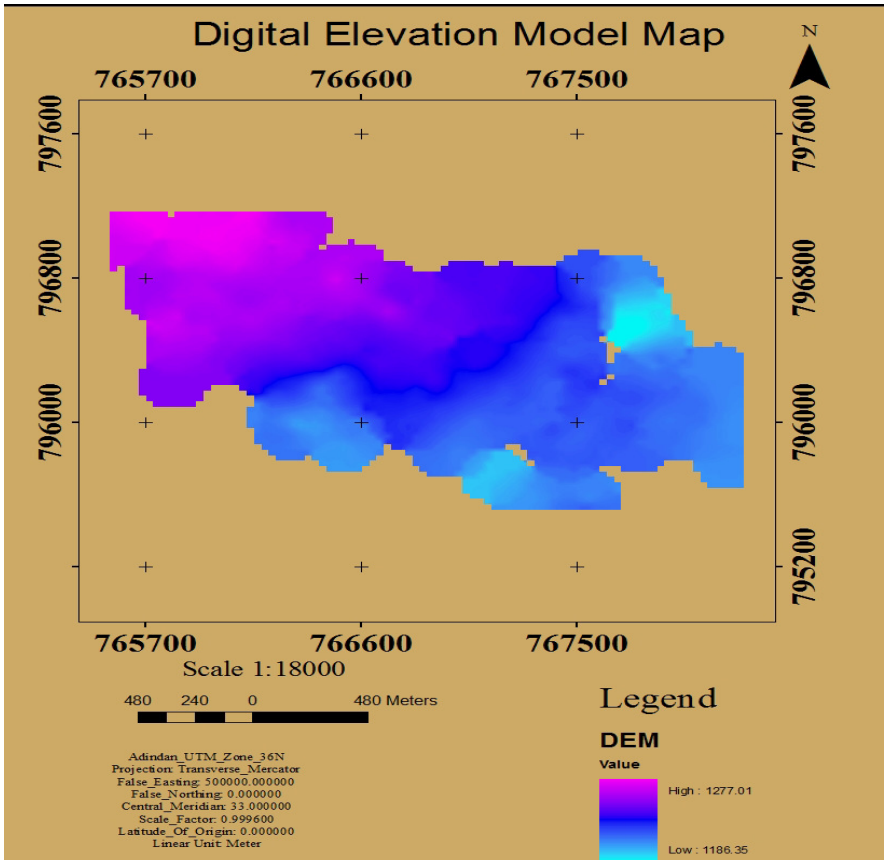

Figure 5.4: Digital Elevation Model map of Tepi town

5.1.5 Slope Factor

Slope is an important factor when selecting a suitable new bus station site since higher slopes would not suitable to stop vehicle in its station with keep its balance. If the slope is too steep, it is difficult and costly to construct the bus station site. As a matter of fact, that is a slope of less than 2% would be very high suitable for the prevention of contaminant stop. Therefore, preference is given to a landform that is somewhat located in flat or undulating land.

The study area comprises different land forms such as flat and mountainous, which indicate that the slope between 0% and 28%. Based on this data for the bus station site selection from 2% to 4% was high suitable. These are the land structures of study area; it is evaluated by developing the slope from DEM (Digital Elevation Model).

Table 5.3: Suitability scores for slope

No.	Slope in percent	Suitability score	Suitability
1	0-2	5	Very high suitable
2	2-4	4	High Suitable
3	4-7	3	Suitable
4	7-13	2	Low Suitable
5	13-28	1	Very low suitable

The final procedure is reclassification of slope in to five classes13-28% very low suitable, 4-7% is suitable 2-4% is high suitable, 0-2% very high suitable and 7-13% is low suitable. The area covered 64.53ha, 10.57ha and 11.30ha suitable, high suitable and very high suitable sites respectively.

