PHYSICAL DEVELOPMENT OF ARAK CITY APPLYING NATURAL INDICATORS.

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Abstract

The purpose of this research is to evaluate the suitable areas for physical development of the Arak city in the future. Also, to found new physical index for developing of the city based on morphological features. For the objective, the spatial indicators of the analysis are climatology, topographic roughness coefficient, tectonic influenced factors, geomorphological landforms, land uses, runoff height and city relation with Mighan Desert which is located in the south of Arak City. TOPSIS and AHP models are majors Multi Criteria Evaluation models that have been used to prioritize the proposed areas. The results of the MCE analysis by AHP and TOPSIS indicated that the first priority for the physical development is an area in the east and northwest part of Arak City that was in parallel with Arak municipality plan for urban development. Sediment analysis of suitable areas represented that the area is located in flood bed which has unfavorable conditions for the establishment of utilities.

***Keywords**: Urban physical development, Arak City, Physical structure, TOPSIS, Flood plain.*

1. INTRODUCTION

With the development of the urban population in Iran since 40 years ago, it is inevitable to pay considerable attention to the natural conditions in the physical development of cities and disregarding these conditions can result in environmental damages and other natural hazards that destroy and influences urban life's (Kaya, 2006). For many years, the cities follow organic growth pattern under the influence of internal factors as accessible resources and physical limitations. In the past decades, the urban land areas were also enough for traditional land uses and they were organically configured based on security, social and economic conditions (Majedi, 1999). Today, the urban lands are not sufficient for the population coming into the areas. Therefore, it is required to carry out substantial studies about optimization site selection establishment and physical development.

With the establishment of industries in Arak City in the 1970s and conversion of the area as a province in 1978, the city experienced rapid growth. Then, it was faced many environmental issues including neighborhood with Mighan Desert, water pollution in agricultural lands, climate change, Air pollution, topography, and lack of spatial coherence. The investigation about the physical expansion of Arak can contribute to the initiation of a suitable spatial model for physical development. Since location planning and selecting a well-fit option from the feasible alternatives is a significant problem in every decision-making process, Multi-Criteria Decision-Making (MCDM) has been found to be an efficient approach to solving this kind of problems.

There are different MCDM models that have been applied for site selection projects in both urban and regional scales. But the simultaneous application of quantitative, quantitative criteria and weighting (importance coefficient) of indicators according to regional features and theoretical principles, make TOPSIS as an optimal model to assess site selection projects. This method emphasizes that selected alternative should have the least distance with positive idea solution (the best possible area) and the most distance with a negative ideal solution (the worst possible area).(Asadzadeh,2014). This process involves several steps but considering location and position features are the first step. In according with urban upstream plans, regional development strategies, access and accessibility and site development potentials are some important factors that should be considered in new towns site selection (Mandelker, 1965). Moreover, Factors such as availability of a water supply, sufficiency of existing connecting roads, availability of such utility services as gas and electricity, potentialities for sewage disposal and the suitability of the land for development are usually considered (Mcfarland, 1965However, a site location problem usually involves a set of locations (alternatives) which are evaluated against a set of weighted criteria independent from each other. The alternative that performs best with respect to all criteria is chosen for implementation (Awasthi, 2011). Therefore site selection can be viewed as a Multiple Criteria Decision-Making or Multiple Attributes Decision-Making (MCDM/MADM) problems. Chen, (2001) developed a fuzzy multi-attribute decision-making approach for the distribution center location selection problem. Chu (2002) has applied a fuzzy TOPSIS model to solve the facility location selection problem under group decision-making. Kahraman et al. (2003) used four fuzzy multi-attribute group decision-making approaches in evaluating facility locations. Chou et al. (2008) have presented a fuzzy simple additive weighting system under group decision-making for facility location selection with objective and subjective attributes.

