**Cloud Publications**
International Journal of Advanced Remote Sensing and GIS
2015, Volume 4, Issue 1, pp. 883-894, Article ID Tech-355
ISSN 2320 - 0243

Research Article | Open Access

# GIS Application to Determine Suitable Sites for Automatic Rice Mills in Joypurhat District, Bangladesh

**Mohammed Aminul Ahesan and Tarmiji Bin Masron**

School of Humanities, Universiti Sains Malaysia, Penang, Malaysia

Correspondence should be addressed to Mohammed Aminul Ahesan, ahesanbd@yahoo.com

Publication Date: 16 March 2015

Article Link: http://technical.cloud-journals.com/index.php/IJARSG/article/view/Tech-355



**Abstract** Determining the optimum locations for automatic rice mills is a critical and complex decision for investors. This decision is an important one because it affects both environmental and financial aspects. This research paper aims to determine optimal sites for setting automatic rice mills in Joypurhat district of Bangladesh considering environmental factors, pre-requisites for running rice mills and paddy production volume in the locality. In the first step the criteria for rice mill site selection are defined and 25 numbers of candidate sites are determined through running a cartographic model, designed for this specific purpose. In the second step 10 numbers of optimal sites are detected amongst the candidate sites by using location-allocation approach.
**Keywords** *Automatic Rice Mill; Cartographic Model; Location-Allocation Approach; Site Selection*

## 1. Introduction

Bangladesh is a densely populated country where about 48% of its rural people depend on agriculture for their livelihood and rice cultivation takes the major part [10]. Bangladesh may be termed as the country of rice growers and rice eaters. Mechanization of rice cultivation particularly minimization of post-harvest losses needs to be considered for combating the future challenges regarding rice issue in Bangladesh [1]. Rice mills for processing paddy into rice are established more or less in each region where paddy is grown. But in many of the cases rice mills are not set up proportionately with the volume of paddy production.

Rice mills produce significant amount of ash as by product, fine dust and odour, these have impact on environment and public health [9]. Considering environmental consequences, rice mills are to be set up at a minimum distance from residential areas so that they do not become hazardous for public health, at the same time maintaining the communication network and electricity for running modern automatic rice mills.

GIS is a useful and important tool which is used for selecting sites to meet up various specific needs. Vector-based methods are most commonly applied to identify suitable sites for different purposes. For example, vector GIS has been used to identify dump sites in Malaysia [12], landfill sites in the United States [4] and Turkey [2], and animal waste application sites in Australia [1]. The vector overlay method is useful in producing a map that differentiates suitable and unsuitable areas.

Selecting sites using a raster-based method in conjunction with the weighted linear combination [WLC] model is a popular one. The WLC is a mathematical model available for delineating and ranking suitable sites for specific purposes. This model has been used to identify and rank suitable sites for land application of sewage waste [3], land filling [11], manure application [5] and emergency evacuation shelters [6].

Industrial site selection is complex and depends on a number of criteria. These criteria also differ depending on the type of industries. So site selection for industries is a Multi Criteria Decision Analysis [MCDA] [8]. The term Multiple Criteria Decisions Analysis applies various methods which help decision makers in finding better solutions. MCDA helps people to be able to consider more than one criterion [7]. Location-allocation approach of Network Analyst Extension is used for locating facilities and to allocate demand points that avail the facility.

In this study a cartographic model is designed for selecting candidate suitable sites for setting up automatic rice mills in the district of Joypurhat in Bangladesh. From these suitable candidate sites by applying location allocation approach specific number of optimal sites are detected considering volume of paddy production of each union as the weight of demand points.

## 2. Methodology

Here in this study to find optimal sites for setting up automatic rice mills two types of GIS analysis are executed in two stages. By using Spatial Analyst extension, a model is prepared for finding suitable candidate sites. Then by applying location-allocation approach and considering the production volume of paddy as the weight of demand points, optimal sites are detected for automatic rice mills.

### 2.1. The Study Area

The study is conducted in the district of Joypurhat in Bangladesh. It is located at the North West part of the country. This region is spread in 88.926˚- 89.287˚ Eastern longitude and 24.838˚ - 25.274˚ Northern latitude, having an area of 965 square km. It is a border district with India and situated beside the province of West Bengal, India. It is the smallest district of Rajshahi division, consisting of only five upazilas (sub-district). The number of smallest administrative unit (unions) here are 32 and there are 988 villages in the district. The population of the district is 938,495. It is a paddy surplus district having both normal husking mills and automatic rice mills (Figure 1).

