ORIGINAL RESEARCH PAPER

Mathematics

IDENTIFYING THE ECONOMIC VIABILITY OF A CROP USING STOCHASTIC EDAS

KEY WORDS: Stochastic EDAS, Irrigation, MCDM, crop selection,water Management

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ABSTRACT

In this paper Stochastic Evaluation Based on Distance from Average Solution (EDAS) method is used for choosing a best crop in terms of economic viability based on water requirement with respect to Duration, Number of Irrigations during cultivation, water consumptionand labour cost involved during the process of crop cultivation. This is numerically solved by a physical data from the field..

INTRODUCTION

Many MCDM methods and techniques have been developed in the past decades.The ANP [13], COPRAS[8], WASPAS[3], ARAS[15],MOORA[4]and EDAS [9] are some of the MCDM methods. These methods have been extended in many studies to handle MCDM problems in different uncertain environments [6,7]

Stochastic EDAS method deals with multi criteria decision making problems. EDAS method is an efficient and relatively new method proposed by KeshavarzGhorabaee [9]. This has been extended to handle MCDMproblems in different uncertain environments [1, 2, 5 ,10, 11]. Recently, the EDAS method has also been applied to some engineering problems [14, 15]. Here the performance values are represented in the form of random variables. Mehdi et.al., [12] depicted the characteristics of normal distribution and EDAS method. In this method the performance values will follow normal distribution. The best alternative is determined based on the positive and negative distance from the average solution.

APPLICATION OF CROP SELECTION

The mathematical procedure for a stochastic EDAS method is given below:

Step1:A stochastic MCDM problem can be expressed in the matrix form as

$$X=\begin{pmatrix}(a_{11},\sigma_{11})(a_{12},\sigma_{12})\cdots(a_{1m},\sigma_{1m})\\(a_{21},\sigma_{21})(a_{22},\sigma_{22})\cdots(a_{2m},\sigma_{2m})\\\vdots\quad\quad\vdots\quad\quad\vdots\\(a_{n_1},\sigma_{n1})(a_{n2},\sigma_{n2})\cdots(a_{nm},\sigma_{nm})\end{pmatrix}$$

whereaijand σij denote the mean and standard deviation of the performance value of ith alternative on jth criterion. . aijand σij is the performance value of alternatives Ai with respect to criterion Cj ,wjis the "eight of criterionCj

Step2:The average solution of each criterion is calculated as

$$A_j=\frac{1}{n}\sum_{i=1}^{n}a_{ij}$$

Step3: Normal Distributions are within the five standard deviation σ_{ij} away from the mean

$$\sigma_{ij}\pm 5\sigma_{ij}$$

The values are derived based on the type of the criteria (Beneficial or Non Beneficial).

We use the below equations to find the optimistic and pessimistic values

If jthcriterion is a Beneficial criterion,

$$pde^o_{ij}=\frac{\max(0,(a_{ij}+5\sigma_{ij}-A_j))}{A_j}$$

$$pde^p_{ij}=\frac{\max(0,(a_{ij}-5\sigma_{ij}-A_j))}{A_j}$$

$$nde^o_{ij}=\frac{\max(0,(A_j-a_{ij}-5\sigma_{ij}))}{A_j}$$

$$nde^p_{ij}=\frac{\max(0,(A_j-a_{ij}+5\sigma_{ij}))}{A_j}$$

If j[th]criterion is a non - Beneficial criterion, then

$$pde^o_{ij}=\frac{\max(0,(A_j-a_{ij}+5\sigma_{ij}))}{A_j}$$

$$pde^p_{ij}=\frac{\max(0,(A_j-a_{ij}-5\sigma_{ij}))}{A_j}$$

$$nde^o_{ij}=\frac{\max(0,(a_{ij}-5\sigma_{ij}-A_j))}{A_j}$$

$$nde^p_{ij}=\frac{\max(0,(a_{ij}+5\sigma_{ij}-A_j))}{A_j}$$

In our problem Duration and No of Irrigation are considered as Beneficial Criteria. Water Consumption and Labour Cost are considered as Non-Beneficial Criteria.

