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SPATIAL LOCATION OF SUITABLE PLACES FOR WATER DISTRIBUTION FACILITIES IN KHULNA CITY, BANGLADESH: APPLICATION OF GIS

Md. Nazmul Haque[1] and Md. Mustafa Saroar[2]

[1]Department of Urban and Regional Planning, Khulna University Engineering & Technology, Khulna-9203, Bangladesh, e-mail: nhaque.kuet13@gmail.com
[2]Professor, Department of Urban and Regional Planning, Khulna University Engineering & Technology, Khulna-9203, Bangladesh.

ABSTRACT

This study helps to find suitable location for water distribution facilities in Khulna city. For adopting the objective this research determined the demand of water supply system in Khulna city and planning of sufficient water supply and distribution location using GIS technique. Three main indicators are selected: (i) Flow Accumulation, (ii) Population density and (iii) Slope of Khulna city for suitability analysis. An increasing demand of water due to population growth and agriculture so proper distribution network system badly needed. Application of GIS in this project will help to planning a sufficient water distribution network. It has been carried out by developing various administrative information in GIS environment. Planning and designing in respective sectors like water distribution network, information of land use and population data has been carried out by using Arc GIS Software. The research suggests that only 2% area within Ward no. 12 & partially 24 are highly suitable for water distribution facilities.

Keywords: *Water supply, Distribution network, Reservoir.*

1. INTRODUCTION

The research will fulfil the agenda to find suitable location for water distribution facilities in Khulna city. Khulna is a low-lying city which has developed in a linear pattern alongside the bhairab and Rupsha Rivers in south western Bangladesh. Khulna is the country's third largest city in Bangladesh and has been known as an industrial city with a port. The whole city area is only 2.5 meters above the mean sea level. Khulna has a history of about one hundred years **(**Islam and Karim, 2006). A large amount of money is invested around the world to provide water supply facilities. Even an enormous population of the world is suffering by inadequate water supply system. Approximately 80% to 85% of the cost of a total water supply system is contributed toward water transmission and the water distribution network (Goulter,1992.) The city is surrounded by lots of industry nevertheless it has plenty of importance for its geographical, political, historical, and financial reasons. The scarcity of water has been increased gradually owing to increasing resettlement from the surrounding districts, for rapid urbanization and industrialization but lack of parallel growth in necessary water supply infrastructure (Islam and Karim, 2006)**.** It is geographic information system (GIS) that is been used for analyzing the data both spatial and attribute. It is convenient to sort out the suitable data from a vast amount of data set using GIS. Geographic information system helps us to analyze all types of data for any purposes.The multi criteria analysis is one of them. The multi criteria analysis helps to find out the suitable places for a desired query.

The outcome of the study shows the demand of the water supply system in Khulna city, existing distribution network of water in the city is not able to distribute sufficient amount of water to every houses in the city. So this study helps to finding suitable location for water distribution to reduce the problem of water supply system as well as minimize the cost. There are 56 production wells and 12000 hand tube wells in Khulna city. The average depth

of the tube well is 270m (IWM, 2011). There are some limitations which should be overcome by this study such as not enough attribute information about existing water distribution system, there is a little provision of criteria for water distribution are found with respect of Bangladesh, so some standards are taken from different country requirement for water distribution properly.

2. LITERATURE REVIEW

For finding suitable location of water distribution system, the existing water distribution system of Khulna city must be known. Existing condition shows that Khulna city water supply system entirely depends on groundwater source. The population of Khulna city is increasing day by day and thus increasing water demand. To meet the future water demand in Khulna city the provision of extension of groundwater development is very limited. Therefore, to fulfil the future water demand it is very essential to find suitable location for water distribution system.

