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Plant Type Selection for Reclamation of Sarcheshmeh Copper Mine by Fuzzy-TOPSIS Method

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Abstract: The extent of lands especially the waste dump areas that are affected by mining activities will increase by mining more and more and widening the operational area of the mines. Thus, the need for performing mine reclamation will increase every day. Plant type Selection and planting to protect the environment and the reclamation of the mine are some of the most important solutions. For this case study in the Sarcheshmeh Copper Mine, which is one of the 10 biggest copper mines of world, plant types were selected based on reclamation plan's primary criteria that are: Kind of post mining land use, Climate, Nature of soil. Then, comparison matrixes based on questionnaires that were completed by experts were obtained and plant types were prioritized by Fuzzy-Topsis method based on secondary criteria that are: Perspective of the region, resistance against disease and insects, strength and method of growth, availability to plant type, economic efficiency, Protection of soil and storing water, prevention from pollution, Respectively suitable plant types in the mining perimeter were prioritized as follows: Amygdalus scoparia, Tamarix, Pistachio Wild, Ephedra, Astragalus, Salsola.

Keywords: Mine Reclamation, Plant Type Selection, Sarcheshmeh Copper Mine, Fuzzy TOPSIS, Amygdalus Scoparia.

1 Introduction

Today, one of the issues highly regarded for developing and even industrialized countries, is the Environment and the environmental preservation. In addition progress and prosperity, in new established mines areas will necessarily exist environmental effects. according to the statistical and findings, in the general sense, reclamation means the preparation of the extracted ground for post mining land use, which is introduced at Surface Mines. From the early stages of mining operations, mine Reclamation should be considered as inseparable part of the whole design of mine. In addition to environment preservation, lands to production cycle can also return (Osanloo and parsaei. 2004). In general, mine site should be reclaimed so that and breeding plant and animal species and Perspective of the region. To mine reclamation the ultimate land-use and morphology of the site are compatible with either the current land-use in the surrounding area, or with the pre-mining environment (Soltanmohammadi et al., 2010). The mine reclamation is important of decrease pollution and annihilating of smoothly and suitable grounds for growing to any subsequent use of the land affected and the area environment protection, species selection and plant types implant one of the steps is important (Xia, Lu. 2008). For instance, Coppin and Bradshaw (1982); Monterroso et al. (1998); Chen et al. (1998); Askenasy et al. (1998); Howat (2000); Maiti and Ghose (2005); Tafi et al. (2006) and Carrick and Kruger (2007) have evaluated the factors limiting plant growth on mined soils and mentioned the most serious soil limitations. Cairns (1982); Alexander (1996); Wisconsin (2000); Coppin and Box (1999); Errington (2001); Paschke et al. (2003); Stellin et al. (2005); and osanloo, akbari, hamidian (2007), have focused on special post-mining land-uses that were exercised in some mine sites (Soltanmohammadi et al.,2010). Bangian (2008) has selected, proper plant species for Sungun Copper Mine Reclamation by traditional AHP method (Bangian and Osanloo., 2008). Alavi et al., (2011) have selected, proper Plant Species for sarcheshmeh Copper Mine Reclamation by fuzzy AHP method. (Alavi et al., 2011).

2. Materials and methods

2.1. Importance of selected plant species in the reconstruction of the mine

Reclamation of the mine is a necessary step, in order to post mining land use, plantership and create green space for the region. Thus plant types selecting, is one of the major steps in reaching to the goals of reclamation project. superior Plant Type Selection in every reclamation program, have the many benefits that contain: health protection and environment restoring, Perspective of the region, economic benefit, the welfare of life for local people, pollution reduce of soil and water and air, underground water supply, prevent of soil erosion (Bangian and Osanloo.,2008).

2.1.1 Factors in selecting plant species

A) The primary factors:

Type of post mining land use, zone climate, Nature of soil. Initial selection of plant types is studied for mine reclamation, must be done based on the primary factors. The Plant types should harmonious and cooridnation with the primary factors.

Types of post mining land use can include: land Revert to the initial state - agricultural activities - afforest and wildlife - beautification and creating tourist attractions-the industrial and residential settlements (Akbari et al., 2007). Species should be compatible with each of the cases mentioned above. A result at this step, only species that are coordinated with type of post mining land use, accede to the next step. Then the present types have been examined according to the second primary factor. The second factor for primary selection of plant types is regional climate condition. So at this stage, among the selected types from the first step, the types that are accorded with local climatic conditions are selected, and other alternative are rejected. At this stage, the indigenous types have priority in terms of the compatibility with the climate. Region Climate is included of Slope and ground type, lighting and sunlight, weather, moisture, temperature, wind, air pollutants. Zone Soil quality also is the third element for the primary factors that among the selected types based on the first and second factors, rejected some of alternatives. The kind of soil is considered based on existence of acid or alkali, salinity, heavy metals, organic materials (Osanloo., 2001).