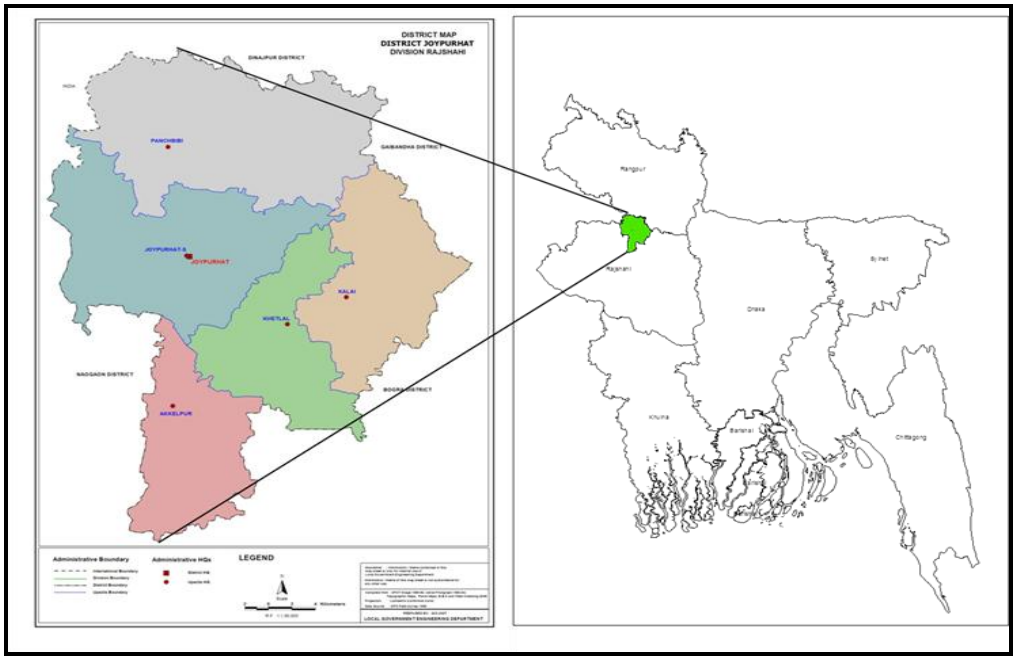


***Figure 1:*** *The Study Area-Joypurhat District, Bangladesh*

## 2.2. Site Selection Process

The formation of the GIS model to find suitable site for sitting new automatic rice mills is done through the following steps

1) Capturing the areas which fulfil the basic requirements to set up an automatic rice mill through consideration of adjacency to the metalled roads and electricity feeder lines.
2) Exclusion of the restricted areas, such as water bodies, minimum distance buffer from the residential areas, from the rivers, from roads and railways which are unsuitable for sitting automatic rice mills.
3) Selecting suitable candidate sites by extracting polygons from the suitable areas having the minimum land area required for setting up an automatic rice mill.

Evaluation criteria that are used in this study for site selection purpose are distance from roads and railways, distance from residential areas, distance from rivers, distance from water bodies and distance from electricity supply line or feeder line. These criteria are categorized as favouring conditions or mandatory facilities and restrictions. The approach for preparing layers through the model builder is explained in Figure 2.

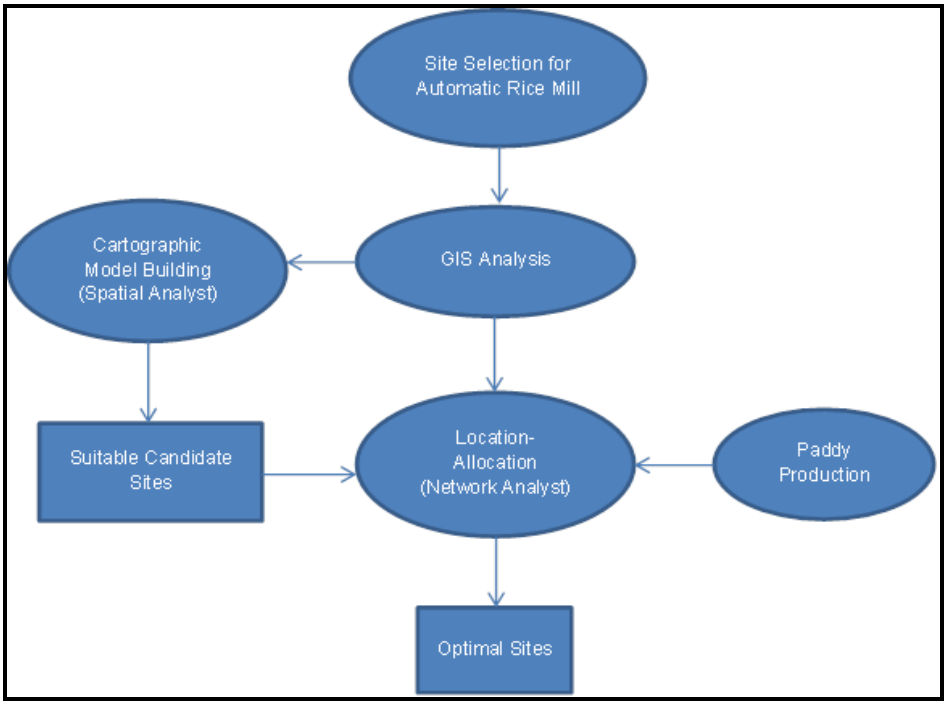


***Figure 2:*** *Conceptual Framework of the Study*

### 2.3. Mandatory Facilities or Favoring Conditions

From the primary field data collected in the study area it is found that there are some basic requirements or proximity of some facilities that are needed for sitting a rice mill. Firstly road communication facility (metalled roads) should be within a minimum distance for transporting paddy/rice. Second most important facility is electricity. Most of the respondents opine that the road communication should be within 100m distance and electricity distribution line or feeder line should be at a maximum distance of 100m from the plant site (Figure 3).

