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ORIGINAL RESEARCH PAPER

Suitable site selection for urban green space development using geographic information system and remote sensing based on multi criterion analysis

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ABSTRACT

BACKGROUND AND OBJECTIVES: The study was conducted with the objective of selecting suitable site for urban green space development of Arba Minch town in Ethiopia using geographic information system and remote sensing based multi criterion analysis.
METHODS: To produce suitable site, four parameters were considered, these are slope, land use land cover, distance to the main river and distance to road. Supervised classification followed by reclassification were done to classify suitable land use land cover for urban green space, digital elevation model data were used to generate slope suitability and buffering with different distance were used to produce suitable site using distance to the road and distance to the main river parameters'. Although a variety of techniques exist for the development of weight, one of the most promising techniques was the Pairwise Comparison Matrix in the context of a decision making process known as the Analytical Hierarchy Process and ratings were provided on a nine-point continuous scale, which ranges from 1 to 9.
FINDINGS: So, on the bases of the ranks given by the experts the highest value was calculated for river which was 51.28%. The result shows that high suitability accounts 36.3 % of the total area, 45.5 % of the area is moderately suitable and the remaining 18.5 % of the town is not suitable for urban green space.
CONCLUSION: The most important parameters' to predict the location of urban green space in the study area were distance to the main river followed by distance to the road as the experts' rate it. Although, slope and land use land cover parameters' are very important, they do not seem to have noticeable effect on urban green space development as of the experts' response.

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INTRODUCTION

In today's changing world, values and standards of human were changed with urbanization (Bayram and Gökyer, 2012). Urban green space is a component of "green infrastructure". It is an important part of public open spaces and common services provided by a city and can serve as a health-promoting setting for all members of the urban community (World Health Organization, 2017). In the other way it is defined as those land uses and land covers that are covered with natural or man-made vegetation in the city and planning areas (Bayram and Gökyer, 2012). Urban areas always present some risk of flooding when rainfall occurs. Buildings, roads, infrastructure and other paved areas prevent rainfall from infiltrating into the soil and so produce more runoff. Heavy and prolonged rainfall produces very large volumes of surface water in any city. In well-governed cities, this is rarely a problem because good provision for storm and surface drainage is easily built into the urban fabric, with complementary measures to protect against flooding for instance, the use of parks and other areas of open space to accommodate floodwaters safely from unusually serious storms (Satterthwaite, 2008). Urbanization is now a common feature of all third world countries. Primate cities and megacities are emerging in developing countries. In Asia, Africa and Latin America, the unprecedented population growth that characterized much of the 20th century has evolved into unparalleled urban growth (Brockerhoff, 2000). In order to realize sustainable and environmentally friendly urbanization, there is an urgent need for comprehensive land use planning and of urban settlements by giving due consideration to create and sustain urban green spaces (UGS) such as parks, gardens, roadside vegetation, etc… (Ramaiah and Avtar, 2019). Because of urbanization the global atmospheric concentration of CO_2 in 2005 was approximately 379 parts per million, an increase from a pre-industrial value of about 280 parts per million. The approximate lifetime of CO_2in the atmosphere is50 to 200 years (UN-HABITAT, 2011). Throughout the world, urban areas have been increased in size over recent decades (Sandstrom, 2002; Cohen *et al.,* 2006). The United Nation report indicates that currently more people of the world (54 %) are living in urban centres and by 2050 urban environment will need to accommodate an additional 2.6 billion people, pushing urbanization to 86% in the developed world and 64% in the developing countries (United Nation, 2014). Urbanization leads to the occupation of green areas, directly contributing to a high level of fragmentation of urban green spaces, which, in turn, results in numerous socioeconomic and environmental problems. Consequently, an understanding of the relationships between patterns of urban green spaces and urbanization processes is essential (Li *et al*., 2019). In Ethiopia, most of the urban canters are unable to meet the minimum standard proposed by World Health Organization that is urban green area components per person is 9m² (Girma *et al.,* 2019). For instance in some Ethiopian cities like Adama, Shashemene, Dese, Jijiga, Dire Dawa and Bahir Dar had 2.1 m² , 1.9 m², 3.1 m², 3.8 m², 5.6 m² and 8.2 m²urban green area components per person, respectively (Ministry of Urban Development and Housing, 2015). Moreover, urban green area components are poorly accessible (Gondo, 2012), they are not well developed and they lack basic facilities discouraging urban dwellers to utilize them (Hailegiorgis, 2017). The environmental impacts of urbanization in Ethiopia include the negative health consequences of crowding and increased exposure to concentrated waste, unsustainable resource consumption and settlement on environmentally fragile land (Mekonnen and Kohlin, 2008**)**. So the issue of urban planning should be given much emphasis in order to reduce all environmental consequences resulted from rapid urbanization rates (Mikyas, 2011). Article 44 of the Ethiopian Constitution states that the people of Ethiopia have the right to live in a healthy environment