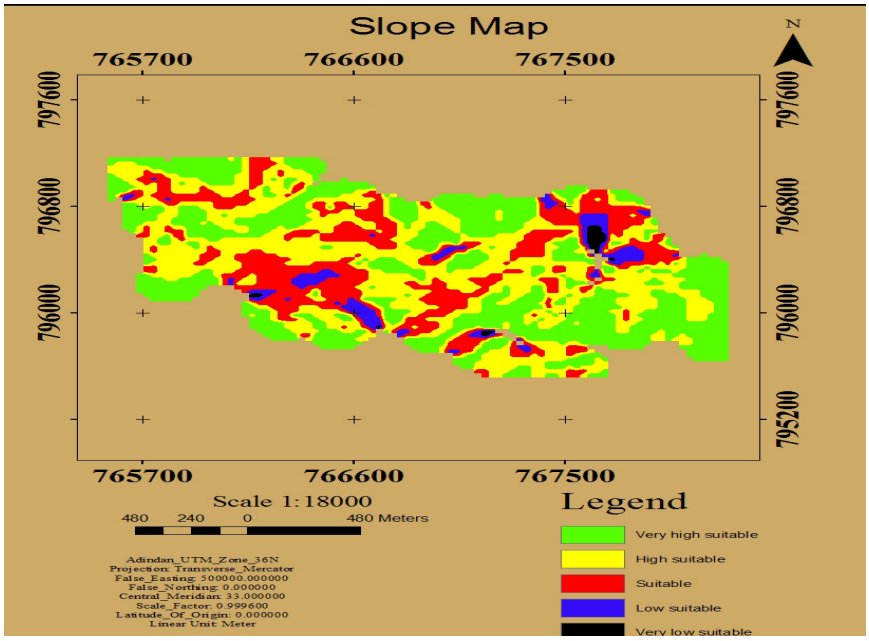

Figure 5.5: Reclassified slope map of Tepi Town

5.1.6 Distance from existing bus station site Factor

The existing bus station in Tepi Town was established in1972 E.C with only few number of bus.