B) Secondary factors

C1) Perspective of the region, C2) resistance against disease and insects, C3) strength and method of growth, C4) availability to plant type, C5) economic efficiency, C6) Protection of soil and storing water, C7) prevention from pollution (Alavi et al., 2011)

2.2. Case Study

Rafsanjan city in Lut Desert the southern margin and the northwest province of Kerman in latitude 30 degrees north and longitude 56 degrees east is located. Sarcheshmeh Copper Mine with coordinates 55° 52' 20" east longitude and 29° 56 ' 40" north latitude and altitude 2620 m on average, is one of the 10 biggest copper mines of world that in 65 km southwest of Rafsanjan is located. Sarcheshmeh Copper mine in southeastern Iran is located (Alavi et al., 2011). In this research, according to the necessary parameters to mine reclamation, first overall studies are accomplished about the past and present regional environment, for Sarcheshmeh Copper Mine. Objectives of this research are, mine reclamation and maintain of mine environment, apposite Plant type Selection for reclamation mine and beautify the area around the mine and mine tailings dam. In Kerman sarcheshmeh Copper Mine as one of the world's largest open pit mines and one of country′s the mineral and industrial poles also should attention to the reconstruction plans. Because Sarcheshmeh Copper Mine is created many environment problems for district people and lands and underground waters, for beauty of Perspective of the region and the environment protection need to reclamation to different ways that due to the remoteness the mine of city and the lack of verdant region, apposite Plant type Selection is best method.

2.2.1 Primary factors check of Plant types Selection in Sarcheshmeh Copper Mine

1- Type of post mining land use: Considering the situation of the region and being away from the city, plant is best option for post mining land use.

2- climate: Rafsanjan have cold winters and hot summers, which is desert region with temperate dry climate and average rainfall 91mm. during statistics terms in the mine stations, the average relative humidity is 38%. Annual changes of temperature in the area are of - 22 till +32 C. Desired plants should be compatible with the climate (Alavi et al., 2011).

3-Nature of soil: according to Experimentations of the region soil, due to being pyrite in regional soil, acidity soil is very high. The amount of lead and copper and molybdenum and sulfate exceeded standards. With regard to the mentioned properties of the soil, plant types are proposed as to consistency and viability against acidic condition. These plants absorb elements and prevent the pollution from reaching to around of the residential areas (Alavi et al., 2011).

2.3. Plant type Selection based on secondary factors by Fuzzy-TOPSIS method

The TOPSIS method was firstly proposed by Hwang and Yoon. The basic concept of this method is that the chosen alternative should have the shortest distance from the positive ideal solution and the farthest distance from negative ideal solution. Positive ideal solution is a solution that maximizes the benefit criteria and minimizes cost criteria, whereas the negative ideal solution maximizes the cost criteria and minimizes the benefit criteria. The fuzzy TOPSIS method is proposed where the weights of criteria and ratings of alternatives are evaluated by linguistic variables represented by fuzzy numbers to deal with the deficiency in the traditional TOPSIS. Chen extended the TOPSIS to the fuzzy environment (Chen. 2000). The algorithm of this method can be described as follows (Momeni. 2009):

1. Construct the fuzzy decision matrix:

Considering the listed factors and expert opinions, questionnaires was prepared such that For example, criteria questionnaire toward goal and alternatives importance questionnaire than the sixth criteria (Protection of soil and storing water) are shown in Table 1 and Table 2. Decision matrix is displayed in Table 3. Below, the importance

Table1. Criteria questionnaire toward goal

Importance /criteria	Very low	low	Medium	High	Very high
C1					
C2					
C3					
C4					
C5					
C6					
C7					

Table2. Alternatives questionnaire toward C6

Importance / Alternative in C6	Very low	low	Medium	High	Very high
Pistachio					
Amygdalus					
Ephedra					
Astragalus					
Salsola					
Tamarix					