(Mpofu, 2013). The share of the population living in cities has increased from an estimated 7.1% in 1994 (Lamson-Hall *et al*., 2018) to 16% in 2016 and is expected to reach 60% by 2040 at the current annual growth rate of 3.5% (United Nations, 2014; Lamson-Hall *et al*., 2018). The selection of suitable sites for specific land uses must be based upon a set of local criteria to ensure that the maximizing cost benefit ratio for a community is attained. The various characteristics of a site (e.g. present land use, slope, water availability, distance to employment, development costs, surface water quality, urbanization, slope, landscape quality etc...) influence its suitability for a specific land use. A scoring and weighting system can be applied to the various aspects of suitability to assess the overall suitability for a specific land use (Hazrat, 2019). According to the Arba Minch town municipality report the dominant green spaces available in the town are unplanned left over spaces which are reserved for future settlement programs. In the town priority is given for urban expansion than urban greening and majority of the investment of the town administration goes to housing expansion. Left over spaces are now become places of solid waste disposal which in turn affect the heath of the peoples in the town. Even different green areas found in the peripheral area of the town are rigorously depleted in seeking of hosing expansion for growing population. This makes the town climate to get worse (Wonbera, 2019). This indicates that there is a need for the development of urban green spaces such as large urban parks, area closure, public green spaces and others so as to keep the urban environment balanced with disturbances resulted from different sources (Weldegebrieal, 2013). The major purpose of this study were to identify the potential value of remote sensing and GIS techniques in selecting suitable site for urban green space system using different variables, so as to answer question of**:** Where is the suitable area for UGS using distance to the main river parameter? Where is the suitable area for UGS using land use land cover of the study area? Where is the suitable area for UGS using distance to road and slope parameters? And how are overlay of all single factor maps processed to generate the suitability map of urban green space system in the study area. The studies were carried out in Arba Minch town, Ethiopia in the year of 2019.

MATERIALS AND METHODS

Study Area

Arba Minch town is one of the rapidly growing urban areas of Ethiopia. It is located in the Southern Nations, Nationalities and Peoples Region at about 505 km south of Addis Ababa (the capital city of Ethiopia) and 275km of Hawasa (the capital of the regional state). Currently the town is serving as the capital of GamoZone. The geographical location of the town extends from 5˚8’26”N to 6˚3‟22”N and 37˚32‟13”E to 37˚36‟20”E as the grids levelled in Fig. 1. The elevation of Arba Minch ranges between 1100 and 1350meter above sea level in altitude which makes the town one of the lowland places of the country (Wonbera, 2019).

The procedure used in the current study is stated in Fig. 2, which is beginning from the acquisition and classification of multi-temporal satellite image of the study area to the extraction of the required

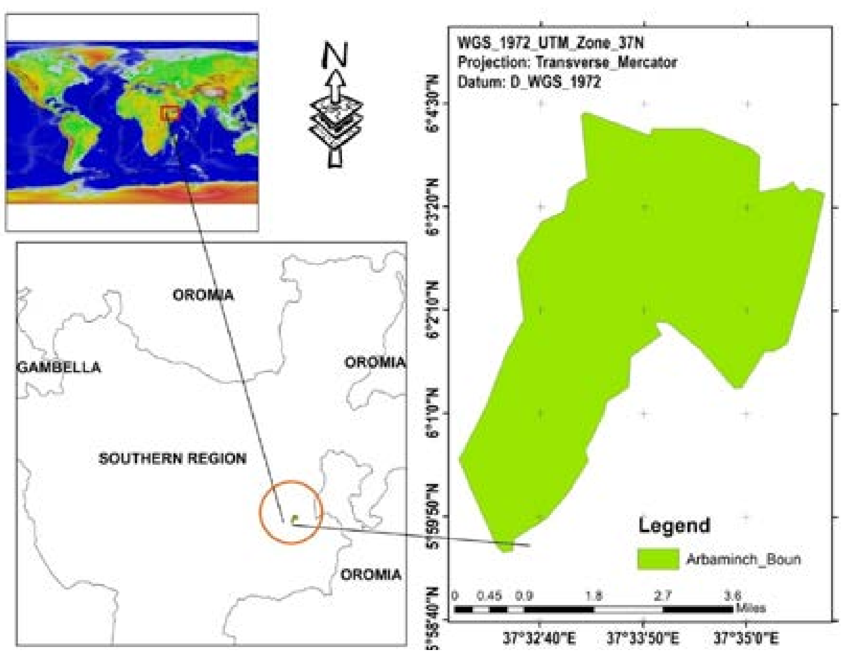

Fig. 1: Locational Map of the study area

suitability site selection. Both quantitative and qualitative research designs were employed in this study. So it was mixed type of research. Difficulties to come with successful result with a single research design, the primary and secondary data to be used in the study were analysed in both research design methods (qualitatively and quantitatively). The study employed judgmental sampling. The reason why the researcher uses this technique were since it is based on the researcher decision, since the issue of urban green space is mostly known by environmentalist and urban planners, this study by applying this method and selected ten sample respondents (six environmentalist and four urban planners) and they were interviewed to rate the suitability factors urban green space. To achieve the stated objectives both primary and secondary data were collected from various data sources. The primary data for the study were collected from ground truth data, key informant interview, and field observation while secondary data was collected from reviewing documents, books, internet and other related written materials obtained from governmental and non-governmental institutions. And AHP ranking method which was developed by saaty (1987) were used to rank as it is described in Table 1.

Slope was extracted from DEM data of 20 m spatial resolution. The analysis of slope was based on surface analyst of Arc GIS spatial analyst tool box. Classification followed by reclassification was done in the software. And the Land Use Land Cover (LULC) factor analysis was based on the acquisition of Landsat images. This was followed by image analysis for specifying the LULC classes of the study area based on the GPS points for classification. For compatibility of this data with other maps, standardization using reclassification method from spatial analyst of Arc GIS environment are used. Distance to the road and distance to the main river were analysed using road and river exported from the master plan of study area. Buffering technique was done followed by masking at the extent of the study area after rasterization depending on the distance set. Reclassification was applied to analyse the suitable sites. Traditional methods of GIS site selection are based on the transformation of effective layers into a classified map, such as using a Boolean model or Index Overlay operations. Nowadays, the GIS approaches used in