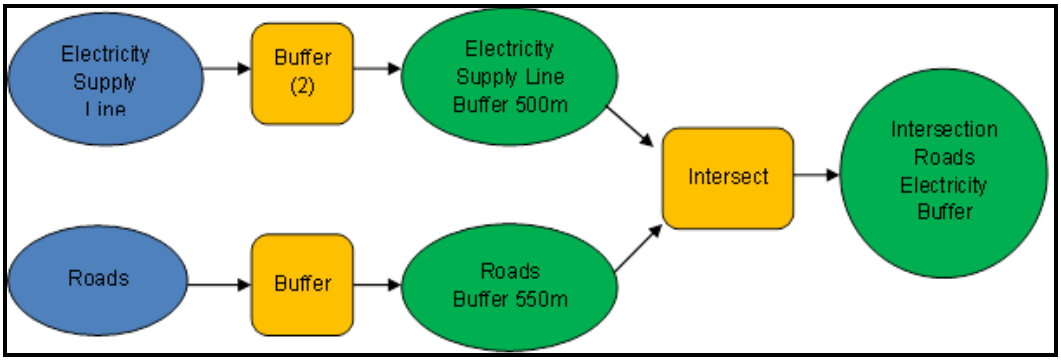


***Figure 3:*** *Intersect of Mandatory Criteria (Roads and Electric Supply Line Buffer)*

After maintaining certain distance from any feature like roads, the suitable site itself will have some dimension. From the study it is seen that a standard automatic rice mill requires about 25,000 square meter of land area [5]. The dimension of the land may be like 250x100 or 200x125 or different other combinations. Considering this assumption up to a distance of 500m from the power distribution line and 550m (500m after 50m clearance) from metalled roads are taken as suitable places (Table 1).

***Table 1:*** *Favouring Conditions for Suitability*

| Factors | Comment | Reference |
|---|---|---|
| Metalled Road Network | Maximum allowable distance 550 meter Buffer (50 meter clearance) | Respondents perception |
| Electricity Supply Line | Maximum allowable distance 500 meter Buffer | Respondents perception |

## 2.4. Constraints or Restrictions

There are some strong restrictions for selecting sites for setting up a rice mill in any area. Obviously the distance from the residential areas is the vital most. Central Pollution Control Board of India gives direction to maintain a minimum distance of 1Km from the residential areas. Most of the respondents in the study area also agreed with this minimum distance.

Another restriction is to maintain minimum distance from different roads. Central Pollution Control Board of India directs to keep rice mills at least 100m far from National High Ways, 50m far from State Highways and 25m far from Village Roads. Many of the respondents i.e. rice mill owners want to set up the mills within 100m distance from metalled roads. As only a small portion of the metalled roads in the study area are National High Way, the minimum distance of 50m from the roads is maintained for this study. Bangladesh is the closest neighbouring country of India and it is surrounded by India mostly. Besides this the socio-economic condition, population density and agricultural practices are almost same. Furthermore the study area is a border district beside the West Bengal province of India. So the standards for setting up rice mills in India can be followed for this study easily.

A good majority of respondents think that a minimum distance of 100m should be maintained from rivers for setting up an automatic rice mill in order to avoid the risk of landslide or flash flooding. Water bodies, other than rivers are also unsuitable for the site. For safety purpose a small distance of only 10m is maintained from the water bodies. As certain sphere of land is owned by railway authority round the rail tracks, there should a clearance of distance from the railways. It may be 100m in both the sides.

The entire study area is almost flat and there are no such hills or forests. It is mainly an agriculture based locality and residential areas are scattered almost all over the district. As like the whole country the study area is much populous and the settlement areas are close to one another. It becomes really very difficult to maintain the required minimum distance from all the settlement areas (Figure 4).

In fact after creating a buffer of 1000m around each settlement area and imposing restriction on those areas, their remains almost no suitable land surface for selecting a site. Only one suitable candidate site could be found if 1000m distance would be maintained from all the settlement areas. There would be no optimal site for setting up automatic mills in the study area if a restriction 1000m distance would be maintained from all the settlement areas (Figure 5).