This model of city development can be based on some visible indices including the rate of roughness in topography, tectonic and geomorphologic factors, and elevation of runoffs. Consideration of natural factors in the physical development of cities was important for researchers according to some approaches (Servati et al, 2008). Some researchers mentioned the natural limitations in urban development (Hosseini et al., 2012). Some others proposed the approach of getting away the limitations and development far from the natural obstacles (Ahmadi, et al., 2013), (Karam and Mohammadi, 2009), (Nazarian et al., 2009). Positive and negative impacts of natural factors in physical development were also studied by some researchers (Ruzbahani et al., 2010), (Rezai and Malakrudi, 2010). There are also many case studies in the subject (Adeli, et al., 2011), (Geyme and Baz. 2007), (Sener, et al., 2010). Water quality and its development issues were also considered by some scientists in models of urban development (Marinoni, et al., 2013). In the present research, the physical development of Arak City has been investigated in terms of geographical factors and optimum suitable areas have been analyzed in terms of environmental and natural hazards by TOPSIS model that the research team found the best model for site selection based on characterizing by Arak city.

2. STUDY AREA

The area of Arak is about 5340 hectares that extended in a linear east-west alignment. It is located in the position of 49° 42´ E and 34° 05´ N, with 1755 m above sea level (Figure 1).

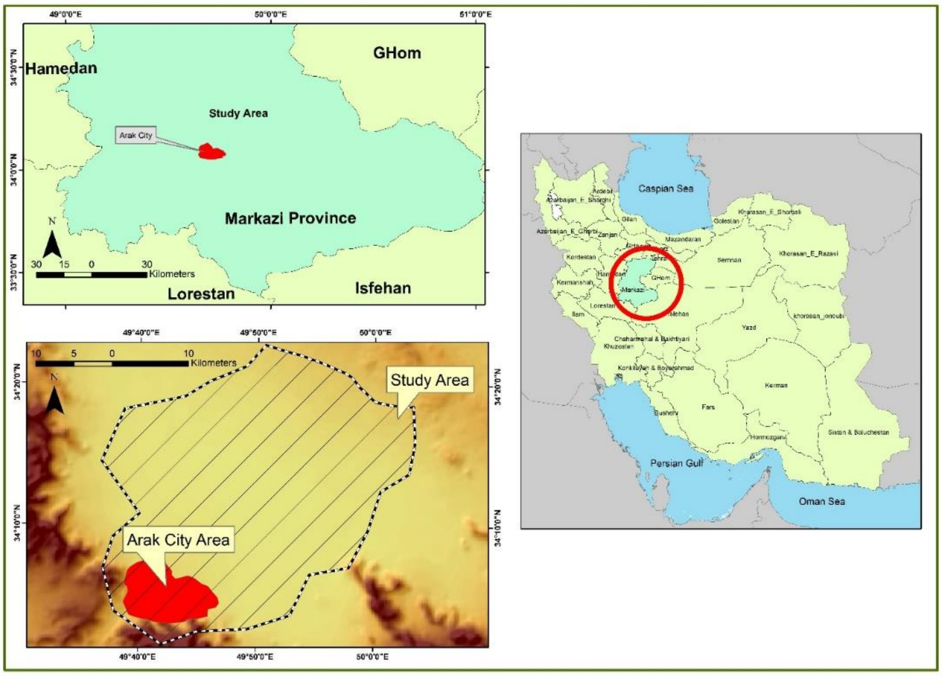

Figure 1. Position of the study area

Also watershed of Arak Plain known as Mighan Lake drainage influence city. The Mighan Lake is positioned in the center of the plain and in the northeast Arak City. The city, located in the southwestern margin of the Arak Plain. Arak city limited to mountain ridges in the south that this ridges named Nazmabad, Kuh Sorkh, Sheykh Ebrahim, and Kuh Darband. The distance of the city to Mighan Desert is about 15 km (Sharman Architect and Urban Planner Consulting Engineering, 2009). Some Temporary rivers flow in the city and made bed sediment of city bed form and is located in the alluvial sediments. Hot summer and cold winters are Arak's climate conditions that product evaporation sediments as salt, chalk, limeade chill are active in the study area. For determining physical limitation of city growth, study area boundary is specified bigger than arak city boundary. Figure 1 shows the study area's position and physical geography features.