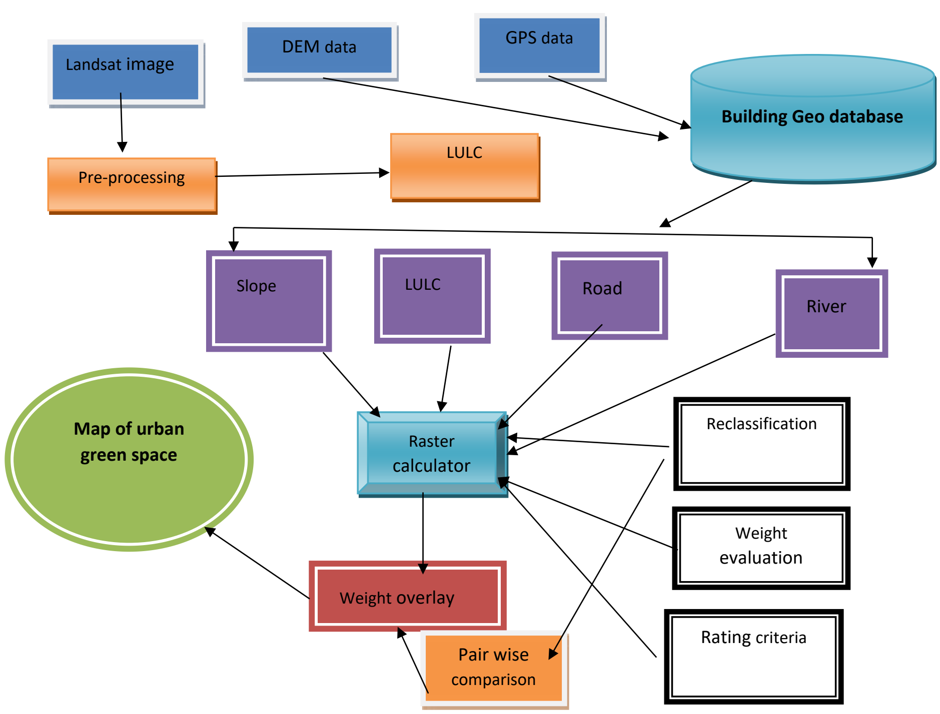

Fig. 2: Flow Chart Illustrating the Process of Digital Image processing

Table 1: Sample of AHP rating of factors for urban green space suitability by experts

Factors	LULC	Slope	River	Road
LULC	1			
Slope		1		
River			1	
Road				1

the site selection usually are network analysis, spatial analysis, proximity analysis, MCA with AHP, FAHP or ROM, etc. (Lina and Wu, 2012). In the case of this study, GIS-based MCA with AHP wins the bidding. GIS-based MCA includes two essential parts: factor criteria and constraint criteria. Each of the criteria is appeared as a map layer, no matter for factor or constraint criterion. Factor maps are represented as spatial distributions to display the opportunity criteria and the quality of achieving an objective. Constraint maps are limitations or restrictions which prohibit certain elements to be taken into account the analysis (Malczewski, 2006). Correspondingly, the GIS-based MCA includes two major methods: weighted summations procedures and Boolean overlay operations. As for the weighted summations procedures, the weighted linear combination of factor criteria is shown as Eq. 1

$$S = \Sigma\ w_i f_i \quad (1)$$

Where, S = Suitability to the objective being considered,
w_i= Weight of factor i [the sum of all weights equal 1],
f_i = Criteria score of factor i.
As for the Boolean overlay operations, the formula for the constraint criteria is depicted in Eq. 2

$$C = C_1 * C_2 * \ldots * C_n \quad (2)$$

Where C = Integrated constraint
C_n = Criteria score of constraint n

After the factor criteria and constraint criteria being settled separately, the GIS-based MCA process integrates them together by multiplying S with C, and gets the final result. But in this research the first method of MCEA were applied. GIS-based MCA has been widely used in various studies, especially in the resources allocation and land suitability evaluations (Lina and Wu, 2012). When all kinds of ecological factors' influences on the specific land use are very obvious, it can't make a direct overlay to get the composite suitability. It must take advantage of the method of weighted score. The principle of this method is similar to that of the equal-weight summation. The difference is that it needs to identify each factor's relative importance (weight) in the weighted score. Saaty (1987) has shown that this weighting of activities in MCDM can be dealt with using a theory of measurement in a hierarchical structure. The analytic hierarchy process (AHP) is a comprehensive, logical and structural framework, which allows improving the understanding of complex decisions by decomposing the problem in a hierarchical structure (Al-Shalabi *et al*., 2006). The incorporation of all relevant decision criteria, and their pair wise comparison allows the decision maker to determine the trade-offs among objectives. The AHP allows decision-makers to model a complex problem in a hierarchical structure showing the relationship of the goal, objectives (criteria), sub-objectives, and alternatives. Uncertainties and other influencing factors can also be included. It is not only supports decision makers by enabling them to structure complexity and exercise judgment, but also allows them to incorporate both objective and subjective considerations in the decision process saaty (1987) as cited in Al-Shalabi *et al*., (2006).

RESULT AND DISCUSSION

Problems existing in the green space system

Public green space are not uniformly distributed in the town in addition to this greening rate is relatively low in contrast to numerous population in the urban centre. And some of the parks are not well protected from external influence. There is no uniform distributed park system integrated with large scale parks, middle scale parks and small scale parks. The ecological diversity is poor it lacks science and rationality to distribute the parks. That is more and more green areas are continuously replaced by other commercial land use every year. In the study area, one of the urban construction emphases is to improve the environmental quality in the residential areas and the work unities. However, now it only focuses on the housing construction, regardless of the residential green spaces. Particularly residential greening is the weakness in the urban centre. So, greening rate of residential districts and work units is relatively low in the study area. Moreover, the quality and management of residential green space are not very good (Xiao, 2009).