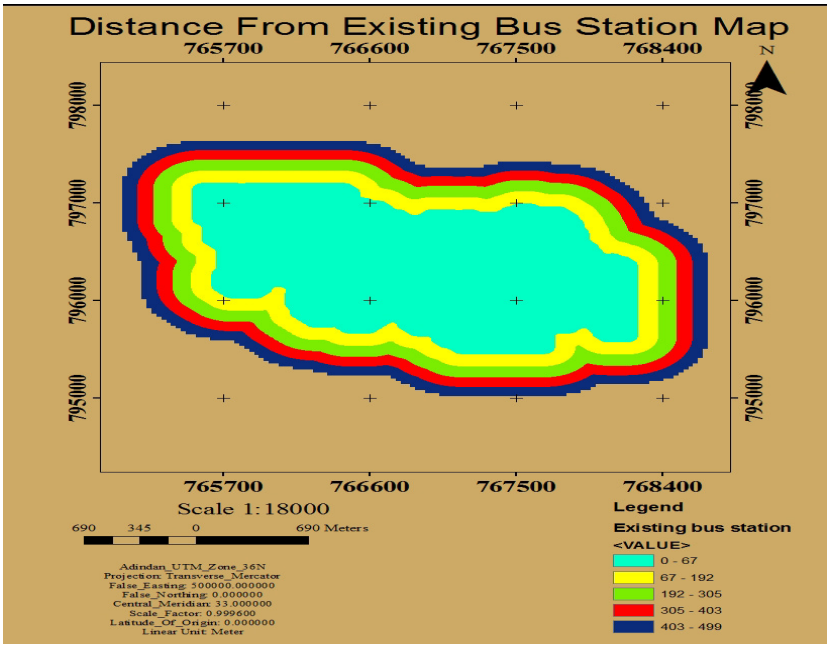

Figure 5.6: Raster existing bus station site map of Tepi Town

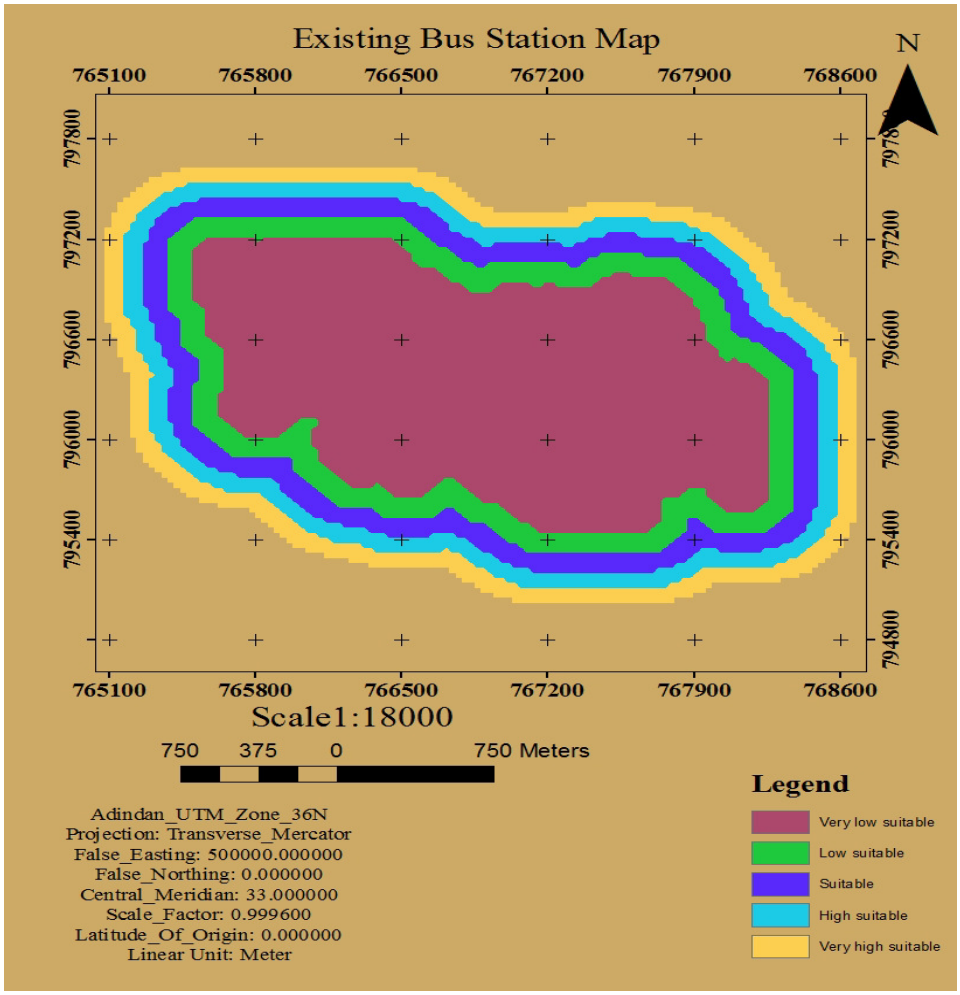

Figure 5.7: Reclassified existing bus station site map of Tepi Town.

The factor layer classified into five classes the first class contain 0-67m which very low suitable, from 67-192m low suitable, 192-306m suitable, 306-404m high suitable and lastly 404 499m very high suitable. Generally the closest distance to the existing bus station site is low suitable. The developed factor was reclassified to determine the suitable new bus station sites.

Table 5.4: Suitability score for existing bus station site

No.	Distance Classification	Suitability score	Suitability	Area (ha) or Percentage of Total (%)
1	0-67	1	very low suitable	34.67ha or 21.96%
2	67-192	2	Low suitable	11.15ha or 7.06%
3	192-306	3	Suitable	10.69ha or 6.77%
4	306-404	4	high suitable	91.35ha or 57.86%
5	404-499	5	very high suitable	10.0ha or 6.34%

5.1.7 Suitability Analysis

One of the major strengths of the Analytical Hierarchy Processes (AHP) is Pairwise comparisons to derive ratio scale priorities. This is better than the traditional method of assigned weight. Pairwise comparison is the process of comparing the relative importance of one factor with respect to another factor. This comparison assists decision makers to evaluate the contribution of each factor to the objective independently, hence simplifying the decision-making process. All reclassified factors are assigned weight based on importance of the factors for bus station site selection. The weight assign by using Idrisi 32 software, the importance factors are land use, road, population density, slope, and existing bus station site respectively.

Based on these important values the weights assigned for all factors, the following table shows the principal eigenvector weight for the factors

All factor weight is multiplied by its factor and sum up, by using spatial analysis tools in GIS environment. After this calculation the following result is appear.

Table 5.5: Principal Eigenvector (Weights) of the pair wise comparison matrix.

