Jurnal Teknologi

Full paper

Identifying the Optimum Locations for Food Industries in Qaemshahr-Iran, Using GIS and Image Processing Techniques

Sharifeh Hazini[a], Mazlan Hashim[a*], Komeil Rokni[b], Arezou Shafaghat[c]

[a]*Institute of Geospatial Science and Technology (INSTeG), Faculty of Geoinformation and Real Estate, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia*

[b]*GNSS & Geodynamics Research Group (G & G), Faculty of Geoinformation and Real Estate, University Technology Malaysia, 81310 81310 UTM Johor Bahru, Johor, Malaysia*

[c]*Construction Research Center (CRC), Institute of Smart Infrastructure and Innovative Construction (ISIIC), Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia*

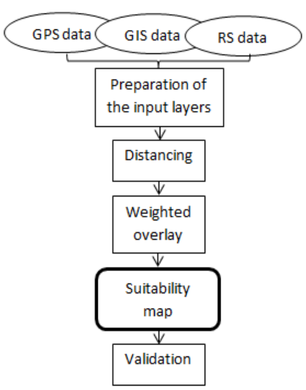
*Corresponding author: mazlanhashim@utm.my

Article history

Received:
Received in revised form:

Accepted:

Graphical abstract



Abstract

Determining optimum locations for an industry is a critical and complex decision for manufacturers. To select a potential site to establish food industries, various criteria should be considered regarding accessibility, delivery, market, and environmental factors. In this study, the weighted overlay method was employed to develop an up-to-date geodatabase providing the potential areas for establishing food industries to assist urban development in Qaemshahr city, Iran. The required data were acquired through various sources including remote sensing, Global Positioning System (GPS), and Geographical Information System (GIS). To achieve the aim, firstly the criteria of food industries settlement in Qaemshahr city have been measures, and the corresponding maps have been prepared. Using weighted overlay method all weighted maps were aggregated and final suitability map was established. Finally, the suitable sites for food industries in Qaemshahr were determined. The results have been validated by experts practicing Qaemshahr urban development. The results showed that around 172 sites are suitable for establishing the food industries in Qaemshahr. Accuracy assessment analysis proved the effectiveness of the achieved results with the accuracy level of 90%. The study concluded that the geodatabase model prepared in this study could be useful for future food industry development plans in Qaemshahr city, Iran.

Keywords: Food industry; site selection; remote sensing; GIS

1.0 INTRODUCTION

Urban development is composed of industrial development [1]. Despite the important role of industries in employment and economic issues, they have large effects on environmental pollution [2]. Making decisions on industries location identification is a key aspect of strategic and logistical decision making for manufacturers [3]. Location identification must consider a wide range of factors in order to coordinate socio-economic benefits and environmental sustainability. Site selection can be defined as the process of finding the best site for a project establishment based on socio-economic and environmental conditions [2].

Food conversion and complementary industry is known as the industry that convert the raw materials from food sources such as agriculture, cultivated, livestock, poultry, and fish to comestible products with higher shelf-life time. The processing operations include sorting, physical and chemical changes, packaging, storage, transportation, and distribution [4, 5]. Establishment in a suitable place is a key element in success and survival of food industrial centers [6]. Location identification analysis has been grown over the last decades, evolving earliest roots to current widespread use [7]. The general issues for determining a specific location for food industry are: environmental, geographical, and economic factors.

Finding a suitable location for food industry is a complex process which considers various criteria [8]. In most of developing countries, the required data for food location identification are collected via traditional methods which are tedious and time consuming, and using old data [9]. To overcome these issues, geospatial technologies; namely, Remote Sensing (RS) and Geographic Information System (GIS) would be employed as the excessive tools to identify the potential sites for food industry settlement. GIS has been used in several studies for different site selection applications [10-13].

In this study, combination of GIS and remote sensing technologies were employed to identify the potential sites for establishing food industries in city of Qaemshahr, Iran. Several data acquired using remote sensing techniques, Global Positioning System (GPS) survey, and GIS were collected as input layers. The weighted overlay method was employed to aggregate the maps to identify the potential areas for food industries in Qaemshahr, Iran. Finally, the achieved sites were validated by the urban development organizations of the study area.