Suitability analysis of green space system based on GIS

Stakeholder analysis for suitability

Stakeholders are those whose interests are affected by the issue or those whose activities strongly affect the issue. Stakeholder Analysis is a vital tool for identifying those people, groups and organizations who have significant and legitimate interests in specific urban issues. Clear understanding of the potential roles and contributions of the many different stakeholders is a fundamental prerequisite for a successful participatory urban governance process, and stakeholder analysis is a basic tool for achieving this understanding (Hemmati, 2002). As such, two group stakeholders are involved in the analysis. Six urban planners and environmentalist, who has experience in UGS, were invited for in-depth interview. This group provided the most vivid interview, mostly about the potential for the development of tourism and the problems existing in the green space system. Four urban planners acknowledged that a suitable green space system could not only play an ecological role, but also attract more tourists just because of its rational layout and high landscape quality. But two planners only concerned about the ecological benefits of urban green spaces. They felt the most important was that green spaces can effectively clean air, improve urban climate and eliminate noise, and social benefits such as improving landscape quality, historic culture value and economic benefits were not very important. Overall, the group accepted the comment that the problems existing in the green space system were because it was not systematically planned and the number of green spaces was not enough. The other and the main reason according to the group were high in-migration of the peoples form the surrounding *areas* which makes urban greening to shrink since they need housing to live in and this land can be get from the peripheral part of the town, in this areas forests are the dominant land covers which will be deforested for settlement. So, urban planners had the responsibility to solve these problems by planning a suitable green space system. The group of environmentalists comprised four individuals. They were mostly concerned about the pollution being generated by degrading the urban environment; the existing green spaces were not enough compared with the fast increase of urban population. If possible, urban green spaces can be expanded at the expense of other land uses, as long as they can play an ecological role to the urban environment.

Current land use land cover of the study area

A modern nation, as a modern business, must have adequate information on many complex interrelated aspects of its activities in order to make decisions. Land use is only one such aspect, but knowledge about land use and land cover has become increasingly important as the Nation plans to overcome the problems of haphazard, uncontrolled development, deteriorating environmental quality, loss of prime agricultural lands, destruction of important wetlands, and loss of fish and wildlife habitat. Land use data are needed in the analysis of environmental processes and problems that must be understood if living conditions and standards are to be improved or maintained at current levels (James *et al.*, 2001).

The current land use land cover of the study area falls in five classes shown in Fig. 3 they are urban agriculture, forest, built- up area, banana plantation and barren land. The majority of the study area is covered by built-up areas which accounts 1666 ha of the total area. In decreasing order of the share of the coverage banana plantation come next, urban agriculture, barren land and forest which account969, 385,237 and 37 hectare respectively.

Green space site selection factors in the study area

Land Use Land Cover /LULC/ suitability

This suitability classes of LULC of the study area was done in two three classes this are high suitability, moderate suitability and no suitability. The study area was classified in two five land use land cover classes. This are urban built ups, urban agriculture, banana

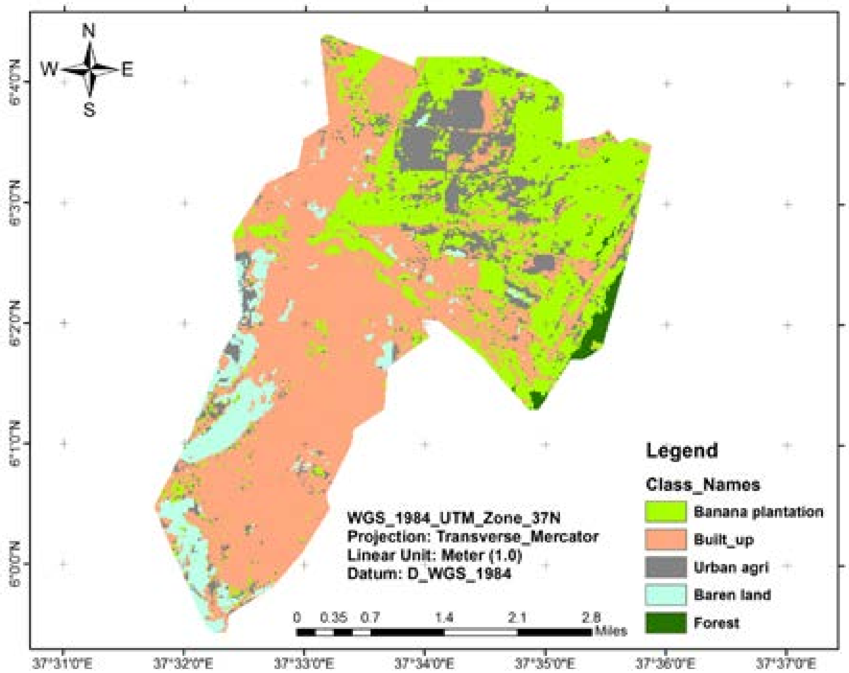

Fig. 3: Map of 2017 land use land cover of the study area

plantation, barren land and forest. This land use and cover classes are classified in to three suitability ranges in terms of their importance for urban green space site suitability analysis. In their suitability level, banana plantation is categorized under high suitability class; while urban agriculture, forest and barren land area categorized under moderate suitability classes and the remaining land use class that is built-ups are perceived as no suitability for urban green space site selection (Li *et al*., 2018). As shown in Fig.4 land use land cover suitability, areas in which built up land use classes are not suitable for urban green space, so the central area of the town are not suitable for urban green space since most of the town built ups are concentrated at the centre of the town. The moderately suitable areas are urban agriculture areas, forest areas and barren lands. The other areas of the town which are found in the peripheral part of the town are very suitable for urban green space since this area is mostly covered by banana plantation and this is very suitable for urban green space. So considering LULC suitability in the town the green areas should be located outside of the built up areas, that means one has to think the peripheral (remote) and near the central areas to site urban green space. According to the interview with the urban planner the built- ups are left with no suitability because the town was not planned, which is constructed randomly with no plan in the past, so it needs compensation for the peoples to make urban green space on behalf of the built-ups which is difficult for the municipality.