Step4: Calculate the Optimistic weighted sum of positive and negative distance & pessimistic weighted sum of positive and negative distance. In this method we have assumed the weights of each criterion as 0.25 Optimistic weighted sum of positive and negative distance is calculated using the formula,

$$sp^o_i=\sum_{j=1}^{m}w_j\,pde^o_{ij}$$

$$sn^o_i=\sum_{j=1}^{m}w_j\,pde^o_{ij}$$

Pessimistic weighted sum of positive and negative distance is calculated using the formula,

$$sp^p_i=\sum_{j=1}^{m}w_j\,pde^p_{ij}$$

$$sn^p_i=\sum_{j=1}^{m}w_j\,nde^p_{ij}$$

wherew^j is the weight of jth Criterion and

$$\sum_{j=1}^{m} w_j = 1$$

Step5: Calculate the Normalized values of optimistic weighted sum of positive & negative distance. Similarly calculate the Normalized values of pessimistic weighted sum of positive & negative distance using the below formulas.

$$nsp_i^o = \frac{sp_i^o}{max_i(sp_i^o)},$$

$$nsn_i^o = 1 - \frac{sn_i^o}{max_i(sn_i^o)}$$

$$nsp_i^p = \frac{sp_i^p}{max_i(sp_i^p)},$$

$$nsn_i^p = 1 - \frac{sn_i^p}{max_i(sn_i^p)}$$

Step6: Determine the optimistic appraisal score as_i^o and pessimistic appraisal score as_i^p of the alternatives. With the optimistic appraisal score and pessimistic appraisal score derive the adjusted appraisal score as_i^γ with parameter γ using the formulas

TABLE – 1

Criteria	Duration (C_1)	Number of Irrigation (C_2)	Water Consumption (C_3)	Labour Cost (C_4)
Average Solution Aj	176.78	16.22	4451.56	19711.00

$$as_i^o = \left(\frac{1}{2(nsp_i^o + nsn_i^o)}\right), \quad as_i^p = \left(\frac{1}{2(nsp_i^p + nsn_i^p)}\right)$$

Adjusted appraisal score

$$as_i^\gamma = \gamma . as_i^o + (1-\gamma) as_i^p$$

Step7: Ranking the alternatives based on the highest score of adjusted appraisal score.

CASE ANALYSIS

A data has been collected for nine major crops with three replications in each type of crop in a particular region of South India and the parameters such as Duration of the crop, Number of irrigation involved in the crop cultivation, Water Consumption and labour cost involved in crop cultivation in the three different fields and the mean and standard deviation of all the alternatives of the corresponding criteria are arrived for our analysis.

TABLE – 2 INPUT DATA OF NINE DIFFERENT CROPS

Criteria	Description
Duration (C_1)	Duration of the crop
Number of Irrigation(C_2)	Number of Irrigation
Water Consumption(C_3)	Quantity of Water required
Labour Cost(C_4)	Labour Cost involved in crop cultivation

TABLE-3
AVERAGE SOLUTION OF CRITERION

Cri	Duration		No of Irrigation		Water Consumption		Labor Cost	
Alt	Mean	STD	Mean	STD	Mean	STD	Mean	STD
A_1	349	3.6	30	3.0	6966	152.7	36000	250
A_2	303	25.1	35	5.5	8050	132.2	41933	404.1
A_3	270	26.4	24	5.5	9533	152.7	29950	229.1
A_4	166	17.5	11	4.5	3231	59.2	13216	125.8
A_5	146	40.4	12	3.0	2516	76.3	14303	268.3
A_6	131	38.8	14	3.0	2820	81.8	18016	76.3
A_7	63	15.2	6	2.5	1840	96.4	7175	66.1
A_8	95	27.8	9	3.0	2083	76.3	10783	76.3
A_9	68	33.2	5	1.5	3025	66.14	6023	87.3

TABLE -.4
OPTIMISTIC POSITIVE DISTANCE

Alt	(C_1)	(C_2)	(C_3)	(C_4)
A_1	1.0861	1.7740	0.0000	0.0000
A_2	1.4239	2.8527	0.0000	0.0000
A_3	1.2740	2.1747	0.0000	0.0000
A_4	0.4340	1.0651	0.3407	0.3614
A_5	0.9686	0.6644	0.5205	0.3424
A_6	0.8385	0.7877	0.4584	0.1053
A_7	0.0000	0.1404	0.6949	0.6528
A_8	0.3237	0.4795	0.6178	0.4723
A_9	0.3237	0.0000	0.3948	0.7166