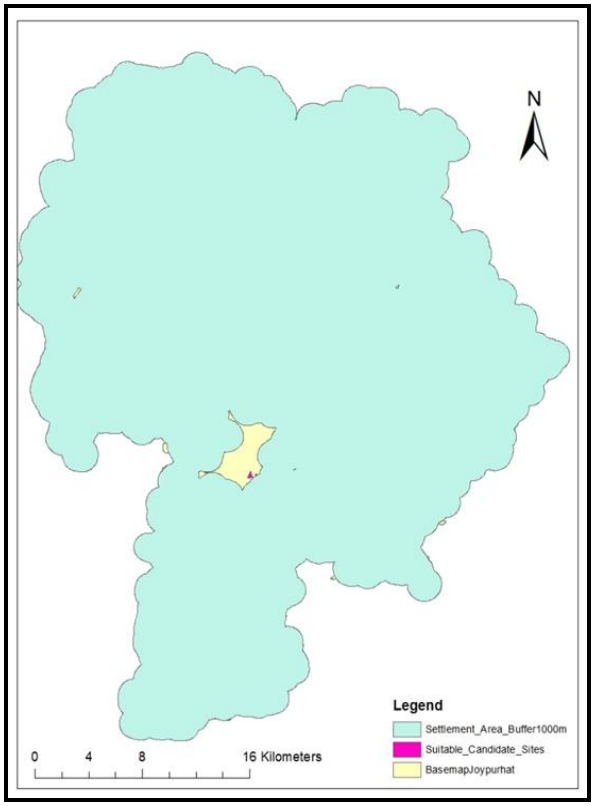


***Figure 4:*** *Suitable Candidate Sites with 1000m Buffer in all Settlement Areas*

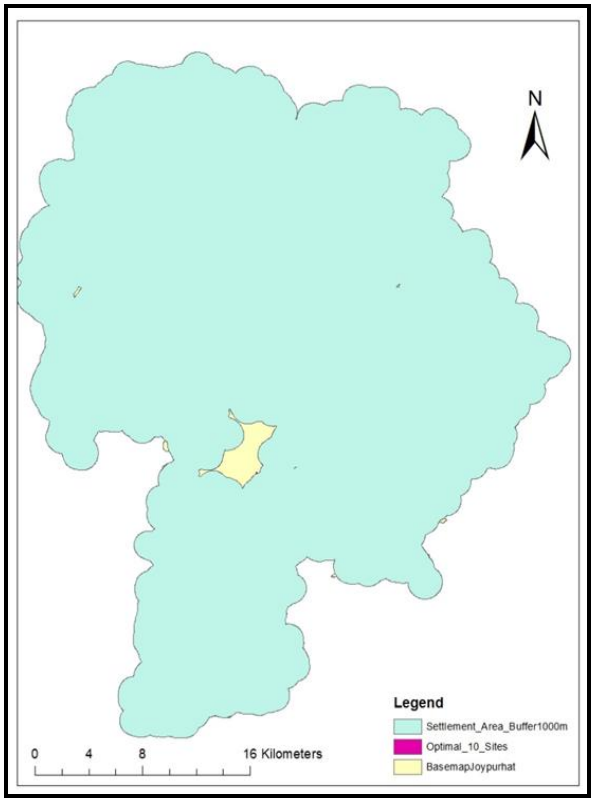


***Figure 5:*** *Optimal Sites with 1000m Buffer in all Settlement Areas*

This is why the total settlement areas are distributed into three separate maps based on the square meter area of the polygons (Figure 6, 7, 8, 9 and 10). These are:

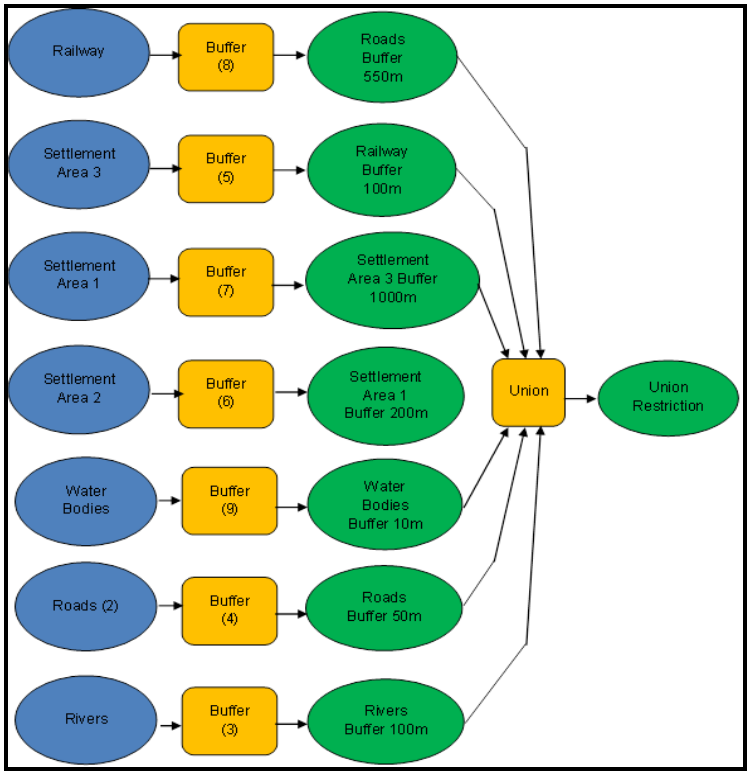


***Figure 6:*** *Combining Restriction Criteria*

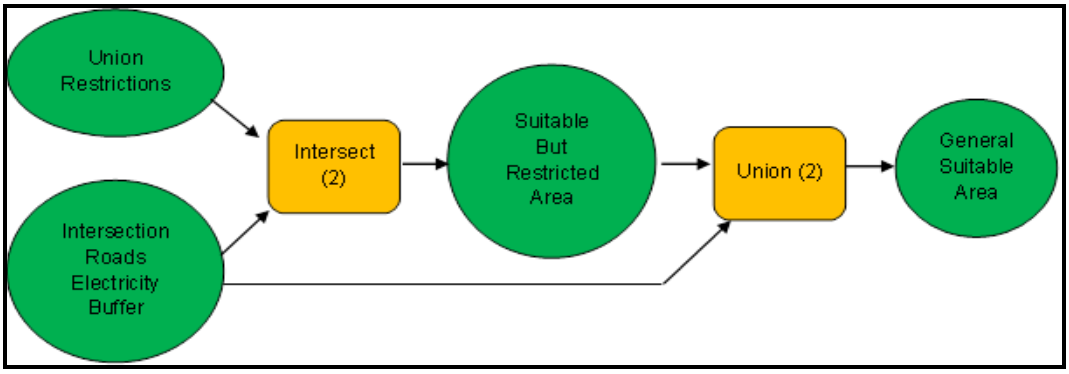


***Figure 7:*** *Combining Restrictions and Favoring Criteria*

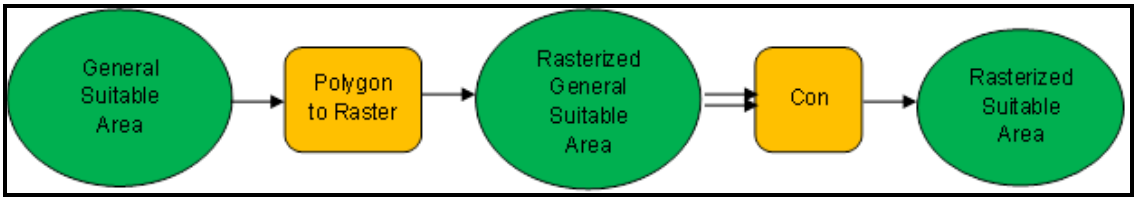


***Figure 8:*** *Detecting Suitable Areas*

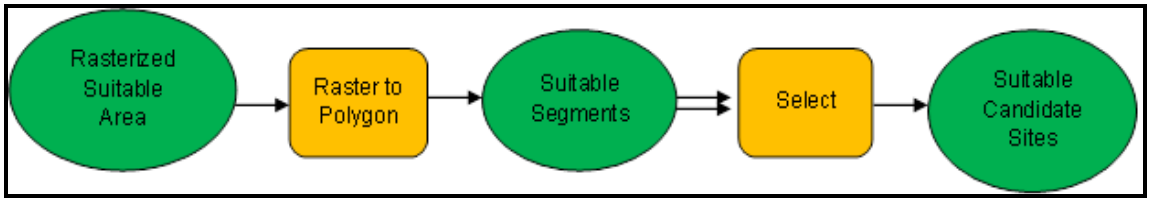


***Figure 9:*** *Selecting Suitable Candidate Sites*

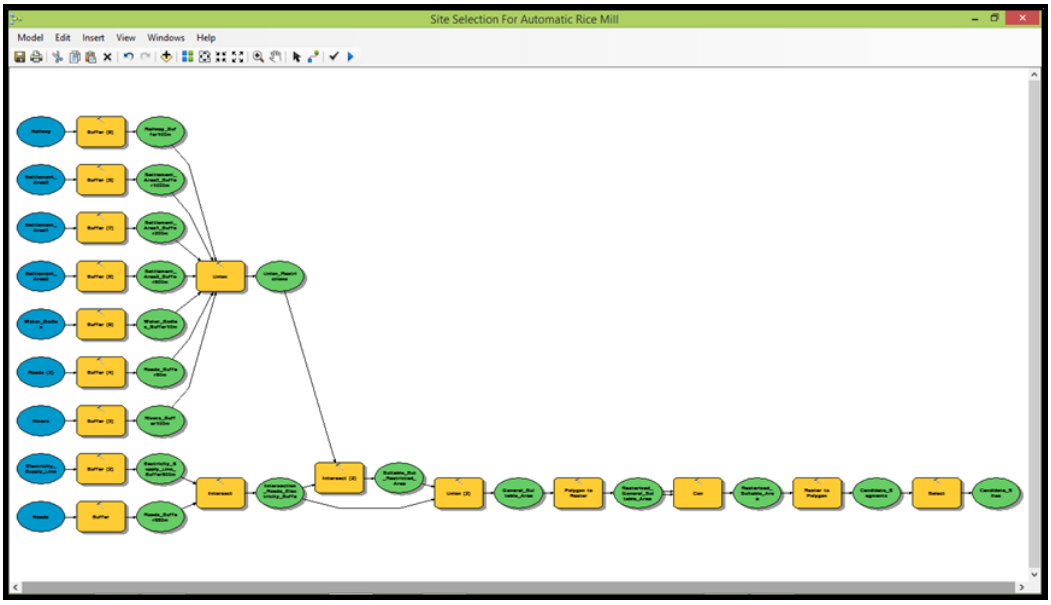


***Figure 10:*** *The Cartographic Model to Find Suitable Sites for Automatic Rice Mill*

1) Settlement area-1 map containing polygons of area up to 100,000 square meter. A buffer of 200m was created around these polygons.
2) Settlement area-2 map containing polygons of area in between 100,000 and 200,000 square meter. A buffer of 500m was created around these polygons.
3) Settlement area-3 map containing polygons of area more than 200,000 square meter. A buffer of 1000m width was created around these polygons (Table 2).

***Table 2:*** *Constraints or Restrictions of Suitability*

| Factors | Comment |
|---|---|
| Metalled Roads | Minimum distance 50 meter Buffer |
| Settlement Area-1 (Less than 0.1 square km) | Minimum distance 200 meter Buffer |
| Settlement Area- (From 0.1 to 0.2 square km) | Minimum distance 500 meter Buffer |
| Settlement Area-1 (More than 0.2 square km) | Minimum distance 1000 meter Buffer |
| Rivers | Minimum distance 100 meter Buffer |
| Water bodies | Minimum distance 10 meter Buffer |