The percentage share show that 29.4 % of the total area are categorised as high suitability because this area is covered with banana plantation and this land cover type is highly suitable according to James *et al*., (2001) and 20.1 % of the area are moderately suitable and this land is covered by urban agriculture, forest and barren land. The remaining 50.5 % of the land is totally not suitable for urban green space this is mainly due to the land is covered by built-ups. Now a day, the municipality of the town also gives expansion of housing for the rapid population growth. So emphasis should be given for urban green space also since the expansion of built-ups is mainly done on behalf of the extinction of forests which are moderately suitable for urban green space.

Slope suitability

Slope is the measurement of the rate of change of elevation of the land per unit distance. This slope data

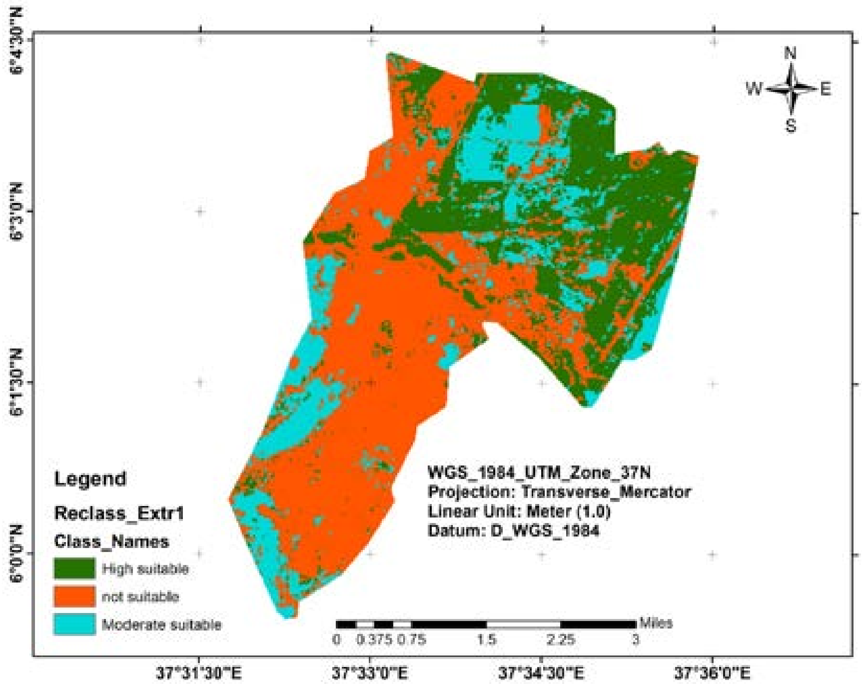

Fig. 4: Reclassified map of land use land cover factor

was generated from DEM with the spatial resolution of 20 meter. According to Manlun, (2003) the range suitably lies in to three classes. That is slope from 0-5 is categorized as high suitability, slope from 5-15 in the other way categorised as moderate suitability and slope which is above than 15 are no suitability and not recommended for urban green space development. On behalf of this standards majority of the study area falls suitable. Most part of the central as well as the peripheral part of the study area slope is categorized in suitable class for urban green space development. Fig.5 shows the suitability of slope for urban green space development. From the total area around 25 km2 of the area is categorized under high suitable and moderate suitability. The remaining 8 km2 is the only slope which is not suitable for urban green space development.

Distance to the main river suitability

Arba Minch has one major river which falls all year round. The suitability levels of distance to the main river were done within three ranges of suitability classes. Areas within the buffer of 250 m from the river is in the suitability range of high, areas between 250m and 750 m are moderately suitable and above 750 m from the main river are not totally suitable for urban green space (Manlun, 2003). The main rivers of the town were exported to shape file from the master plan of the study area. Buffering in to different distance followed, after this reclassification to different range of suitability classes was done. According to the reclassified data the central part of the town in which the river *Kulfo* flows is highly suitable for urban green space as shown in Fig. 6. From the field observation data the researcher found one public recreation area near the *Kulfo* River.

The calculated area shows 15.2 % is suitable for urban green space. Since this areas are not far more than 250 m from *Kulfo* River. And the other 48.3% of the area falls in the suitability range of moderate suitability. This range of suitability is in the distance between 250 m to 750 from the main river of the town. The remaining 36.5 % in the graph below is not suitable for urban green space and since this area is far more than 750 mater from the main river. According to (Manlun, 2003), areas which are far 750 meter away from the main river are categorized as no suitability.