2.1 Materials and methods

Given the important role for landforms plays in the appropriate physical development of cities, the landform units have initially been extracted from topographic maps analyses at a scale of 1:25000 and other spatial criteria's that shown in figure 2, (Goudie and Viles, 2010). After determining the target of study that was allocated the best area for urban developed based on review literature, the procedures for reaching the best answer identified. The evaluation indicators of the best area for urban developing determined. After finding spatial indicators that influenced urban development, AHP method is used for weighting of criteria. Then, the weights of each attribute are combined with the expert's opinions. TOPSIS algorithm is applied to achieve final results. Figure 2 shows the procedure of study for determining the best area for urban development.

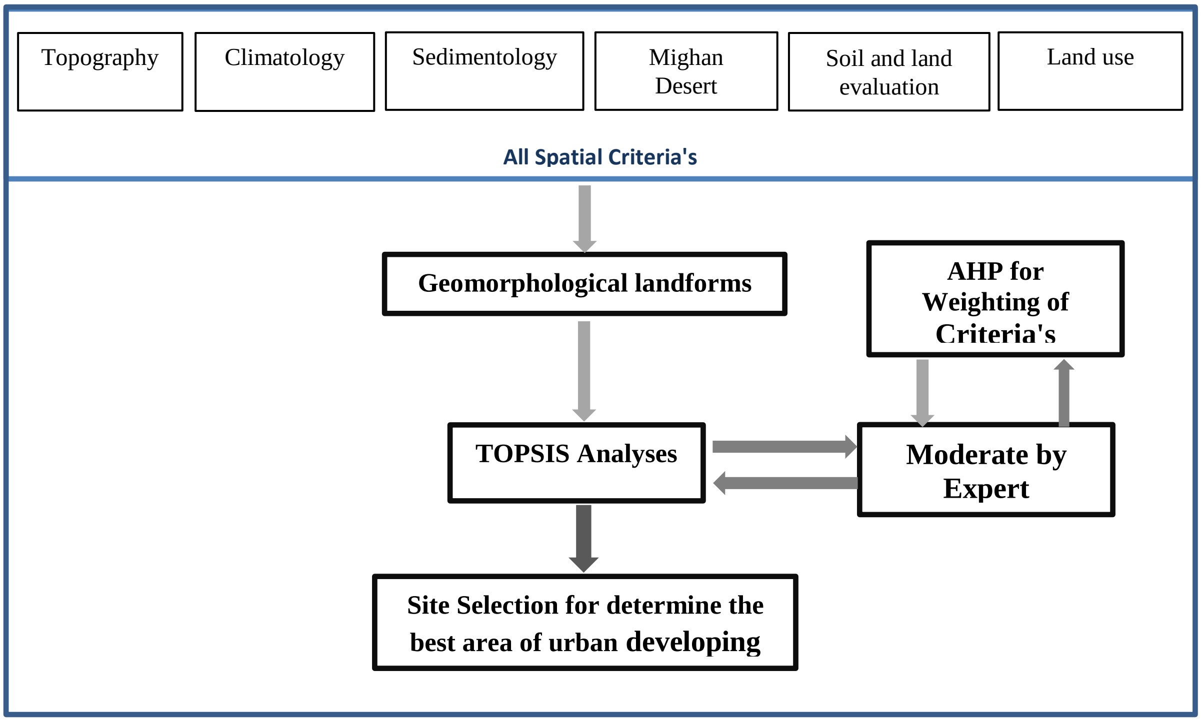

Figure 2. Procedure of site selection for determine the best area of urban developing

Based on analyses of spatial criteria's, land use analyses of IRS satellite images and also field study, twenty landform units have been identified that main landforms are flood sediment forms, hills (old glacier cirques), low elevated terraces, high elevation terraces, old alluvial fans and playas. Given the qualitative and quantitative characteristics of the landforms to form a matrix of qualitative indices, the bipolar scale has been used for the analysis and weight among landforms. This measurement of the positive aspects is based on a 10 point scale. The 0 value represent the least possible value and 1 the highest one for determining suitable areas in urban development that were based on fuzzy logic theory. The middle point is the break between suitable and unsuitable indexes. This scale is applied inverse for negative indices. (Moradi and Akhtarkavan, 2009). As the maximum and minimum numeral value and the scale range of the selected layers have been different from each other, the standardization between criteria's weight has been carried out based on the relations of 1 and 2 that described in below. The relation 1 has been used for the spatial layers that increase in their values represents more suitability and the relation 2 is used for the layers that decrease in their values represents more suitability. Thus, all layers have been standardized from 0 to 1 according to the combination mathematic relation and expert knowledge.