Table3. Decision matrix for Fuzzy Topsis method

	C1	C2	C3	C4	C5	C6	C7
A1	5,7,9	2,3,5	2,3,5	5,7,9	3,5,7	7,9,9	7,9,9
A2	3,5,7	3,5,7	5,7,9	7,9,9	5,7,9	5,7,9	5,7,9
A3	3,5,7	5,7,9	3,5,7	5,7,9	3,5,7	3,5,7	5,7,9
A4	2,3,5	3,5,7	3,5,7	5,7,9	2,3,5	3,5,7	2,3,5
A5	3,5,7	3,5,7	2,3,5	5,7,9	2,3,5	3,5,7	2,3,5
A6	5,7,9	5,7,9	3,5,7	5,7,9	2,3,5	5,7,9	3,5,7

Table4. The distances from FNIS

Distance	C1	C2	C3	C4	C5	C6	C7	SUM
d(A1,A+)	0,153	0,221	0,221	0,132	0,119	0,076	0,076	0,999
d(A2,A+)	0,196	0,171	0,117	0,108	0,101	0,117	0,117	0,928
d(A3,A+)	0,196	0,117	0,171	0,161	0,119	0,171	0,117	1,053
d(A4,A+)	0,237	0,171	0,171	0,132	0,138	0,171	0,221	1,242
d(A5,A+)	0,196	0,171	0,221	0,132	0,138	0,171	0,221	1,251
d(A6,A+)	0,153	0,117	0,171	0,132	0,138	0,117	0,171	1,000

Table5. The distances from FPIS

Distance	C1	C2	C3	C4	C5	C6	C7	SUM
d(A1,A-)	0,196	0,079	0,079	0,123	0,079	0,212	0,239	1,008
d(A2,A-)	0,140	0,138	0,203	0,135	0,107	0,177	0,203	1,102
d(A3,A-)	0,140	0,203	0,138	0,123	0,079	0,115	0,203	1,000
d(A4,A-)	0,087	0,138	0,138	0,123	0,052	0,115	0,079	0,733
d(A5,A-)	0,140	0,138	0,079	0,123	0,052	0,115	0,079	0,727
d(A6,A-)	0,196	0,203	0,138	0,123	0,052	0,177	0,138	1,027

coefficient of questionnaire to both qualitative and quantitative is come. Importance of qualitative displace by quantitative. Fuzzy numbers defined the very low [1, 2 , 3], low [2,3,5], medium [3,5,7],high [5,7,9], very high [7,9,9].

2. Determine criteria weight: weight vector (0 till 1) is obtained from to normalize the importance coefficient that by division the fuzzy numbers of importance coefficient on their total accounts.

[1 = 0.037, 2 = 0.074, 3 = 0.111, 5 = 0.185, 7 = 0.259, 9 = 0.333]

3. Normalize the fuzzy decision matrix: for positive criteria, selected the highest number in each column, then all numbers are divided thereon. For negative criteria, selected the lowest number for each column and divide on the all number. (Note that in denominator, are displaced lower bound and upper bound.) Because this research, all criteria are positive, formula is based on positive criteria.

$$\tilde{r}ij = \Bigg(\qquad (1)$$

$\tilde{r}$ij= element of normalized matrix, aij: the first component = = maximum component of each column , .

4. Construct weighted normalized fuzzy decision matrix

$$\tilde{V}ij = \tilde{r}ij\ (.)\ \tilde{W}ij \quad (2)$$

$\tilde{V}$ ij = weight vector, $\tilde{W}$ ij = weighted normalized

5. Determine FPIS and FNIS: the fuzzy positive ideal solution (FPIS, A+) and fuzzy negative ideal solution (FNIS, A−) are determined as:

$V_j^{+} = \max_i \{\tilde{v}_{ij3}\}$ = most ideal in each column.

$V_j^{-} = \min_i \{\tilde{v}_{ij1}\}$ = most anti ideal in each column.

$$A^{+} = (\tilde{v}_1^{+}, \tilde{v}_2^{+}, \ldots, \tilde{v}_n^{+}) \quad (3)$$

.