■2.0 MATERIALS AND METHODS

In order to achieve the aim of the study, the following tasks were performed: area study, data collection, preparation of the layers, Distancing based on criteria, site selection, and validation of the results on map suitability.

2.1 Area Study

Qaemshahr city is located in Mazandaran province, Iran, This region is a pole of country's citrus and rice [5, 14, 15]. Qaemshahr is located between 36 21” N to 36 38” N and 52 43” E to 53 3” E of the Greenwich meridian. The study area is an average about 51.2 meters above mean sea level, with the area around 458.5 km^2. Qaemshahr has 17.7 Celsius mean yearly temperature, 621.5 millimeter sum of yearly rain, and 79 percent mean relative humidity [16]. According to the 2011 census, population of the study area is more than 320,741 people containing 10 percent of the province population, in which 203,741 people live in urban areas and 117,000 people live in rural areas [16]. The study area is composed of two towns including Qaemshahr (in the central part) and Kiakola (in the northern part), two sectors, and 165 villages [17]. Qaemshahr has a prominent position in the province because it is just 260 km away from the capital city (i.e. Tehran) and is connected to Tehran by rail and road links. Figure 1 shows location of Qaemshahr city, Iran.

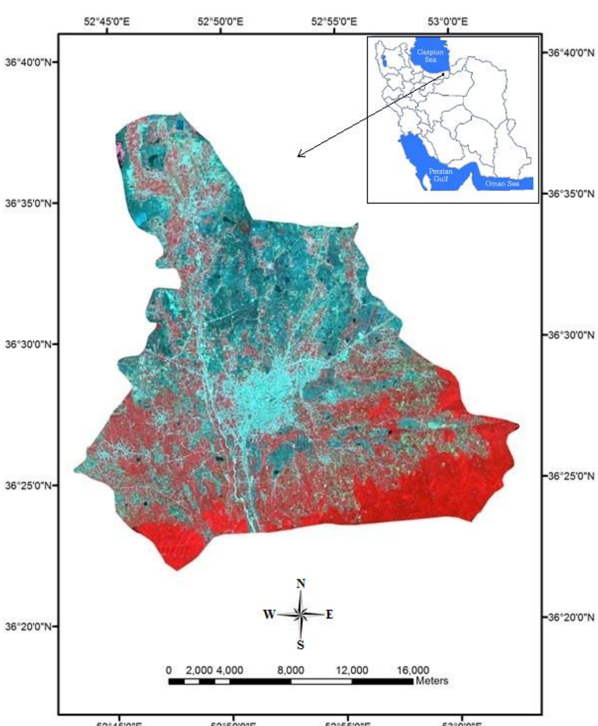


Figure 1 Location of the study area (Qaemshahr, Iran)

2.2 Data collection

Two scenes of ASTER Level-1B data acquired on 27 May 2010 and one scene of Landsat-5 TM image acquired on 7 August 2010; all obtained from the US Geological Survey Global Visualization Viewer (http://glovis.usgs.gov/) are used as input satellite data in this study. The ASTER images are then mosaicked in order to cover the entire study area. Landsat imagery is used in this study to fulfill the lack of blue and shortwave infrared bands of ASTER data. The satellite images are used to provide some of the required layers in site selection process, including water bodies, built-up areas, forests, roads, and slope.

In addition, topographic map, geological map, GPS data, and GIS data are used to provide the other required input layers. The topographic and geology maps of the study area were obtained from National Geographical Organization (NGO) of Iran. These maps are used to extract various layers through on-screen digitizing. Moreover, field observation was employed using GPS technology to collect locations of various factors including medical, education and military centers, aqueduct, villages, concrete, asphalt, cement, casting, abattoir and cemetery factories, waste accumulation, waste water treatment, as input data for food industry site selection.