Relation 1 $\frac{X - Min(x)}{Max(x) - Min(x)},$

Relation 2 $\frac{Max(x) - X}{Max(x) - Min(x)}$

The weighting of the indicators has been conducted by pairwise comparison matrix and Analytical Hierarchy Process (AHP). The AHP proposed by Saaty in 1970's is a method frequently applied to Multi-Criteria Decision-Making analyses (MCDM) (Momeni and Sharifi Salim, 2011). The model is based on a pairwise comparison and determining the preferences of the elements on each other relative to a certain criterion (Rahnama and Kazemi Biniaz, 2011:

102). The AHP factors have been performed by the opinion of senior experts of the municipality and general governance of Arak City. In doing the effort, a list of the selected factors has been prepared to make an order of their opinions for comparison based on the orders.

Technique to Order Preferences by Similarity to Ideal Solution (TOPSIS) model has been employed to determine the optimum location. Based on literature review and also the structure of spatial criteria's, TOPSIS is a supplementary method for MCDM. It is possible to exchange the scores of indicators based on the intensity of influences. In this method that is used for achieving suitable areas, M options are evaluated by N indicators each problem can be considered as a geometric system of M point in an N dimensional space. The premise of the method is that the selected option should have the least minimum distance with the positive ideal state and the highest distance with the negative ideal state. This is supposed that the suitability of each indicator has smoothly increased or decreasing and defined for both the positive (A+) and negative (A-) ideal options. Using Euclidian theory, the separation distance of i^{th} option can be calculated by the ideals. The relative vicinity of Ai to the ideal solution is initially calculated and, then a ranking is made of the descending order of the available options. (Ghohroudi Tali et al., 2012). For the best result when we used TOPSIS model, the procedure of run this model is carried out in 6 steps as follows:

1- Decision-making matrix has been formed from the collected data about the landforms.
2- The matrix has been normalized using the standardization method.
3- Weighted normalized decision matrix has been calculated by multiplying the normalized decision matrix by the corresponding weights.
4- Finding the positive and negative ideals. The greatest value of each indicator is determined as a positive ideal (A+) and the least value as a negative ideal (A-). j+ is with positive criteria and j- with negative criteria.
5- Calculating the size of separation. The distance to the positive and negative ideal has been calculated by the Euclidian method.

"The relation 3 and relation 4 are used for determining positive ideal (A+) and the least value as a negative ideal (A-)".

Relation 3 $$D_i^+ = \sqrt{\sum_{j=1}^{n}(v_{ij}-v_j^+)^2} \rightarrow i = 1,2,\dots,m$$

Relation 4 $$D_i^- = \sqrt{\sum_{j=1}^{n}(v_{ij}-v_j^-)^2} \rightarrow i = 1,2,\dots,m$$

6- Relative proximity of each option to the ideal solution. This has been calculated by relation 5.

Relation 5 $$CL_1 = \frac{D_i^-}{D_i^- + D_i^+} \rightarrow i = 1,2 \dots ,m: 0 \leq CL_1 \leq 1$$

The value of CL index is ranged from 0 to 1. The highest score of the index represents the priority of that option for selection (Sepehr and Zucca, 2012). Based on the 6 steps of Topsis analysis on the landforms and indices showed a range of change among landforms based on the indices. The range of changes landforms based on indices in landforms by TOPSIS analyses in percent shows in Figure 3.