$$= (\tilde{v}_1^{-}, \tilde{v}_2^{-}, \ldots, \tilde{v}_n^{-}) \quad (4)$$

6. Calculate the distance of each alternative from FPIS and FNIS: in tables 4 and 5 are shown.

$$d_i^{+} = \sqrt{\frac{1}{3}\sum_{j=1}^{n}(\tilde{V}_{ij} - v_j^{+})^2} \quad (5)$$

$$= \sqrt{\frac{1}{3}\sum_{j=1}^{n}(\tilde{V}_{ij} - v_j^{-})^2} \quad (6)$$

7. Calculate the closeness coefficient of each alternative: a closeness coefficient (CC) is defined to rank all possible alternatives. The closeness coefficient represents the distances to the fuzzy positive ideal solution (A+) and fuzzy negative ideal solution (A−) simultaneously. The closeness coefficient of each alternative is calculated as:

$$C = \quad (7)$$

8. Rank the alternatives according to their closeness coefficient: According to the closeness coefficient, the ranking of the alternatives can be determined in table 6. Obviously, according to Eq. an alternative A would be closer to FPIS and farther from FNIS as CC approaches to first. Finally, in table 6, indicated ranking of plants.

3. Result

Firstly around the of Kerman sarcheshmeh copper mine area, are surveyed, for choosing the best plant type. Then a series of tests, including testing of soil, water and native plants growing in the area are performed. Samplings in this study were several crescive plant types in near the Sarcheshmeh copper mine, which have been evaluated. According to opinions of the natural resources and environmental administration experts and Rafsanjan mine engineers expertism in questionnaire form and by using fuzzy TOPSIS method, results show that the best plant types according to the region conditions and criteria, is Amygdalus scoparia,. However, Tamarix, Pistachio, Ephedra, Astragalus, Salsola, have good condition too.

In fuzzy TOPSIS decision makers used the linguistic variables the importance of the criteria and to evaluate the each alternative with respect to each criteria. These linguistic variables converted into triangular fuzzy numbers and fuzzy decision matrix was formed. Then normalized fuzzy decision matrix and weighted normalized fuzzy decision matrix were formed. FPIS and FNIS were defined that most ideal in each column are = (0.333, 0.333, 0.333, 0.259, 0.185, 0.333, 0.333) and most anti ideal in each column are = (0.041, 0.057, 0.057, 0.061, 0.016, 0.086, 0.057). Distances of each alternative were calculated from FPIS and FNIS that are shown in tables 4 and 5. Then the closeness coefficient of each alternative was calculated separately. According to the closeness coefficient of six alternatives, the ranking order of six alternatives has been determined as A2>A6>A1 >A3>A4>A5 that is shown table 6.

Table6. Values of plant types by fuzzy TOPSIS method

A2= 0.543	1.Amygdalus Scoparia
A6= 0.507	2.Tamarix
A1= 0.502	3.Pistachio
A3= 0.487	4.Ephedra
A4= 0.371	5.Astragalus
A5=0.367	6.Salsola

4. Conclusion

Decision-makers face up to the uncertainty and vagueness from subjective perceptions and experiences in the decision making process. By using fuzzy Topsis, uncertainty and vagueness from subjective perception and the experiences of decision-maker can be effectively represented and reached to a more effective decision. Firstly around the of Kerman sarcheshmeh copper mine area, are surveyed, for choosing the best plant type. Then a series of tests, including testing of soil, water and native plants growing in the area are performed. Samplings in this study were several coercive plant types in near the Sarcheshmeh copper mine, which have been evaluated. According to opinions of the natural resources and environmental administration experts and Rafsanjan mine engineers expertism in questionnaire form and by using fuzzy Topsis method, results show that the best plant types according to the region conditions and criteria, is Amygdalus scoparia. However, Pistachio, Tamarix, Ephedra, Astragalus, Salsola, have good condition too. It’s citable that because this study has been done in sarcheshmeh copper mine, for the first time, it is necessary to do it as a practical implementation in next years. However, due to the dire environmental situation happened around of the mine, planting the plant types should be placed in sarcheshmeh mine responsibles priority, to absorb different pollutions and harmful elements and is given certain beauty to the surrounding landscape.

Results are codified based on Controller program that help to improvement the environment around of the sarcheshmeh copper complex that main program is described below:

1. Control program of soil erosion: the amount of soil erosion should study and stabilize eroded lands, once every six months.
2. Management program of Water resources: must apply effectively rules, for water resource control and to balance the water level and to prevent of additional removal of water and. this process every six months can be done once.

3. Control Program of Environmental Pollution: With regard to environmental conditions, pollutant sources and environmental impacts associated with them, at different levels of soil and water, should be reported sampling and tests, to EPA organization periodically and analyze with environmental standards.

4. Control program of plant cover: in order to control of region plant cover, must implant native plant types that are compatible with region condition and decrease pollution. Every six months the plant cover study and sample than past in region.

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