2.3 Preparation of the Input Layers

The required layers are defined according to the criteria for food industry site selection. The required data were acquired through various sources as follows:

2.3.1 Image Processing

The remote sensing based data were obtained using satellite-derived indexes, Digital Elevation Model (DEM), and LOC-Road methods. The built-up areas, water bodies, and broadleaf forests layers were obtained through the calculation of Normalized Difference Built-up Index (NDBI), Normalized Difference Water Index (NDWI), and Normalized Difference Vegetation Index (NDVI), respectively. The slope layer was obtained from a digital elevation model of the study area which was created using ASTER stereo imagery. The stereo pair bands of ASTER imagery (3N and 3B) are capable of creating absolute DEM using defined ground control points. The processing procedures to generated ASTER DEM include: input stereo images pair, defining GCPs, defining tie points, calculating epipolar geometry and images, specifying DEM output projection parameters, specifying DEM extraction parameters, and creating the DEM. Using the ArcGIS software, the slope layer was derived from the generated ASTER DEM.

The main roads in the study area were extracted using Lines of Communication (LOC)-Roads technique. The LOC-Roads algorithm, streamlines spectral processing for mapping road lines of communication (LOCs) using multispectral data. To perform LOC-Roads to extract the main roads, a multispectral image containing Red, Green, Blue, and Near IR bands is required. In this study, a layer stacked image containing the ASTER Red, ASTER Green, ASTER NIR, and Landsat Blue bands was used for this purpose. To perform the LOC-Roads method, supervised technique using selected ROI was applied, and spectral matching, principal component, and red soil were selected as spectral processing parameters. The output image was a black and white image which enhanced the roads for purpose of digitizing the main roads.

2.3.2 GPS Source

Some of the required data such as the locations of educational centers, medical centers, military centers, villages, castings, abattoirs, cemeteries, Aqueduct, waste accumulation centers, waste water treatment, and concrete, Asphalt, and cement factories were collected through GPS survey in the study area. The GPS collected points were then imported to ArcGIS environment to prepare the layers.

2.3.3 Official Source

The topographic and geological maps of the study area were collected from National Geographical Organization (NGO) of Iran. These maps were used to extract some of the required layers including railway, river, tectonic, and fault layers through on-screen digitizing.

2.4 Distancing Based on Criteria

Distancing for each layer was implemented using Euclidean (straight-line) Distance tools in ArcGIS Spatial Analyst, based on the criteria defined for food industry site selection in Iran (as presented in Table 1).

2.5 Weighted Overlay

Since the input layers are in different numbering systems with different ranges, to combine them in a single analysis, each cell for each criterion must be reclassified [18]. To do so, first the distanced layers were reclassified into two classes: allowed and not-allowed. Equal influence was defined for input raster layers. The obtained maps were then aggregated to generate the final suitability map and finally the suitable sites have been determined.

2.6 Validation of the Results on Map Suitability

In order to evaluate the accuracy of results of map suitability, an investigation was conducted via field work and experts input study. The experts have been invited from Department of Environment and Ministry of Agricultural Jihad, Mazandaran city, Iran. Total 20 random samples have been selected within the study area. The applicability of food industries settlement has been also investigated.

Table 1 The criteria for food industry site selection in Iran

Row	Criteria		Distances from place (m)						Source
	Places and facilities		Category 1	Category 2	Category 3	Category 4	Category 5	Category 6	
1	settlements	Provincial centers (last of residence)	-	500	1000	1500	2000	2500	*
2		City centers (last of residence)	-	250	500	1000	1500	2000	*
3		City	-	200	500	1000	1500	2000	*
4		Village	-	200	500	750	1000	1500	*
5	Medical and education centers		-	200	500	750	1000	1500	*
6	Military centers		50	200	500	750	1000	1500	
7	National park- Water body (pond-Lake) -Forest		150	150	500	1000	1500	2000	*
8	Wildlife refuge-protected area		-	150	200	250	500	1000	*
9	Permanent river of non-potable		100	100	150	150	250	500	*
10	Permanent river of potable		150	150	500	1000	1500	2000	*
11	Drinking water wells-agriculture- aqueducts		50	50	150	200	250	500	*
12	Cement plants, sand preparation, asphalt, Isogum		3000						*
13	First degree pollutants: poultry- cattle farms- traditional slaughterhouses- chalk and lime plants- accumulation of garbage or manure-tanned- leather and wastewater treatment		1000						**
14	Secondary pollutants include: casting- mosaics and ceramics- cemetery- industrial abattoir		250						**
15	villages that somehow have livestock-traditional poultry farming buildings		500						**
16	On a 100-year flood pass away		Not located						**
17	Fault		200						***
18	Main Road		100						***
19	Railway		100						***
20	Slope		10%						***