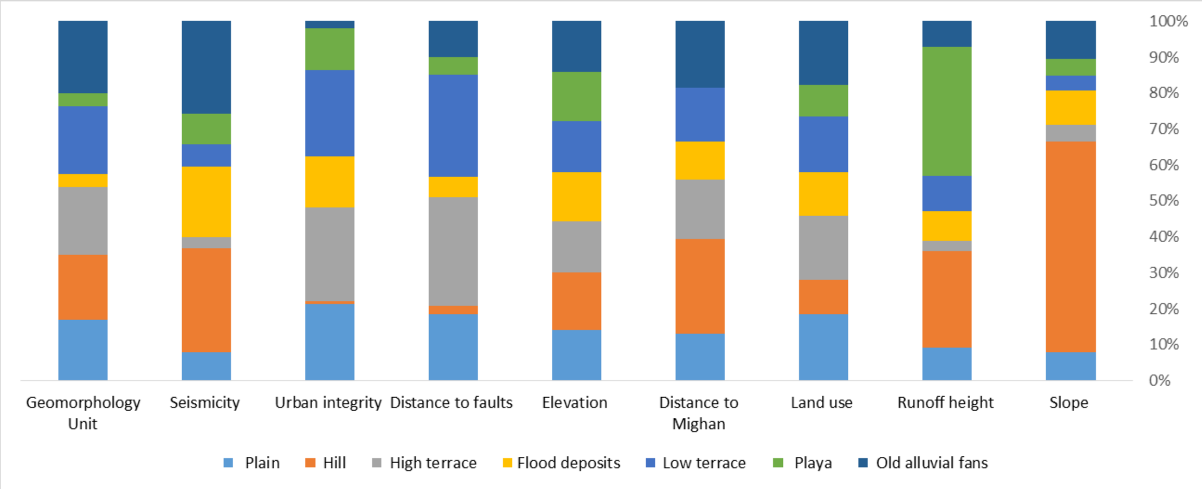

Figure 3. Range of changes of the indices in landforms

3. RESULTS

As it has been mentioned, the units of the study area have been determined based on the landforms, and the selected indices have been extracted in each landform. The standardized matrix has been converted into a pairwise comparison matrix using AHP according to the expert opinions to obtain the weights of the spatial criteria. Then, the weights have been included in the decision-making matrix. Finally, the ranking matrix of landforms has been obtained and the ideal conditions for physical development have also been determined by AHP. The weights of the criteria by AHP for obtaining the best areas for urban developing are represented in Table 1.

Table 1. Weights of effective criteria based on AHP

Criteria	Geomorphology unit	Seismicity	Urban integrity	Distance to faults	Elevation	Distance to Mighan desert	Land use	Runoff height	Slope
Weights of criteria	0.04477	0.0324	0.2005	0.1150	0.246	0.0758	0.24	0.0242	0.01

Priority of landforms for urban development that weighted and resulted by the AHP method are used in TOPSIS method. The highest score of TOPSIS determined the priority of the option for selecting as suitable for the physical development. Table 2 illustrates prioritization of landforms using TOPSIS model to achieve best areas of the city for development planning.

Table 2. Prioritization of landforms using TOPSIS model

Landform	Distance to positive ideal	Distance to negative ideal	TOPSIS value	Priority
Plain	0.199	0.297	0.597	11
Hill	0.319	0.221	0.408	20
High terrace	0.222	0.295	0.570	13
Plain	0.111	0.336	0.075	2
Flood deposits	0.244	0.266	0.521	16
Plain	0.161	0.326	0.668	9
Flood deposits	0.249	0.268	0.518	17
Low terrace	0.235	0.276	0.539	15
Playa	0.297	0.268	0.474	18
Flood deposits	0.166	0.347	0.676	6
Old alluvial fans	0.120	0.336	0.737	3
Plain	0.166	0.345	0.675	7
Plain	0.182	0.330	0.644	10
Old alluvial fans	0.109	0.374	0.774	1
Old alluvial fans	0.156	0.322	0.673	8
Plain	0.136	0.373	0.732	4
Plain	0.209	0.278	0.570	12
Flood deposits	0.136	0.335	0.711	5
low terrace	0.220	0.277	0.557	14
Hills	0.313	0.227	0.420	19

Figure 4 indicates the prioritization of landforms by TOPSIS and the position of the study area.