TABLE-.5
PESSIMISTIC POSITIVE DISTANCE

Alt	(C_1)	(C_2)	(C_3)	(C_4)
A_1	0.8724	0.0000	0.0000	0.0000
A_2	0.0041	0.0000	0.0000	0.0000
A_3	0.0000	0.0000	0.0000	0.0000
A_4	0.0000	0.0000	0.2077	0.2976
A_5	0.0000	0.0000	0.3491	0.2063
A_6	0.0000	0.0000	0.2746	0.0666
A_7	0.0000	0.0000	0.4784	0.6192
A_8	0.0000	0.0000	0.4464	0.4336
A_9	0.0000	0.0000	0.2462	0.6723

TABLE-.6
OPTIMISTIC NEGATIVE DISTANCE

Alt	(C_1)	(C_2)	(C_3)	(C_4)
A_1	0.0000	0.0000	0.3933	0.7630
A_2	0.0000	0.0000	0.6599	1.0249
A_3	0.0000	0.0000	0.9700	0.4613
A_4	0.0000	0.0000	0.0000	0.0000
A_5	0.0000	0.0000	0.0000	0.0000
A_6	0.0000	0.0000	0.0000	0.0000
A_7	0.2137	0.0000	0.0000	0.0000
A_8	0.0000	0.0000	0.0000	0.0000
A_9	0.0000	0.2295	0.0000	0.0000

TABLE-.7
PESSIMISTIC NEGATIVE DISTANCE

Alt	(C_1)	(C_2)	(C_3)	(C_4)
A_1	0.0000	0.0753	0.7364	0.8898
A_2	0.0000	0.5377	0.9568	1.2299
A_3	0.2194	1.2158	1.3130	0.5776
A_4	0.5559	1.7089	0.0000	0.0000
A_5	1.3168	1.1849	0.0000	0.0000
A_6	1.3564	1.0616	0.0000	0.0000
A_7	1.0735	1.4007	0.0000	0.0000
A_8	1.2489	1.3699	0.0000	0.0000
A_9	1.5544	1.1541	0.0000	0.0000

TABLE -8
OPTIMISTIC WEIGHTED SUM OF POSITIVE DISTANCE

Alt	(C_1)	(C_2)	(C_3)	(C_4)	Weighted sum
A_1	0.2690	0.4435	0.0000	0.0000	0.7125
A_2	0.3560	0.7132	0.0000	0.0000	1.0692
A_3	0.3185	0.5437	0.0000	0.0000	0.8622
A_4	0.1085	0.2663	0.0852	0.0904	0.5503
A_5	0.2421	0.1661	0.1301	0.0856	0.6240
A_6	0.2096	0.1969	0.1146	0.0263	0.5475
A_7	0.0000	0.0351	0.1737	0.1632	0.3720
A_8	0.0809	0.1199	0.1544	0.1181	0.4733
A_9	0.0809	0.0000	0.0987	0.1791	0.3588

TABLE-9
PESSIMISTIC WEIGHTED SUM OF POSITIVE DISTANCE

Alt	(C_1)	(C_2)	(C_3)	(C_4)	Weighted sum
A_1	0.2181	0.0000	0.0000	0.0000	0.2181
A_2	0.0010	0.0000	0.0000	0.0000	0.0010
A_3	0.0000	0.0000	0.0000	0.0000	0.0000
A_4	0.0000	0.0000	0.0519	0.0744	0.1263
A_5	0.0000	0.0000	0.0873	0.0516	0.1389
A_6	0.0000	0.0000	0.0687	0.0167	0.0853
A_7	0.0000	0.0000	0.1196	0.1548	0.2744
A_8	0.0000	0.0000	0.1116	0.1084	0.2200
A_9	0.0000	0.0000	0.0615	0.1681	0.2296

TABLE-10
OPTIMISTIC WEIGHTED SUM OF NEGATIVE DISTANCE

Alt	(C_1)	(C_2)	(C_3)	(C_4)	Weighted sum
A_1	0.0000	0.0000	0.0983	0.1907	0.2891
A_2	0.0000	0.0000	0.1650	0.2562	0.4212
A_3	0.0000	0.0000	0.2425	0.1153	0.3578
A_4	0.0000	0.0000	0.0000	0.0000	0.0000
A_5	0.0000	0.0000	0.0000	0.0000	0.0000
A_6	0.0000	0.0000	0.0000	0.0000	0.0000
A_7	0.0534	0.0000	0.0000	0.0000	0.0534
A_8	0.0000	0.0000	0.0000	0.0000	0.0000
A_9	0.0000	0.0574	0.0000	0.0000	0.0574