Table 1: Basic Demographic Information

Ward	Pop 2001	Pop 2009	Pop 2010	Pop 2015	Pop 2020	Area(sq.km)
Ward-1	20311	25230	25730	28420	31370	2.227856
Ward-2	18815	23370	23830	26320	29060	2.179358
Ward-3	23016	28590	29150	32200	35550	3.657733
Ward-4	14299	17760	18110	20010	22080	2.034172
Ward-5	15314	19020	19400	21430	23650	0.775361
Ward-6	20995	26080	26590	29370	32430	2.159462
Ward-7	14808	18390	18760	20720	22870	0.471743
Ward-8	18545	23030	23490	25950	28640	0.943937
Ward-9	34614	42990	43850	48430	53460	3.540127
Ward-10	18518	23000	23460	25910	28600	0.809781
Ward-11	19398	24090	24570	27140	29960	0.364905
Ward-12	52036	64630	65910	72800	80370	0.659046
Ward-13	19959	24790	25280	27920	30830	1.119565
Ward-14	26444	32840	33500	37000	40840	2.691663
Ward-15	25724	31950	32580	35990	39730	1.659229
Ward-16	35881	44570	45450	50200	55420	2.253474
Ward-17	30352	37700	38450	42470	46880	2.298736
Ward-18	16765	20820	21240	23460	25890	1.617838
Ward-19	26321	32690	33340	36830	40650	0.492191
Ward-20	22539	27990	28550	31530	34810	0.499665
Ward-21	24984	31030	31650	34950	38590	1.725098
Ward-22	21633	26870	27400	30270	33410	0.825691
Ward-23	18332	22770	23220	25650	28310	0.510105
Ward-24	42959	53360	54420	60100	66350	1.678222
Ward-25	27106	33670	34340	37920	41860	0.762184
Ward-26	18087	22470	22910	25310	27930	0.664920
Ward-27	31489	39110	39890	44060	48630	0.811904
Ward-28	22404	27830	28380	31350	34600	0.735918
Ward-29	20431	25380	25880	28580	31550	0.659339
Ward-30	35827	44500	45380	50130	55330	1.320933
Ward-31	32592	40480	41290	45580	50350	3.902639

Table 1 shows the population wise data of KCC and the area of each ward. Demand of safe water of the people should increase with the increase of population. As a general rule, a goal must be: S M A R T

(Specific – measurable – attainable – relevant – time-bound)

The aim of the study is to identify the suitable location for the water distribution system in Khulna city, Bangladesh. Through investigation by GIS and decision making process is done.

3. MATERIALS AND METHODS

3.1 Study Area

Khulna city was selected as the study area. Khulna is a low-lying city which has developed in a linear pattern alongside the Bhairab and Rupsha Rivers in south western Bangladesh.