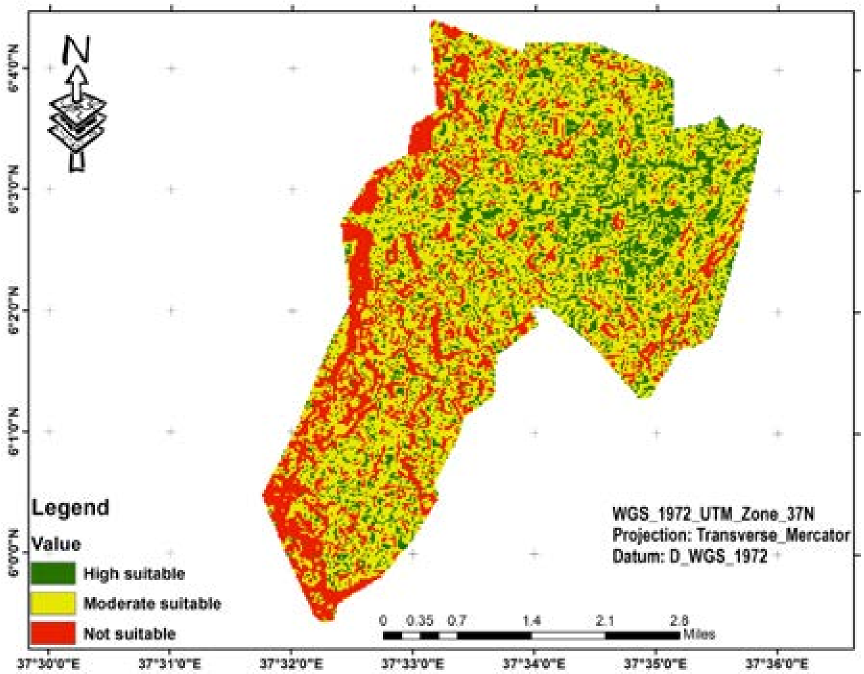

Fig. 5: Slope suitability analysis results

Distance to road suitability

English Nature believes that local authorities should consider the provision of natural areas as part of a balanced policy to ensure that local communities have access to an appropriate mix of green spaces providing for a range of recreational needs. English Nature recommends that provision should be made of at least 2ha of accessible natural green space per 1000 population. No person should live more than 300m from their nearest area of natural green space. Thus taking this data in to account areas with the buffer of 300m form the main road is considered as high suitability. And between 300m-600m buffer distance are considered as moderately suitable areas and greater than 600 m are not suitable for urban green space according to English nature. The major road of the town was exported to the shape file in Arc GIS from the town master plan of the town. After this multiple ring buffering followed and the major road buffering done with three ranges of suitability classes. That is areas within 300 m form the main road and between 300m to 600m and above than 600m. After multiple ring buffering technique has got over, rasterization by distance followed and masking to the shape of the area were done. The last step was reclassification of the buffer road on the bases of the criteria which was set by English nature. Areas within 300m are high suitable between 300 to 600m are moderate suitable and above than 600 m are classified as permanently not suitable for urban green space site selection (Fig. 7). So, on the base of this data most areas of the town in which this road falls are highly suitable within 300 m distance from the road in any direction. So remote (peripheral) part of the town are not suitable for urban green space this is mainly due to absence of major roads on such areas and there remoteness from the major road of the town since it is above 600 m form the main road (Badri and Houssaini, 2012).

Considering distance to the main road factor, 40.6% of the land is highly suitable for urban green space and 25% of the land is moderately suitable and 34.4 % of the land is not suitable for urban green space since these areas are found far from the main road. So a total of 65.6% of the area is suitable for urban green space.

Weight results

In order to apply multi criteria evaluation (MCE), a set of relative Weight was assigned for each variable

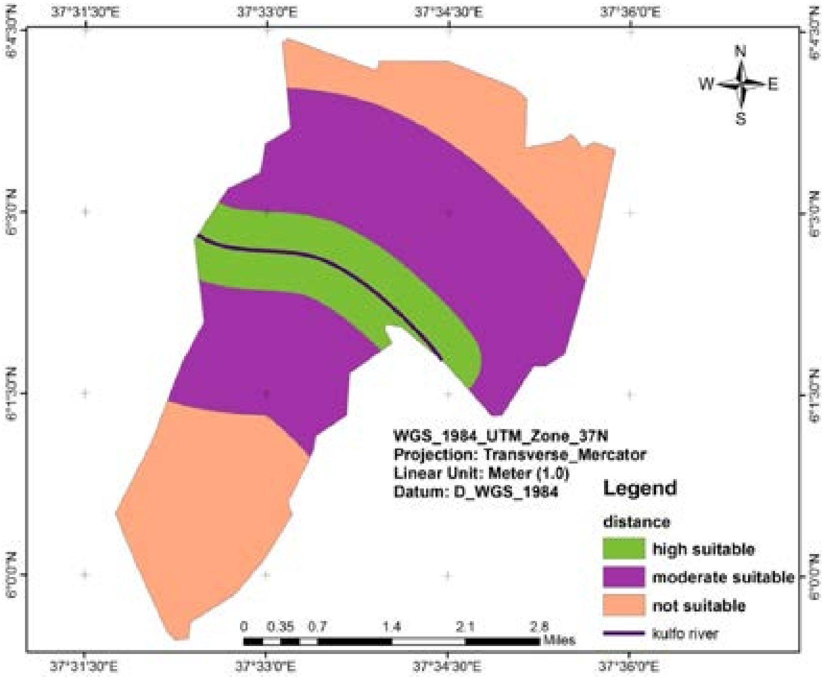

Fig. 6. Reclassified distance to the main river suitability factor

using weight module of IDRISI Andes software. The procedure was followed using continues rating scale developed by saaty (1987) The weights calculated for each variable were the results of pair-wise comparisons of each variable based on the relative importance for urban green space suitability. The ranks of the factors were done by experts, and based on the rank given by the experts IDRISI Andes were used to weight this ranks. The ranks are given by the experts as shown in the Table 2.