Note: * Iran Department of Environment, ** Iran Food and Drug organization, ***Iran Construction Engineering Organization

■3.0 RESULTS AND DISCUSSION

To identify the potential areas for food industries in the study area, the required data were collected, the criteria for food industry were defined, the layers were prepared, and finally using the adopted overlay method the suitability map was generated.

Figure 2 shows the final suitability map for food industries generated using weighted overlay method.

In the generated map, the areas highlighted by red color are the suitable locations for establishing food industries in the study area. To determine the optimum sites for food industries, the generated suitability map was converted to polygon. Therefore, several polygons/sites were identified in the study area suitable for food industries. The area of each site was then calculated, as presented in Table 2. The results showed that a total of 172 sites are suitable for establishing food industries in the study area, while the biggest and smallest sites are 31146793 m^2 and 8765 m^2, respectively.

To evaluate the accuracy of the achieved results, a total of 20 sample points were randomly selected within the study area. The selected points were then sent to the Ministry of Agriculture Jihad (Mazandaran branch) to assess whether they are allowed for food industries or restricted. The inquiry results were then compared with the site selection results achieved in this. The results are presented in Table 3.

The results showed that there is 90% (18 points) similarity between the reference inquiry and weighted overlay outcomes. The results indicated high accuracy of the food industry site selection model generated in this study. This model could be useful for future food industry plans in Qaemshahr city, Iran.

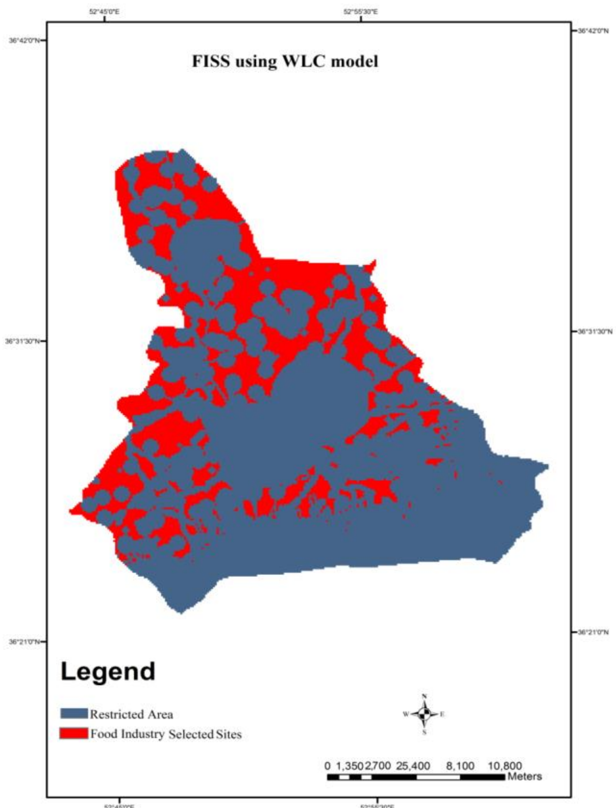


Figure 2 The suitability map for food industries in the study area

■4.0 CONCLUSION

The study determined the optimum locations for establishing food industries in Qaemshahr city, Iran. The required data were acquired through satellite image processing, global positioning system, and geographical information system. To conduct the site selection procedure, first the criteria of establishing the food industries in the study area were identified, and then, the corresponding maps were prepared in ArcGIS environment. Secondly, the weighted overlay method was employed to develop an up-to-date geodatabase providing the potential areas for establishing food industries to assist urban development in Qaemshahr city, Iran. The weighted overlay method was employed to generate the final map of food industries site identification. Accuracy assessment analysis demonstrated validity of the output sites for food industries settlement in the study area. The study concluded that the identified sites for food industries are reliable and could be used for future food industry plans in Qaemshahr city, Iran.