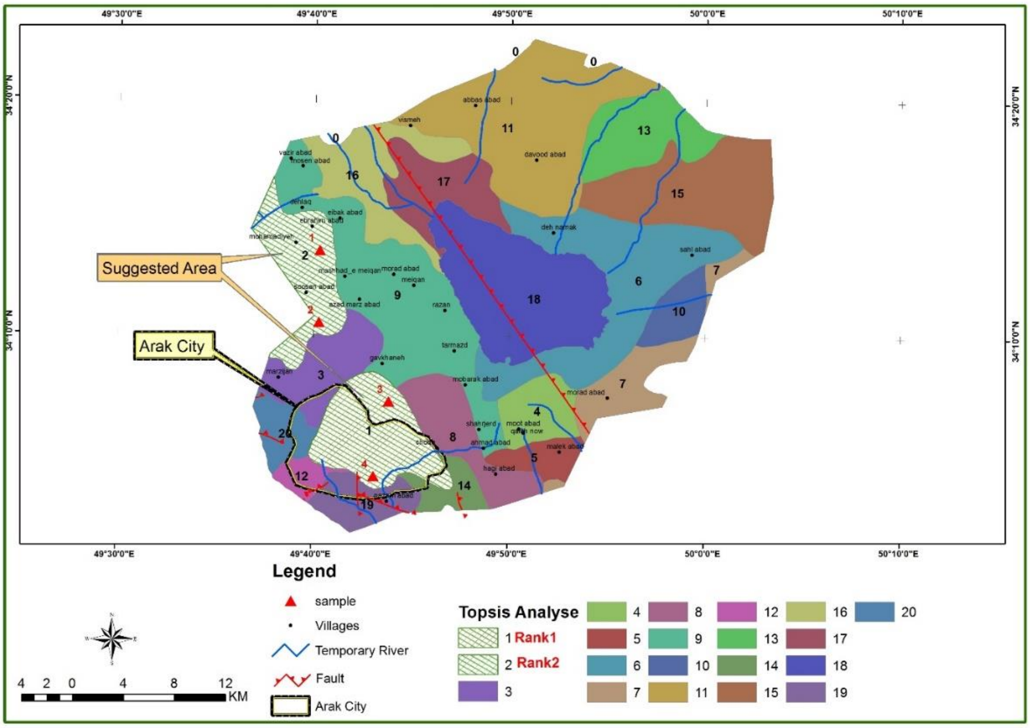

Figure 4. Ranking of landforms by TOPSIS

3.1 Discussion

Execution of TOPSIS has resulted in the suggestion of two areas for physical development in Arak City. The 1st priority is the area that Arak City is located on. Thus the location of the city at present is good and the result of TOPSIS model was close to real conditions. This is indicative of the facts that it is required to find the geographical conditions similar to those of the current city of Arak for physical development and residence in future. Therefore, according to the expert knowledge and Arak municipalities, urban planning and architecture department's standards, the revival of the old urban texture and vertical expansion of the city can be a priority. The 2nd priority based on TOPSIS model is an area in the northwestern part of Arak City, at a distance of 9590 meters from the city center. This is in the vicinity of Arak-Farmahin transportation road. There are three villages of Mohammadieh, Susanabad, and Ebrahimabad in this area that located in the second priority of arak city development. Figure 5 shows the location of suitable area's position for urban development of Arak city.