As shown in the Table 2 which is ranked by experts, river is considered as the first principal for urban green space site suitability, road as the second factor, slope and LULC were considered as the third and the fourth respectively. So, on the bases of the ranks given by the experts the highest value was calculated for river which is 51.28%. The consistency ratio of the matrix was acceptable which 0.005. Consistency Ratio (CR) is used to measure how consistent the judgments have been relative to large samples of purely random judgments. If the CR is much in excess of 0.1 the judgments are untrustworthy because they are too close for comfort to randomness and the exercise is valueless or must be repeated.

The overall suitability analysis for the potential of urban green space development was then made by overlaying each of the suitability intermediate factor maps. The Weighted Overlay tool applies one of the most used approaches for overlay analysis to solve multi-criteria problems such as site selection and suitability models (Lina and Wu, 2012). The Weighted Overlay tool used to implement several of the steps in the general overlay analysis process within a single tool.

The tool combines the following steps:

- Reclassifies values in the input raster into a common evaluation scale of suitability or preference, risk, or some similarly unifying scale
- Multiplies the cell values of each input raster by the weight of importance
- Adds the resulting cell values together to produce the output raster

In a weighted overlay analysis, each of the general overlay analysis steps is followed. The respective eigenvector weight for LULC, slope, river and road is calculated as it is shown above in Table 3. So the final suitable map can be obtained by multiplying this eigenvector weight by each of the factors and adding this all factors and this were done in raster calculator.

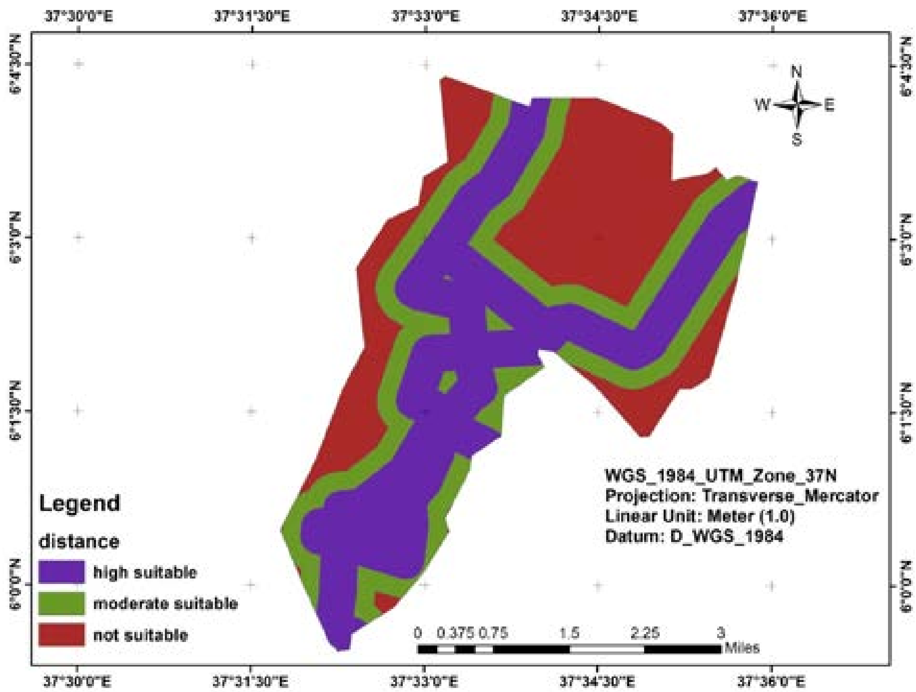

Fig. 7: Reclassified map of distance to the main road factor

Table 2. Compared and rated relative importance between row and column variables for UGS using the Pairwise Comparison Nine Point continuous rating scale

Factors	LULC	Slope	River	Road
LULC	1			
Slope	3	1		
River	7	5	1	
Road	5	3	1/3	1

In the raster calculator the weighted eigenvector for each factor multiplied by its corresponding classified factors and summing up of each factors were done.

*Final urban green space map = 0.0634 * "classified map of LULC" + 0.1290 * "classified map of slope" + 0.5128 * "classified map of river" + 0.2615 * "classified map of road"*

So based on the above formula it was written as the software understands in the raster calculator. The Raster Calculator tool allows creating and executing Map Algebra expressions in a tool. Like other geo-processing tools, the Raster Calculator can be used in Model Builder, allowing the power of Map Algebra to be more easily integrated into workflows in addition to this; Raster Calculator is designed to execute a single-line algebraic expression using multiple tools and operators using the calculator tool interface. As the experts rate distance to the main river as the highest which accounts around 51 % of the other factors (Table 3), this is high suitable area of urban green space goes in line with the direction of the river. The high suitable area for urban green space based on distance to the main river is Less than250m buffer, and the overall weighted overlay map of the study area shows the high suitable area of urban green space is concentrated in line with this factor. Since this factor has got 51% of weight by the experts. The effect of distance to the road is also visible especially in the north eastern and north western part of the study area. Road parameter has got rank of the second next to distance to the main river which

Table 3. The weight of factors calculated for urban green space suitability map

Factors	LULC	Slope	River	Road	Weight	Weight (%)
LULC	1				0.0634	6.34
slope	3	1			0.1290	12.90
river	7	5	1		0.5128	51.28
Road	5	3	1/3	1	0.2615	26.15