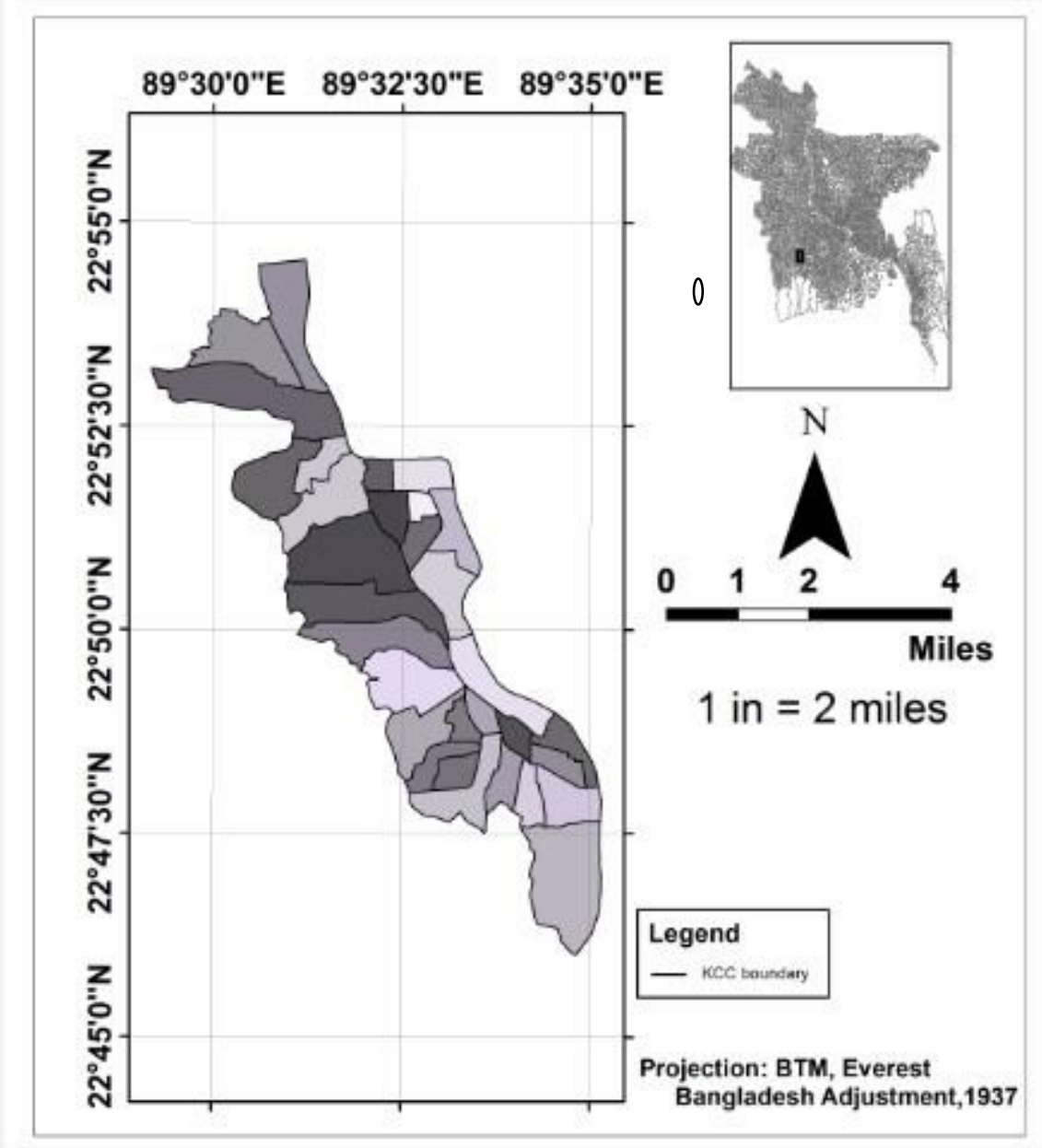

Figure 1: Study Area (KCC), Author 2017

Khulna is the country's third largest city in Bangladesh and has been known as an industrial city with a port. The whole city area is only 2.5 meters above the mean sea level. Khulna has a history of about one hundred years(Islam and Karim, 2006).

Khulna was declared a municipality in 1884, became a railway link in 1985, district headquarters in 1961, and a city corporation in 1984. The linkages of Khulna city with other towns and growth centers can make it a most important city.

3.2 Criteria Selection

The criteria standards are taken from the GIS analysis of KCC boundary and spatial data. The divisions of the classes are randomly taken on the basis of the data by analysing the highest and the lowest value are observed from the study

Table 2: Criteria Selection

Criteria	**Suitability classes**		
	Highly suitable (3)	Moderately suitable (2)	Less suitable (1)
Flow accumulation	3227 to 6453	851 to 3227	0 to 851
Population	4146 to 6089	2183 to 4146	230 to 2183
Slope (mm)	2440 to 3660	1220 to 2440	0 to 1220

Source: Expert opinion Survey, 2017

Here the suitability classes are classified on the basis of Author's calculation from the data collected. Three equal interval value are taken to identify the classes. For weighing the criteria's (%) of influence also setting up on the basis of expert opinion survey that what (%) may be given for each factor.

Table 3: Weight of Criteria's

Criteria	**(%) influences**
Flow accumulation	20%
Population	50%
Slope	30%

Source: Expert opinion Survey, 2017

As the influence of population is very high in any spatial planning, the value of % influences are high than any other Criteria. Here the influences are taken randomly on the basis of traditional thoughts.