TABLE-11
PESSIMISTIC WEIGHTED SUM OF NEGATIVE DISTANCE

Alt	(C_1)	(C_2)	(C_3)	(C_4)	Weighted sum
A_1	0.0000	0.0188	0.1841	0.2225	0.4254
A_2	0.0000	0.1344	0.2392	0.3075	0.6811
A_3	0.0548	0.3039	0.3283	0.1444	0.8314
A_4	0.1390	0.4272	0.0000	0.0000	0.5662
A_5	0.3292	0.2962	0.0000	0.0000	0.6254
A_6	0.3391	0.2654	0.0000	0.0000	0.6045
A_7	0.2684	0.3502	0.0000	0.0000	0.6186
A_8	0.3122	0.3425	0.0000	0.0000	0.6547
A_9	0.3886	0.2885	0.0000	0.0000	0.6771

TABLE-12
NORMALIZED VALUE OF OPTIMISTIC WEIGHTED SUM OF POSITIVE DISTANCE

Alternative	Weighted Sum_Optimistic Positive	Normalized Optimistic Positive
A_1	0.7125	0.6664
A_2	1.0692	1.0000
A_3	0.8622	0.8064
A_4	0.5503	0.5147
A_5	0.6240	0.5836
A_6	0.5475	0.5120
A_7	0.3720	0.3480
A_8	0.4733	0.4427
A_9	0.3588	0.3355

TABLE -13
NORMALIZED VALUE OF PESSIMISTIC WEIGHTED SUM OF POSITIVE DISTANCE

Alternative	Weighted Sum_Pessimistic Positive	Normalized Pessimistic Positive
A_1	0.2181	0.7948
A_2	0.0010	0.0037
A_3	0.0000	0.0000
A_4	0.1263	0.4604
A_5	0.1389	0.5060
A_6	0.0853	0.3109
A_7	0.2744	1.0000
A_8	0.2200	0.8017
A_9	0.2296	0.8368

TABLE -14
NORMALIZED VALUE OF OPTIMISTIC WEIGHTED SUM OF NEGATIVE DISTANCE

Alternative	Weighted Sum_Optimistic Negative	Normalized Optimistic Negative
A_1	0.2891	0.3137
A_2	0.4212	0.0000
A_3	0.3578	0.1504
A_4	0.0000	1.0000
A_5	0.0000	1.0000
A_6	0.0000	1.0000
A_7	0.0534	0.8732
A_8	0.0000	1.0000
A_9	0.0574	0.8638

TABLE -15
NORMALIZED VALUE OF PESSIMISTIC WEIGHTED SUM OF NEGATIVE DISTANCE

Alternative	Weighted Sum_Pessimistic Negative	Normalized Pessimistic
A_1	0.4254	0.4884
A_2	0.6811	0.1808
A_3	0.8314	0.0000
A_4	0.5662	0.3190
A_5	0.6254	0.2478
A_6	0.6045	0.2729
A_7	0.6186	0.2560
A_8	0.6547	0.2126
A_9	0.6771	0.1856

TABLE-16
ADJUSTED APPRAISAL SCORE

Alt	Optimistic appraisal score	Pessimistic appraisal score	Adjusted appraisal score	Ranking
A_1	0.4900	0.6416	0.5658	5
A_2	0.5000	0.0923	0.2961	8
A_3	0.4784	0.0000	0.2392	9

A_4	0.7573	0.3897	0.5735	4
A_5	0.7918	0.3769	0.5843	3
A_6	0.7560	0.2919	0.5240	7
A_7	0.6106	0.6280	0.6193	1
A_8	0.7213	0.5071	0.6142	2
A_9	0.5997	0.5112	0.5554	6

CONCLUSIONS

In this paper we have discussed stochastic EDAS method for determining the Best crop which consumes less amount of water with additional parameters such as duration, no of irrigation and labour cost involved in crop cultivation. From the above results we conclude that ^{A7} is the best crop with highest adjusted appraisal score value of 0.6193.

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