Consistency ratio = 0.05

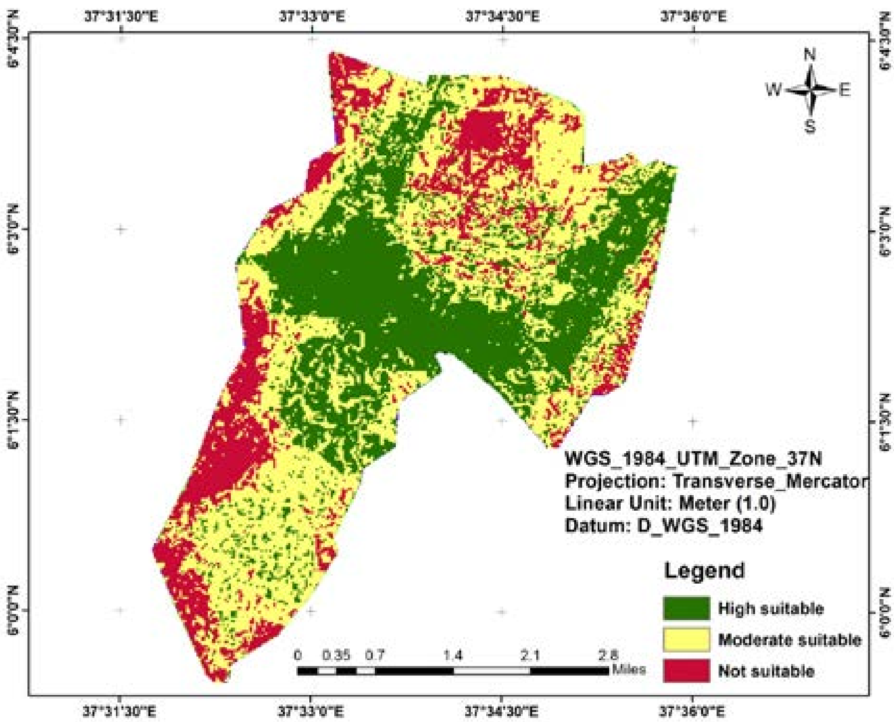

Fig. 8: Final weighted overlay map of suitability ranges of urban green space of the study area.

has a weight of 26%. So more than 75% of the overall weighted overlay map of the study area suitability for urban green space is determined by this two factors. The same is true for moderate suitability of weighted overlay map. As shown in the Fig. 8, the yellow colour indicates the moderate suitable area. It goes in line with the distance to the main river factor suitability. In the other way areas which are not suitable for green space are dispersed in the whole study area. But it is mostly concentrated in the built-ups and according to (James *et al*., 2001) these built-ups are not suitable for urban green space.

The result of weighted overlay map was done to see the percentage of the range of suitability factors. The high suitability accounts 36.3 % of the total area, 45.5 % of the area is moderate suitability and the remaining 18.5 % of the study area is left which is not suitable for urban green space. In the same way this area is not suitable in the final weighted overlay map of the study area. Generally 81.8% of the study area has potential for green space development.

CONCLUSION

Urbanization remains a single predominant factor that is continuously linked to the destruction of urban green spaces. In Ethiopia, urban green areas have been consumed by industrial, commercial, residential and infrastructural developments, as well as by spontaneous and illegal settlements along mountain slopes, river valleys and other open spaces. However, following the Rio Summit held in Brazil in 1992, Ethiopia took a number of initiatives to address its environmental problems, including minimizing environmental impacts induced by the urbanization process. In Arba Minch town, some green spaces are being converted to the other land uses every year. This has caused some serious environmental consequences, increased soil temperature, local climate change, instability in hydrological regime and loss of important specious and all of which ultimately have negative effect on ecological environment and human settlement. So selecting suitable site for green space system by considering four environmental and socio economic parameters that is slope, land use land cover, distance to the Main River, and distance to road infrastructure are very essential for the study area. Different data, materials and software's were employed to generate suitable green space site for the study are. To produce suitable site for green space system in the study area four parameters are considered. These are slope, land use land cover, distance to the main river, and distance to road. After identifying all the parameters the next step were to go through with different data processing and analysis methods. As the expert's rate distance to the main river as the highest this accounts around 51 % of the other factors. This s high suitable area of urban green space goes in line with the direction of the river. The high suitable area for urban green space based on distance to the main river is Less than250m buffer, and the overall weighted overlay map of the study area shows the high suitable area of urban green space is concentrated in line with this factor. Since this factor has got 51% of weight by experts. The effect of distance to the road is also visible especially in the north eastern and north western part of the study area. This road has got rank of the second next to distance to the main river which has a weight of 26%. So more than 75% of the overall weighted overlay map of the study area suitability for urban green space is determined by this two factors. On the basis of the findings and conclusion drawn with respect to suitable site selection for urban green space development using geographic information system and remote sensing multi criterion analysis, the following recommendations are identified.

- ✓ It's better if the urban green space of the town goes in line with the river *kulfo*, the software result shows that as well there will be a chance of getting water from the river all year round.
- ✓ One of the main cause for diminishing of urban green space is high migration from the surrounding *kebeles* to the study area, so the concerned body needs to give due attention for illegal settlements especially in the peripheral part of the town.
- ✓ It will be good other studies incorporate soil as one factor in selecting urban green space.

AUTHOR CONTRIBUTIONS

B. A. Hailemariam performed conceptualization, methodology, literature review, manuscript preparation, writing original draft preparation, writing reviewing, and editing references and did all the software tasks.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy has been completely observed by the authors.

ABBREVIATION

%	Percent
AHP	Analytical Hierarchy Process
CR	Consistency Ratio
DEM	Digital elevation model
GPS	Global positioning system
LULC	Land use Land cover
MCA	Multi criteria Analysis
MCE	Multi criteria evaluation
UGS	Urban Green Space
USGS	United States Geological Survey

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