3.3 Ranking

The ranking are done here on the basis of preliminary investigation where 1 shows the least important, 2 shows moderate important and 3 shows the most important class. At last the suitable locations are selected for the proposed water distribution. Expert opinion survey was done to get the sequence of ranking of the suitability.

4. RESULTS AND DISCUSSION

In this section there are different types of DEM are used for the analysis of the suitable location for water distribution. Three types of map are produced to identify the most suitable location for each criteria. From the map the most suitable, less suitable and the moderately suitable sapatial location are marked and further investigation are done to select the overall suitable place for water distribution facilities in Khulna city. Then the zonal districts was calculated from the map to determime the percentage of each portion.

4.1 Population Map

Here the population concentration map was generated by using the spatial and attribute data. The map shown that the maximum and minimum concentration of population 72800 and 20010 respectively. The most suitable ward is 24 and partially 12 for performing the concentrated population density in Khulna city. So, this places should be marked to

introduce new water distribution stations to serve the defeciency need of resedential people as Nirala (Wrad 24) is a high class residential area. It is known that where the resedence are higher the need of water is incresing. If the location of the distribution facilites are very close to the densed area or over popuated area it would be more acceptable.

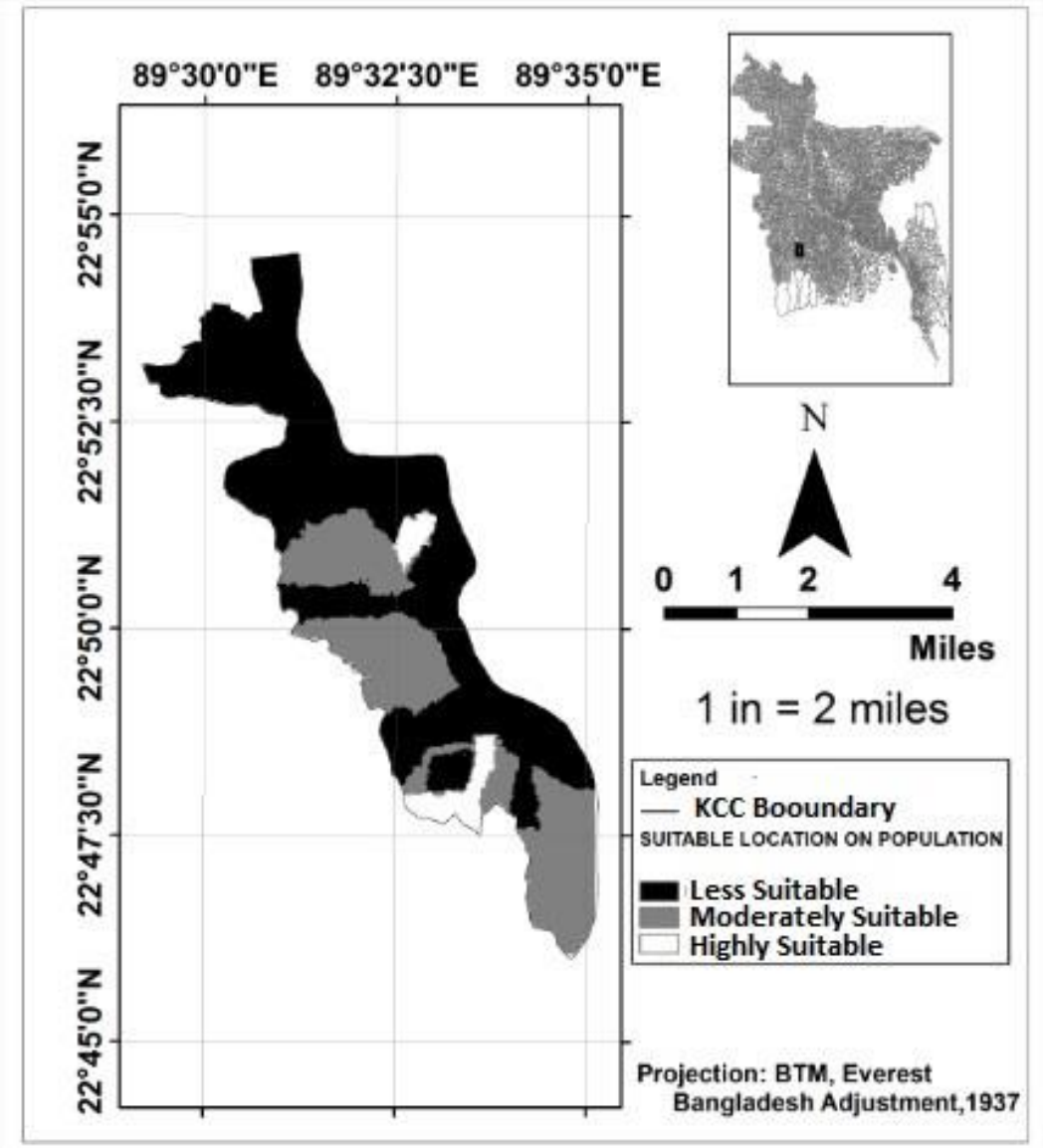

Figure 2: Suitable location on Population Density; Author, 2017

4.2 Flow Direction Map

The flow map shows linear movement between places. As such, they are popular maps to represent migrations, commodity flows, traffic patterns and water movement. Flow maps may be used to show both qualitative data (e.g., connections) and quantitative data (e.g., magnitudes). In qualitative flow mapping, the symbols are of uniform width and typically are arrows. In quantitative flow mapping, the line symbol selected and alters its width based on the data values.When employing this technique, flow lines should be symbolized so they are distinct from the background base map. Use arrows if the direction of the flow is important. Using lines instead of arrows implies that the direction occurs in both directions. Also, place small lines on top of large lines when they overlap.

In the following figure 3 the black coloured area indicates that this areas are less suitable for flow accumulation capacity since the elevation of the area is too high so new water distribution facilities may be established in any other place of white coloured. Generally it is

known that the higher elevation may use to store the water so that water can easily distributed to the locality. The map also indicates that flow of water may prevail much in white portion to other section so it can be easily said that these areas are most suitable to establish new water distribution facilities.