| Railways | Minimum distance 100 meter Buffer |

## 3. Results

### 3.1. Suitable Candidate Sites

By running the model several times total 48 locations were found as unrestricted and usable for setting up automatic rice mills. But many of those sites were having insufficient amount of land area i.e. less

than 25,000 square meter to set up at least one standard automatic rice mill. Among those 48 locations 25 suitable locations were found with adequate surface area of land (Figure 11).

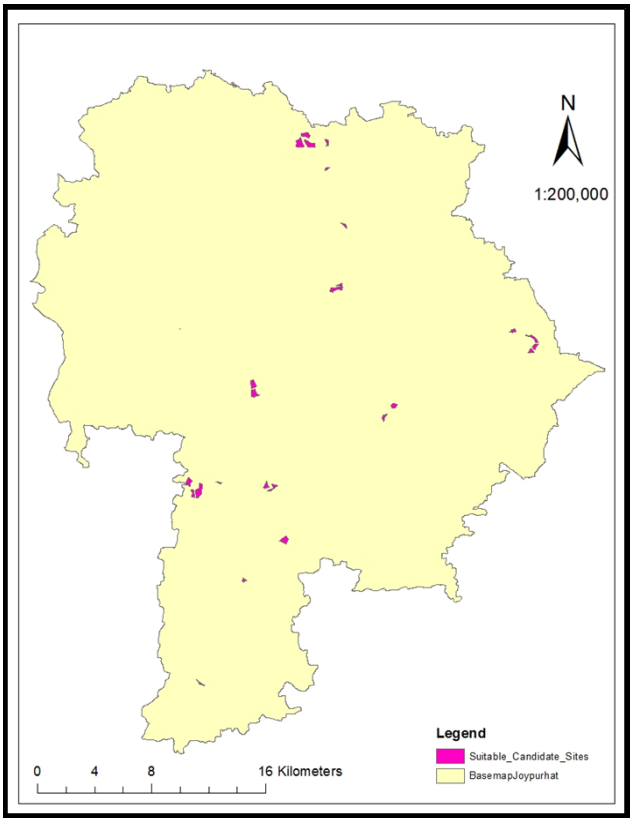


***Figure 11:*** *Suitable Candidate Sites (At least 25000 square meter area)*

### 3.2. Optimal Site Selection

After getting 25 suitable candidate sites through running the model, these sites were used as facilities in the location-allocation analysis using Network Analyst Extension of ArcGIS 10.1. The center of the unions i.e. the agricultural blocks (total 32 in number) were used as demand points and the volume of production of that respective area were used as the weight of demand. Through this process 10 sites were selected as optimal sites by which the total farming areas can be covered.

As the study area is mainly rural type and there were different type of roads (metalled or non-metalled, wide or narrow) in the network there was no specific speed mode. This is why instead of time in minutes; the distance in meter was used as impedance (Figure 12).