Table 3 Validation of the selected sample points

Sample No.	Field work & expert ideas	Weighted overlay
1	Allowed	✓
2	Restricted	✓
3	Allowed	✓
4	Restricted	✓
5	Allowed	✓
6	Restricted	✓
7	Restricted	✓
8	Restricted	×
9	Allowed	✓
10	Allowed	✓
11	Restricted	✓
12	Restricted	✓
13	Allowed	×
14	Restricted	✓
15	Allowed	✓
16	Allowed	✓
17	Allowed	✓
18	Allowed	✓
19	Allowed	✓
20	Restricted	✓

Acknowledgement

The authors would like to acknowledge the support of Universiti Teknologi Malaysia (UTM) for providing the facilities for this investigation. We are also grateful to U.S. Geological Survey server for providing the ASTER and Landsat data.

References

[1] Reisi, M., L. Aye, and A. Soffianian. 2011. Industrial Site Selection by GIS in Isfahan, Iran. 19th International Conference on Geoinformatics. 8 June 2011, Shanghai.

[2] Lamit, H., Shafaghat, A., Abd. Majid, M. Z., Keyvanfar, A., Shafaghat, A, Ahmad, M. H, Malik, T. A. 2013a. The Path Walkability Index (PAWDEX) Model: To Measure Built Environment Variables Influencing Residents' Walking Behavior. *Journal of Advanced Science Letter*. 19(10): 3017–3020.

[3] Abd Majid, M. Z., Zakaria, W. Z., Lamit, H., Keyvanfar, A., Shafaghat, A., Surya Bakti, E. 2012. Construction Information Systems For Executive Management In Monitoring Work Progress. *Journal of Advanced Science Letter*. (15)PP: 169–171.

[4] Lambert, D. M., K. T. McNamara, and M. I. Garrett. 2006. Food Industry Investment Flows: Implications for Rural Development. *The Review of Regional Studies.* 36(2): 140–162.

[5] Trade, I.M.o.I.M.a. 2013. The Portion of Agriculture in Economy of the Iran. Tehran.

[6] Dezyani, M., H.a. Mirzai, and r. Ezati. 2009. *Principles of Design of Food Industry Factories*. Tehran, Iran Agricultural Science.

[7] Lamit, H., Shafaghat, A., Abd. Majid, M. Z., Keyvanfar, A., Ahmad, M. H., Malik, T. A., Zin, R., Yadollahi, M. 2013b. Application Of The Path Walkability Index (Pawdex) Model: A Case Study Of Retail Walking Pattern Recognition In The Taman University Neighborhood, Skudai, Malaysia. *Journal of Advanced Science Letters*. 19(10): 3021–3024. .

[8] Lambert, D., K. McNamara, and M. Garret. 2006. An Application of Spatial Poisson Models to Manufacturing Investment Location Analysis. *Journal of Agriculture and Applied Economics*. 38(1): 102–115.

[9] Mohamed, M. and R. Plante. 2002. Remote Sensing and Geographic Information Systems (GIS) for Developing Countries. International Geoscience and Remote Sensing Symposium, 24–28 June 2002, Toronto.

[10] Afzali, A., *et al.* 2014. Inter-municipal Landfill Site Selection Using Analytic Network Process. *Water Resources Management*. 28(8): 2179–2194.

[11] Lamit, H., Abd Majid, M. Z., Shafaghat, A., Keyvanfar A. 2012. Sidewalk Design Decisionmaking Model Based On Walking Behaviour Pattern Recognition: Proposal Validation. *International Journal of Sustainable Development*. 4(1): 27–34.

[12] Chandio, I. A., *et al.* 2011. GIS-based Land Suitability Analysis Using AHP For Public Parks Planning In Larkana City. *Modern Applied Science*. 5(4): 177.

[13] Afzali, A., J. Samani, and M. Rashid. 2011. Municipal Landfill Site Selection for Isfahan City by Use of Fuzzy Logic and Analytic Hierarchy Process. *Iranian Journal of Environmental Health Science & Engineering*. 8(3): 273–284.

[14] Golafshani, M. B., *et al.* 2012. Compare the Parameters of the Water Balance in Traditional and Land Levening Paddy Fields in Qaemshahr City. *Journal of Soil and Water*. 26(4): 1010–1017.