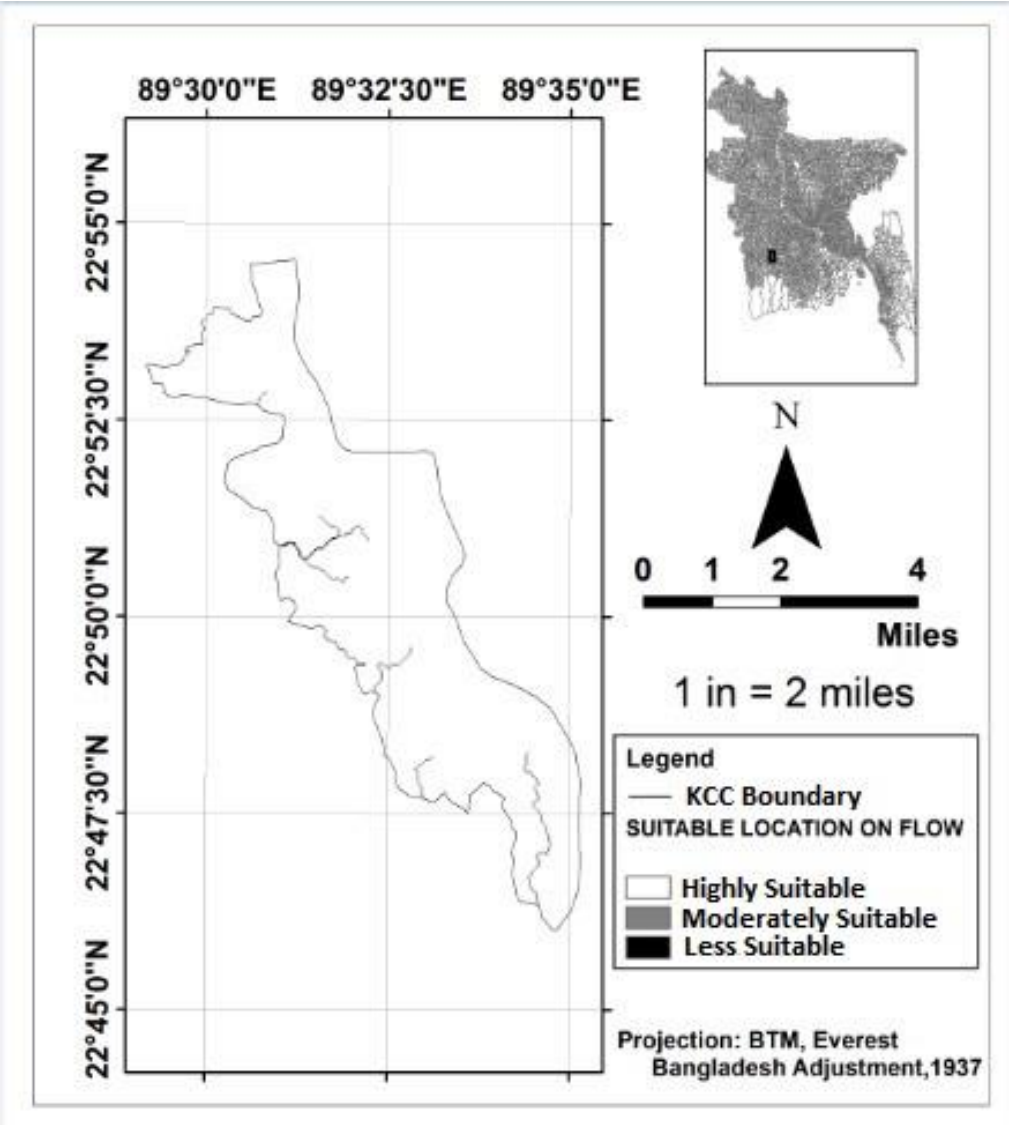

Figure 3: Suitable location onFlow direction; Author, 2017

4.3 Slope Showing Map

Slope is the measure of steepness or the degree of inclination of a feature relative to the horizontal plane. Gradient, grade, incline and pitch are used interchangeably with slope. Slope is typically expressed as a percentage, an angle, or a ratio. To find the slope of a feature, the horizontal distance (run) as well as the vertical distance (rise) between two points on a line parallel to the feature need to be determined. The slope is obtained by dividing the rise over run. Multiply this ratio by 100 to express slope as a percentage.

The highest slope of the area is about 4.70 where the lowest is about – 4.48. Here the less suitable location on the basis of population density shows the highly suitable location for slope identity. So there is a near for introducing a common map where all criteria's should be judged on different influences