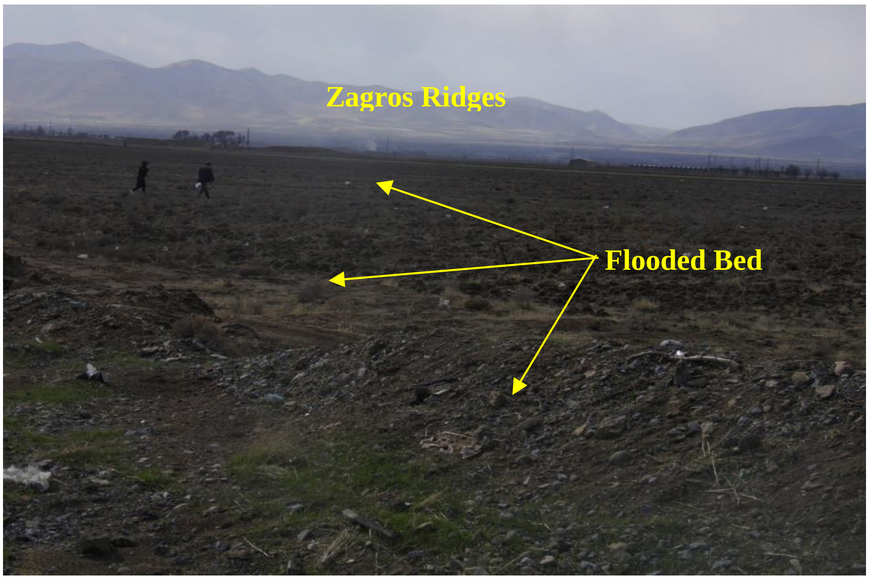

Figure 5. The suggested area (Rank2) in northwest part of Arak City

According to the results, a suitable area for urban development is where it has easy access to engagement sites and satisfied transportation facilities. The site should be suitable for residential development and without any effects of flooding, fogs, annoying air pollution, and intervening industries. The selected site must be in the proximity of suitable neighborhood zones or support the rules of interesting developments (Chiara, et al. 1994). The area that suggested by the result of this research as the suitable areas in terms of the mentioned conditions. The area has also suitable relational situation due to its proximity to the Arak-Farmahin Road. The near distance of the area to Arak City and proper distance to established industries is also important in the suitability of the area.

It is necessary to avoid construction of buildings near the faults due to possible devastating effects. The suggested area is at a distance of 8866 meters to fault lines and 2 km to the cemetery (Institute of Standards and Industrial Researches of Iran, by Kuhsari, 2006). The best topographic condition for houses is a flat ground or a relatively smooth area with a slope less than 10 to 20 percent. The suggested area has a slope of 1.6 percent. The slope between 2 to 6 percent can facilitate the drainage. The smooth and flat areas are likely to be inundated in rainy seasons. (Kakran, 2012)

To evaluate the suggested area and study more precisely the natural conditions and formative processes, a random sediment sampling was made at 4 points to 40 cm depth from the surface. Figure 3 shows the coordinate of samples. Analysis of the granulation of the sediments and the extracted charts revealed that the samples had a mixture of fine and coarse grains. Comparison of the sorting of the samples with Folk Sorting Index revealed also that the samples are not same in sorting. This is indicative of frequent recurrences of water flows into the area and place in different forms on the setting of the region (different slopes and elevation); the lack of uniformity in the samples of different areas is the characteristic of this floodplains that determined as good areas for urban development. Comprehensive sorting index by CRUMBINE index on a logarithmic scale examine the regulation in sediment curves. The smaller value of the index, the more ordered is the sediment curve. The skewness can be used to interpret the sediment environment processes transferring the deposits. The skewness coefficient is positive in three samples. This indicates that the sedimentation occurred in a slow environment with fine grain sediments. This, in turn, represents staying of water after flooding flows (Ghohroudi, 2012). The symmetry coefficient in the curve shows regularity in two sides of the median; because it is likely that there is regularity in the curve but in the two sides the particle distribution is different. The coefficient value is zero for a symmetric curve. If the fine grains are more regular the coefficient will be positive and if the coarse grains are more regular it will be negative. The symmetry coefficient for the three curves indicates that the coarse grains are more regular and just the sample 3 has negative skewness with more regular fine grains.

The results of the sedimentology analysis that is represented in Table 3, emphasizes that the suggested area is located in a flooded bed created by flash floods and sheet flows in climatic conditions different from present times.

Table 3. Results of sediment analysis

Samples Number	Sorting index	Comprehensive sorting	Skewness
1	0.425	0.559	2.122
2	1.404	1.249	2.928
3	2.775	1.992	0.756-
4	0.216	0.342	1.095

4. CONCLUSION

The cities are established over a geographical environment of particular natural conditions involving urban design. Arak City is located in an endorheic basin on a bed composed of flood-alluvial sediments alongside accumulation of evaporative deposits on a broken wetland coast exposed to sheet flows. The possibility of the areas for future physical development of the city has been analyzed by natural indices and quantitative models. The results of the research have indicated that east and northwestern part of the Arak City has the best suitability for future development of the city. It is capable for the future physical development more than other areas. The sedimentology examination of the study area has indicated that the area is located in a flooding bed involving special urban architecture. Also the results of the research have also classified unsuitable areas for the physical development, the areas on which the development may result in many hazards. Therefore, it is required to conduct the physical development of Arak City towards the suggested area.

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