### 3.3. Optimal Sites in Map

Optimal sites selected through location-allocation process are shown in the map below. Out of 25 suitable candidate sites 10 optimal sites were detected by running the process. Both for maximum attendance and maximum coverage the same 10 sites were found (Figure 13).

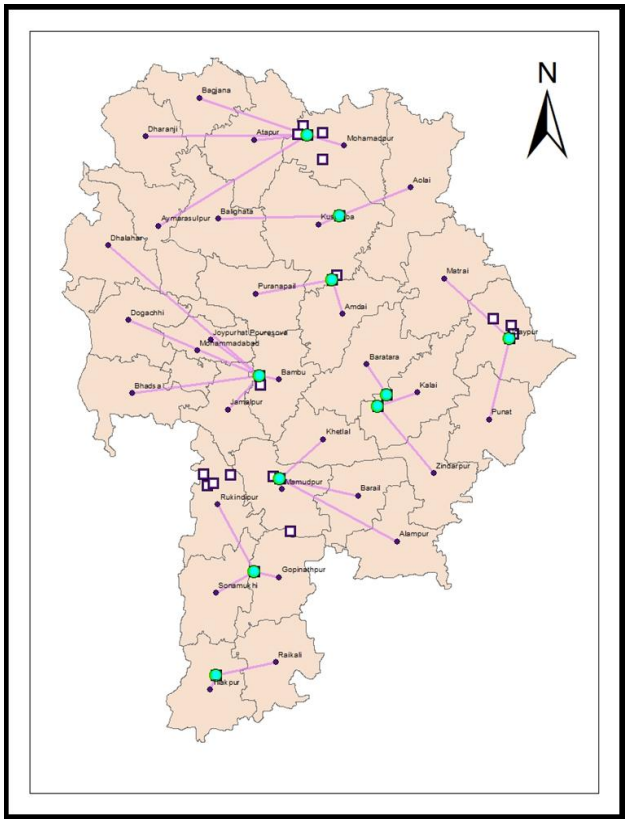


***Figure 12:*** *Optimal Locations Detected through Network Analysis*

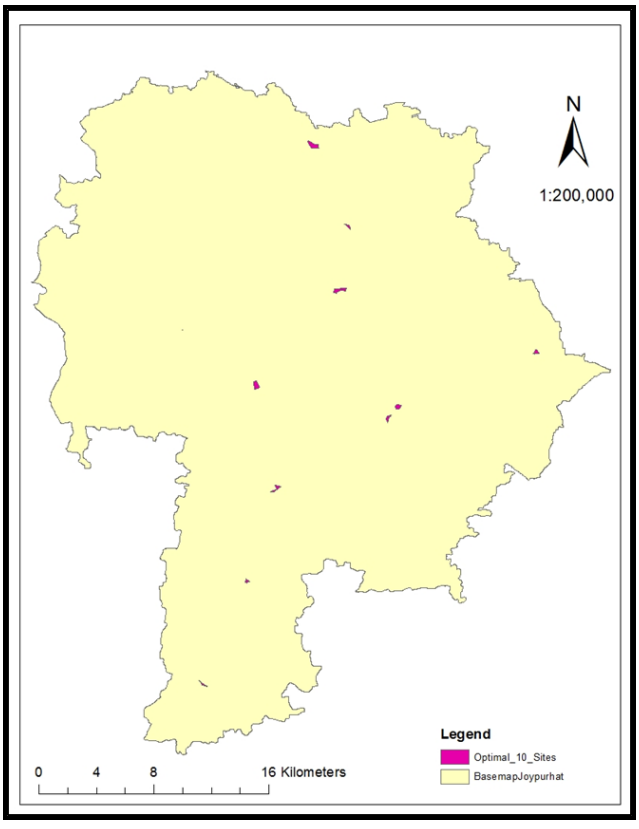


***Figure 13:*** *Optimal 10 Sites (With respect to Paddy Production)*

## 4. Discussion and Conclusion

Bangladesh is a populous country and people depend mostly on rice for living here. Round the year, rice is grown here almost all over the country. But the amount of production varies in different regions. Rice mills for processing paddy into rice are also established more or less in each region. Except some limited area most of the people of the country are fond of parboiled rice, the production process of which goes through relatively complicated stages.

Rice mills are pollutant industries and produce significant amount of ash, dumping of which is also very often much difficult. As modern high capacity rice mills produce fine dust and odour too, these have impact on environment and thus on public health. From environmental aspect, rice mills are to be set at a minimum distance from residential areas so that they do not become hazardous for public health. There are some other restrictions for setting up rice mills.

Presently most of the rice mills for producing parboiled rice in Bangladesh are of smaller capacity named as husking mills. Modern automatic rice mills are being set up nowadays. At present the location of mills are not being selected with proper judgment and prudence. This is why many complains are raised by local people and in some places court cases are also sued against the mill owners. Some mills have already received injunction from the courts on operation.