No.	Criteria	Weight	Weight in percent
1	Land use	0.4182	42%
2	Slope	0.1176	12%
3	Road	0.2591	26%
4	population density	0.0993	10%
5	Existing Bus station	0.1027	10%
	Total	**1**	**100%**
	Consistency Ratio (CR)	0.08	Acceptable

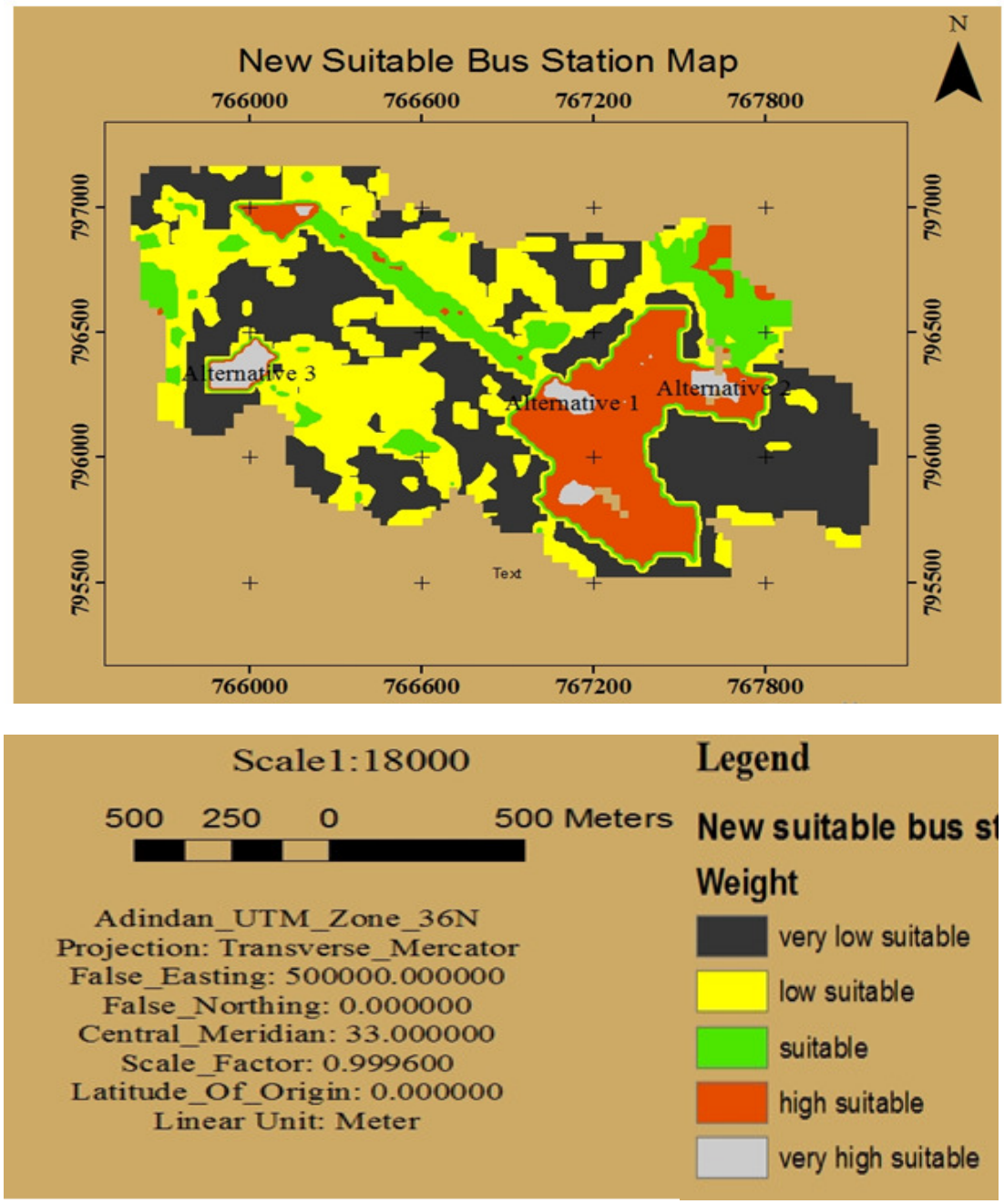

Figure 5.8: suitable new bus station site map of Tepi town

The above figure is the final results for new bus station site selected by using GIS techniques based on the criteria. The selected areas are located in one place that is indicated by number (1) very high suitable.