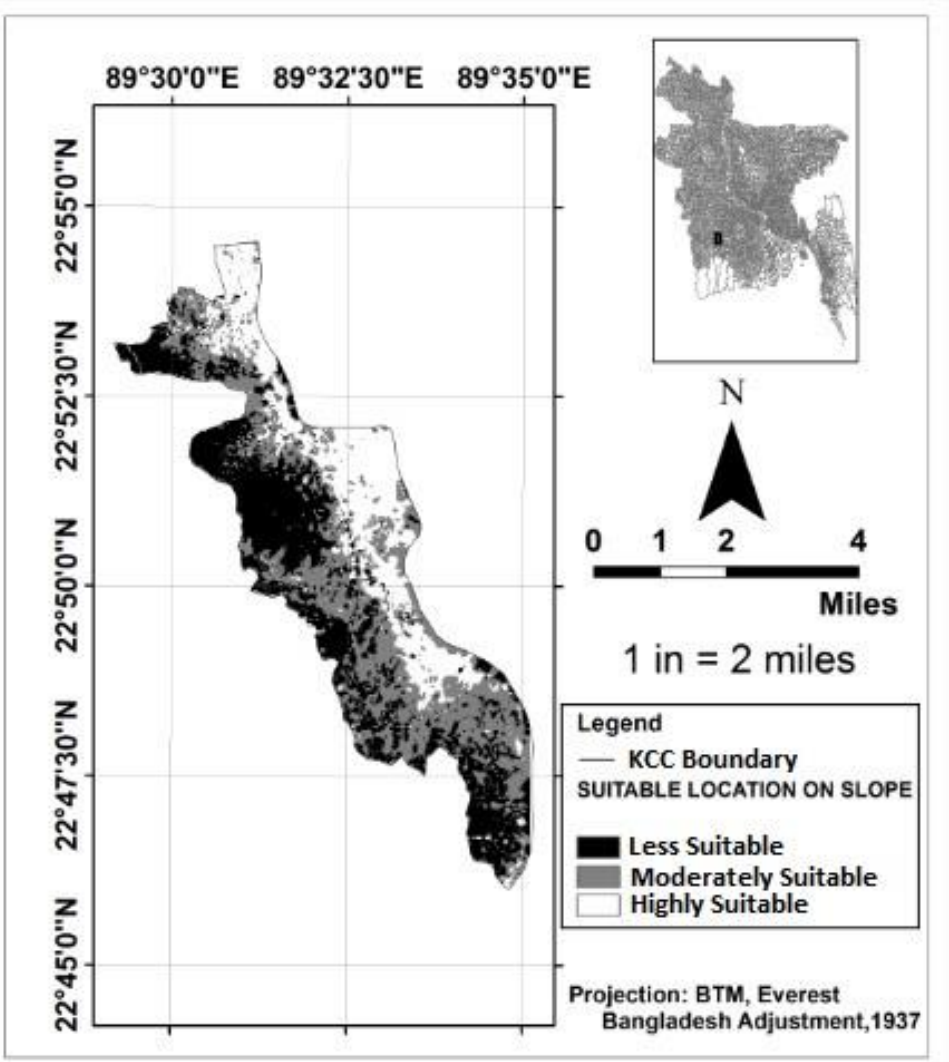

Figure 4: Suitable location onSlope; Author, 2017

4.4 Weighted Overlay Analysis

The three factors used in this weighted overlay analysis, Reclassify from Flow accumulation population concentration, and slope map. Weighted overlay analysis enables factors to be combined and weighted to solve multi-decision problems in this case selecting suitable site for water distribution. The three factors were loaded in the weighted overlay tool by setting the evaluation scale to 1 to 10 to 1 to agree with the reclassification of input to 3 interval classes. These classes were ranked as the high, moderate and less suitable location for siting water distribution. The factors were assigned percentage of influence with Euclidean distance from the slope, flow accumulation and the population concentration and here 30, 20 and 50 percentages was used for the flow accumulation, population concentration and slope respectively. The suitability map was produced from the input as shown in the figure 5 below.

Euclidean distance tools describe each cell's relationship to a source or a set of sources based on the straight-line distance. Second tool is Reclassify .It reclassifies the values in a raster. Here the output of Euclidean distance is reclassify base on established Criteria. Output of reclassify have 3 value one is Less suitable, second is Moderately suitable and other is Highly suitable.