As modern rice mills require huge amount of investment and it is inconvenient to move a rice mill from one place to another after establishment, it is prudent to exercise proper analysis to select the location for automatic rice mills, before setting those up. For running paddy processing plants or rice production business the communication network plays vital role. Electricity is a must for running modern automatic rice mills. There are some other issues also to be considered in site selection process of rice mill.

After finding out the suitable candidate sites, 10 optimal sites are detected through location-allocation approach. Here the area of the suitable candidate sites is used as the weight of the Facilities. The centre the smallest administrative units (Unions) are used as demand points with paddy production of that unit as weight. 10 optimal sites are selected for both maximum coverage and maximum attendance. For both the cases the same optimal sites are found. Before taking the final decision for setting up an automatic mill in any of these 10 location the sites should be visited physically to look for some other issues which may not been addressed through this study but exists in reality.

GIS is frequently used for selecting suitable sites for various purposes. Vector based method is commonly used for solving such problem of site selection. Grid or raster based method with Weighted Linear Combination (WLC) is used where ranking of the candidate sites are necessary to identify. In this study mainly a vector based model is built up for Automatic Rice Mill site selection purpose. The ModelBuilder system in Spatial Analyst Extension of ArcGIS 10.1 is used here for selecting suitable candidate sites. Through this model suitable candidate site selection process is made automated. Running the model again and again 25 numbers of suitable sites with minimum 25,000 square meter area, are found. Amongst the suitable candidate sites specific number of sites are selected through the application of location-allocation approach by using Network Analyst Extension tool of ArcGIS 10.1. Here in this study the paddy production volume of the farm centers are used as the weight for the demand points.

The model constructed in this study can be applied for selecting sites for different industrial purposes also with necessary adjustments i.e. adding or dropping some criteria. The input criteria maps and conditions in each tool can easily be changed in the model and result can be obtained as per requirement. So based on this study future researchers can look for those important criteria for finding suitable sites other agricultural product processing plants or polluting industries.

Suitable or optimal sites with ranking can be selected by using Weighted Linear Combination (WLC) through raster based spatial analysis directly. But assigning weight for different criteria is always a difficult task and very often insignificant for some parameters. Here in this study first suitable sites are found through spatial analyst model. From these suitable sites optimal sites can be identified by location- allocation technique in different approaches, for meeting needs of different aspects.

## References

[1] Basnet, B., Apan, A. and Raine, S., 2000: *Selecting Site Suitable for Animal Waste Application using a Vector GIS.* The Soceity for Engineering in Agriculture Conference.

[2] Basaiaoclu, H., Celenk, E., Mariulo, M.A. and Usul, N. *Selection of Waste Disposal Sites Using Gis1*. Journal of the American Water Resources Association. 1997. 33 (2) 455-464.

[3] Hendrix, W.G. and Buckley, D.J. *Use of a Geographic Information System for Selection of Sites for Land Application of Sewage Waste*. Journal of Soil and Water Conservation. 1992. 47 (3) 271-275.

[4] Herzog, M. 1999: *Suitability Analysis Decision Support System for Landfill Siting (and other Purposes).* Proceedings of the ESRI International User Conference, San Diego, CA, USA.

[5] Jain, D.K., Tim, U.S. and Jolly, R. *Spatial Decision Support System for Planning Sustainable Livestock Production*. Computers, Environment and Urban Systems. 1995. 19 (1) 57-75.

[6] Kar, B. and Hodgson, M.E. *A GIS-Based Model to Determine Site Suitability of Emergency Evacuation Shelters*. Transactions in GIS. 2008. 12 (2) 227-248.

[7] Løken, E. *Use Of Multicriteria Decision Analysis Methods for Energy Planning Problems*. Renewable and Sustainable Energy Reviews. 2007. 11 (7) 1584-1595.

[8] MacCarthy, B.L. and Atthirawong, W. *Factors Affecting Location Decisions in International Operations–A Delphi Study*. International Journal of Operations & Production Management. 2003. 23 (7) 794-818.

[9] Kerala State Industrial Development Corporation, 2012: *Project Profile on Modern Rice Mill*. [http://www.emergingkerala2012.org/pdf/Food%20Processing/Modern%20Rice%20Mill%20-KSIDC.pdf].

[10] Bangladesh Rice Research Institute (BRRI), 2013: *Rice in Bangladesh*. [http://www.knowledgebank-brri.org/riceinban.php]

[11] Siddiqui, M.Z., Everett, J.W. and Vieux, B.E. *Landfill Siting Using Geographic Information Systems: A Demonstration*. Journal Of Environmental Engineering. 1996. 122 (6) 515-523.

[12] Yagoub, M. and Buyong, T., 1998: *GIS Applications for Dumping Site Selection.* Eighteenth Annual ESRI User Conference.