5.2 Discussion

5.2.1 Bus station site in Tepi town

The bus station site selection in Tepi is originally proposed by public transportation management and beatification department. This department selected the area by using manual method. Now in the town there is one existing bus station. The existing bus station site is located in inappropriate area, due to this reason the vehicles are stop irresponsibility in the town. To minimize these problems a new bus station site selected using GIS techniques. To select this new bus station site developed five criteria i.e. land use, road network, population density, slope and existing bus station site. For these paper land use and road network have high contribution for station sites.

Land use is the area utilized and a place where high human activity is involved. Which include, residential area, institutional and commercial area, green area, recreational area, bare land and Industry land. The selection of new bus station site should consider these land use land cover of the town mostly the suitable station site selection check the land use either suitable or not. Table 5.2 shows that the station site located on the bare land and near Recreational land very high suitable and high suitable respectively.

Distance greater than 300m from main roads is unsuitable related to cost. The station site should not be placed too far away from main road networks to avoid the ambiguity and safe time. The factor of main road was reclassified into two classes 0 -60m is very high suitable, 60-153m is high suitable, 153-258m is suitable,258-371m is low suitable and 371-500m is very low suitable. The reclassified factor cover 4.5 ha or 4.71% very high suitable and low suitable covers 36.32ha or 38.05%, Therefore 4.5 ha or 4.71% is acceptable.

6. Conclusion and Recommendation

6.1. Conclusion

Bus station site selection needed a procedure which involves evaluating various factors like road network, population density, DEM, land use and existing bus station site factors. Using GIS for locating bus station sites is an economical and practical way as they have capabilities of producing useful, high quality land use maps for bus station site selection in a short period of time. In this

study, 5 different criteria are defined to select a suitable site for bus station site and used as an input map layers. A method which integrates both GIS and MCE is used for the analysis. To compare the results and check the accuracy, two methods of MCE which are Weighting and Analytic Hierarchy Process are used. The output maps are divided into 5 classes from very low suitable to very high suitable areas.

After the production of output maps, required determining the alternatives sites, five alternatives sites become available. Among these alternative sites, the alternative site one (1) is determined as the most suitable site in the study area due to its easy accessibility.

The study proved that GIS is a powerful tool in handling large amounts of data and narrowing areas of interest for potential new bus station sites.

6.2. Recommendation

There is a need to consider bus station generation rate and population growth in Tepi town.

On the bases of the findings and practical working on the field with regard to this senior project, the following recommendation are forwarded in the hope of that they may be implemented by the responsible department / concerned body .

- ✓ It is good practical to consider the factors for new bus station location. Since there are a lot of problem in existing bus station related to transportation such as far away from road, safety, not consider slope and other factors.
- ✓ There should be a close relationship between the universities, specifically surveying Engineering department and road and transportation administration and municipal administrative to cooperate for the study during field work in every aspect.

REFERENCE

Abad, a. (2006). Environmetal planning collaboratives.

Abdullah nurdeen1, r. R. (2007). Modeling of transportation behavior of coercive measure for car driving in kuala lumpur. *Journal of engineering and applied sciences, 2*.

Barter, p. A. (2000). A community action guide to poeple-centred equitable and sustainable trannsport . *The sunstran network*, isbn 983-40313.

Litman, t. (2007). *Valuing transit service quality improvments journal of public transportion,*. Journal of public transportion,.

Miao wang and lian-yu wei. (2006). Application of analytical hierarchy. *Journal of hebei university of technology,*, pp. 111-115, doi:cnki: issn: 1007-2373.0.2006-06-022.

Program-tcrp19, t. C. (1996). Tcrp-19 guidelines for the location and design of bus stops. *Transportation research board -national research council*.

Rodrigue, j. C. (2006). *The geography of transport systems.* Hostra university: department of economic and geography.

Zakaria, z. H. (2010). Services quality of malaysian public transport. *Acase study in malaysia cross-cultural communication,6, no2.*

Zhou xuemei, j. X. (2001). *Evaluation of importance level of public transit terminal based on.*