[15] Bansouleh, B. F. 2009. Development of a Spatial Planning Support System for Agricultural Policy Formulation Related to Land and Water Resources in Borkhar & Meymeh district, Iran. Dissertation, University of Twente, Enschede.

[16] Organization, I. M. 2012. *Meteorological Information and Statistic.* Tehran.

[17] Iran Statistic Center, P. 2011. *Iran Population and Housing Census 2011*. Tehran.

[18] Önden, İ., C. G. Şen, and A. Şen. 2012. Integration of Integer Programming with GIS Analyzing Abilities for Determining the Convenience Levels of Retail Stores. *Procedia-Social and Behavioral Sciences*. 62: 1144–1149.

Table 2 Statistics of the potential sites for food industry

Num.	Area (m²)	Num.	Area (m²)	Num.	Area (m²)	Num.	Area (m²)
1	204177.1	44	9370.83	87	317852	130	9370.83
2	3313584	45	4539713	88	9370.83	131	52248.23
3	9370.834	46	9370.83	89	85504.24	132	9370.83
4	77501.12	47	43786.91	90	9370.83	133	1301180
5	6590508	48	9370.83	91	9370.83	134	28252.46
6	9370.83	49	2565882	92	153669	135	9370.83
7	1534054	50	146485.5	93	9370.83	136	1828219
8	4435425	51	9370.83	94	9370.83	137	27373.79
9	2251981	52	3017816	95	18688.1	138	32426.07
10	76395.63	53	29992.5	96	38136.55	139	8764.929
11	27373.79	54	478106.1	97	1029404	140	2319008
12	36775.16	55	31146793	98	8764.929	141	18688.1
13	18688.09	56	38136.55	99	9370.83	142	18475.33
14	27373.79	57	57489.52	100	9370.83	143	9370.83
15	27373.79	58	9370.83	101	9370.83	144	528973.3
16	393580.2	59	684598.4	102	1379043	145	18688.22
17	9370.83	60	18475.26	103	9370.83	146	9370.83
18	85210.85	61	204218.4	104	9370.83	147	7720692
19	13686.89	62	479902.7	105	9370.83	148	9370.83
20	66137.07	63	18475.26	106	9370.83	149	9370.83
21	13686.89	64	213646	107	230498	150	9370.83
22	9370.83	65	18475.26	108	154352.4	151	9370.83
23	80382.71	66	3478239	109	13686.89	152	9370.83
24	1209047	67	929933.7	110	211504.5	153	100814.6
25	42259.23	68	31709.22	111	225233.1	154	300650.4
26	9370.83	69	9370.83	112	61788.52	155	38136.37
27	3266580	70	119978.1	113	2105502	156	9370.83
28	9370.83	71	9370.83	114	9370.83	157	27373.79
29	9370.83	72	484579.2	115	9370.83	158	18475.33
30	2348619	73	1431419	116	18688.1	159	1958902
31	9370.83	74	46204.14	117	54437.88	160	9370.83
32	575566.6	75	240995.4	118	28252.42	161	2415446
33	9370.83	76	36921.23	119	18688.16	162	9370.83
34	13686.89	77	13686.89	120	54174.17	163	31709.23
35	9370.83	78	18475.26	121	9370.83	164	9370.83
36	1779483	79	321611.3	122	36355.81	165	18688.16
37	425712.7	80	9370.83	123	9370.83	166	36775.29
38	13686.89	81	137584.3	124	32120.72	167	496511.9

Num.	Area (m²)	Num.	Area (m²)	Num.	Area (m²)	Num.	Area (m²)
39	18475.36	82	18688.22	125	1444155	168	215209.6
40	947224.7	83	18475.26	126	9370.83	169	36775.29
41	59771.52	84	9370.83	127	32426.01	170	9370.83
42	9370.83	85	6883768	128	18688.22	171	9370.83
43	475565.1	86	9370.83	129	18475.26	172	9370.834
Counted sites		172		Sum area (m^2)		116267775.597057	
Max. area (m^2)		31146793		Min. area (m^2)		8764.929	