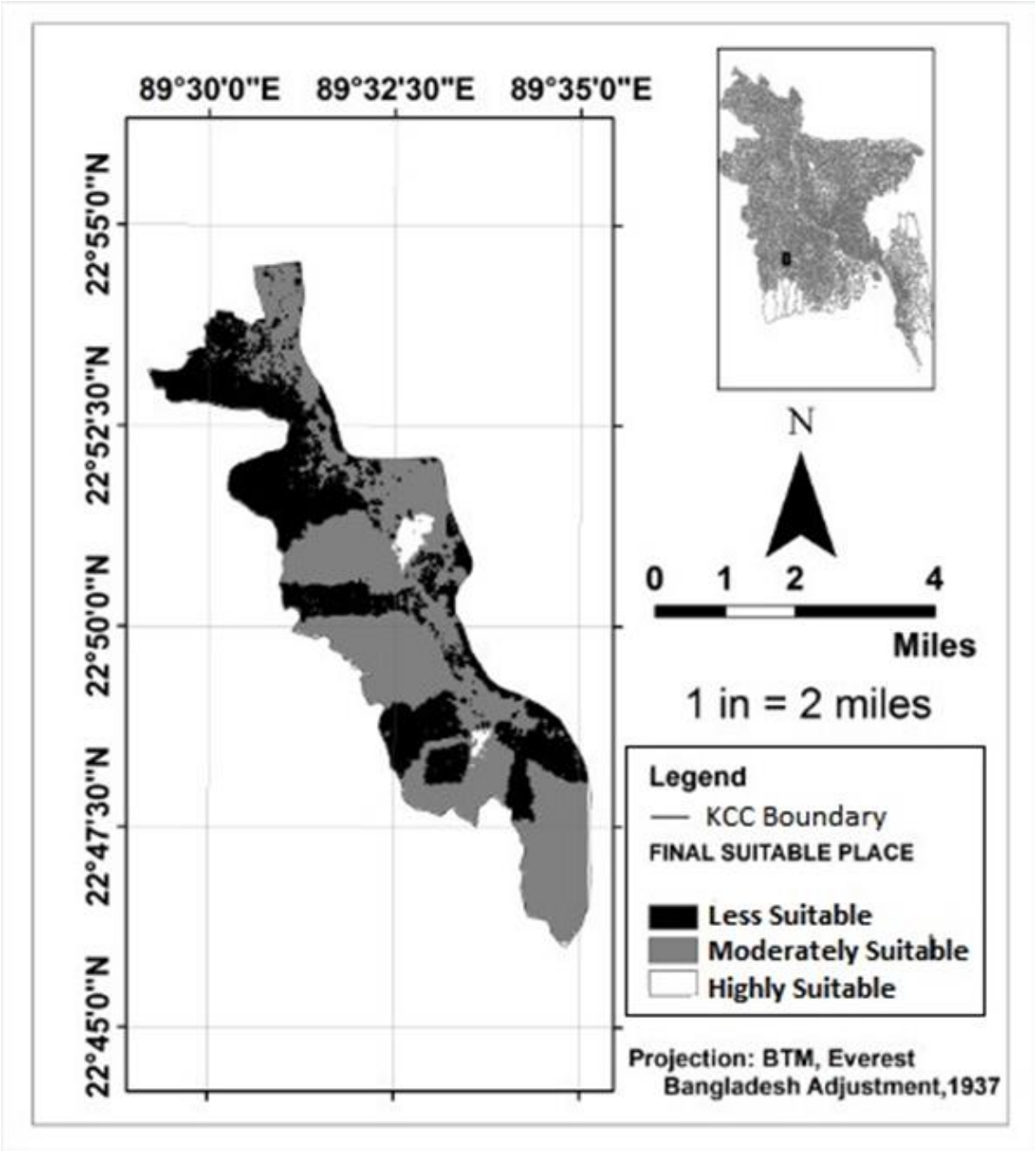

Figure 3: Suitable location for water distribution facilities, Author 2017

5. CONCLUSIONS

The map indicates that black coloured area stands for the less suitable location. That means the water distribution facilities may not give there as the density of population is low as well as low elevated area and flow direction is also not satisfactory.The grey coloured area shows the moderately suitable location for the purpose. Finally the white area is the most suitable for the project area to provide water distribution facilities as the all conditions are satisfied the criteria's. The research suggests that only 2% area within ward no. 12 & partially 24 are highly suitable for water distribution facilities.This kind of study gives knowledge about which involved with their use in each component and be demanding that those components work together, both initially and into the future.

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