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Weighted product model: a mathematical approach for plant selection

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ABSTRACT.

This paper intends to introduce one of the most popular Multi-Criteria Decision Making (MCDM) methods: the 'Weighted product model' (WPM), for botanical applications. Adopting this model, plants can be scored and ranked based on preferred characteristics and the plants with higher scores selected for a specific purpose. Initially, decision has to be made on the number and types of plant categories and characters that should be chosen for the particular experiment and given weights accordingly. The final weighted score for a plant is a measure of its utility for the purpose.

KEYWORDS. Weighted product model; Multi-Criteria Decision Making method; weighted category scores; category weights.

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INTRODUCTION.

Many a times, it becomes necessary to take an appropriate decision in the selection of an article from among many. Such decisions are usually taken considering the different criteria associated with the article, especially, its merits and demerits. Computational and mathematical tools are used for supporting the subjective evaluation of multiple criteria by decision-makers (Mardani, *et al* 2015)[1]. Multi-Criteria Decision Making (MCDM) is a scientific model that helps in decision making. MCDM is a standard term for all decision making methods that exist for assisting people to make decisions according to their inclinations, in cases where there is more than one conflicting criterion (Ho, 2008)[2]. Here, a scoring model is created that finally ranks the article from the others in the group considering its attributes or criteria. Some of the multi-criteria decision making methods are, the Weighted sum model (WSM), the Weighted product model (WPM), the Analytic hierarchy process (AHP), the ELECTRE and the TOPSIS. 'The weighted product model' (WPM) proposed by Triantaphyllou (2000)[3] is one of the most popular MCDM methods.

The weighted product model is based on weighted scores (according to order of their preference) assigned to the separate categories (different samples of a test) and their associated criteria (merits and demerits). First, the category score is calculated by summing the weighted scores for each criterion in the category and dividing by the sum of the weights for the criteria in the category. A weighted category score is calculated by multiplying the category score by the category weight. The final score is calculated by summing the weighted category scores and dividing by the sum of the category weights.

The weighted product model can help in situations where it is necessary to evaluate different options. It is likely to assist in presenting the findings with absolute confidence and providing facts to back up the final choice. However, the crucial problem is how to assess a set of alternatives in terms of the number of criteria for a particular experiment.

In this report, a case study is being presented wherein, the weighted product model has been adopted to select a group of plants from among different plant categories (herbs, shrubs and climbers) to set up a herbal garden consisting of medicinal plants with desirable attributes associated with their external appearance and medicinal value.

MATERIALS AND METHODS

For the study, information about a random sample of sixty two locally available plants was collected from literature (Krithikar and Basu, 2000[4]; Kumar and Nair, 2006[5]; Satyavati*et al*,1987[6] and Chopra *et al*, 1956)[7]. Further selection of plants was based on weighted product method proposed by Triantaphyllou, (2000)[3].

Higher plants belong to different categories or groups, such as trees, small trees, shrubs, climbers and herbs. These plant categories were assigned scores on a five point scale (weighted category scores) based on their importance for the specific purpose (related here to the construction of a herbal garden). The scores are as given below

Trees – 1, Small trees – 2, Shrubs – 3, Climbers – 4, Herbs – 5.

However, trees and small trees were avoided here due to the space constraint. About twenty two characters (morphological - 16 and medicinal - 6) were considered as the criteria and the character states were coded in their order of preference (client's choice) for the purpose (weighted criteria scores).

The category score was calculated by summing the weighted scores for each character in each category and dividing it by the sum of the weights for the characters in the category (category weight). The weighted category score was calculated by multiplying the category score by the category weight as shown below.

RESULTS

Information pertaining to certain locally available medicinal plants (sixty two plants: herbs - 29, climbers - 20 and shrubs - 13) was gathered. The plant names, codes and plant families to which they belong have been compiled here for reference

Table I: Details of plants considered for the study

Name of the plants taken for this study (Botanical name, Code, Family)							
Sl No:	Herbs	Sl No	Herbs	Sl No:	Climbers	Sl No:	Shrubs
1	*Aloe vera(AV)* Liliaceae	21	*Ocimumbasilicum(OB)* Lamiaceae	1	*Aristolochia acuminate(AA)* Aristolochiaceae	1	*Chassaliacurvifolia(CCF)* Rubiaceae
2	*Andrographispaniculata(AP)* Acanthaceae	22	*Ocimum sanctum(OS)* Lamiaceae	2	*Asparagus racemosus (AR)* Liliaceae	2	*Euphorbia pulcherrima(EP)* Euphorbiaceae
3	*Bacopamonnieri(BM)* Scophulariaceae	23	*Plectranthusamboinicus (PR)*Lamiaceae	3	*Centellaasiatica (CA)* Apiaceae	3	*Hamelia patens(HP)* Rubiaceae
4	*Boerhaviadiffusa(BD)*Nyctagenaceae	24	*Phyllanthusniruri(PN)* Eclipta alba	4	*Cissusquadrangularis (CQ)* Vitaceae	4	*Helicteresisora(HI)* Malvaceae
5	*Catharanthusroseus(CR)* Apocynaceae	25	*Sansevieriatrifaciata (ST)*Dracaenaceae	5	*Clitoriaternatea (CT)* Fabaceae	5	*Hibiscus rosasinensis(HRS)* Malvaceae
6	*Chlorophytumcapense(CCA)* Spider plant, Liliaceae	26	*Sidaacuta(SA)* Malvaceae	6	*Cosmostigmaracemosum (CRM)* Asclepiadaceae	6	*Hydrangea macrophylla(HM)* Hydrangeaceae
7	*Chrysanthemum morifolium(CM)* Asteraceae	27	*Sidarhombifolia(SR)* Malvaceae	7	*Epipremnumaureum (EA)* Araceae	7	*Jatrophagossypifolia(JG)* Euphorbiaceae
8	*Citrus lemon(CLM)* Rutaceae	28	*Spathyphyllumwallissi (SW)*Araceae	8	*Hemigraphisalternata (HA)* Acanthaceae	8	*Justiciaadhatoda(JA)* Acanthaceae
9	*Costuspeciosus(CS)* zingeberaceae	29	*Vernoiacinerea(VC)* Asteraceae	9	*Ipomoea quamoclit (IQ)* Convolvulaceae	9	*Lawsoniainermis(LI)* Lythraceae
10	*Curcuma longa (CLN)* Turmeric; Zingiberaceae			10	*Jasminummultiflorum(JM)* Oleaceae	10	*Murrayakoenigii(MK)* Rutaceae
11	*Cynodondactylon(CD)* Bermuda grass; poaceae			11	*Jasminumofficianale(JO)* Oleaceae	11	*Mussaendaerythrophylla(ME)* Rubeaceae
12	*Dendrobium* species (D) orchidaceae			12	*Jasminumsambac(JS)* Oleaceae	12	*Solanumkhasianum(SK)* Solanaceae
13	*Elettariacardamomum(EC)* Zingeberaceae			13	*Merremiavitifolia(MV)* Convolvulacea	13	*Tabernaemontana divaricate(TD)* Apocynaceae
14	*Emilia sonchifolia(ES)* Red tassel flower; Compositae			14	*Pipperlongum (PL)* Piperaceae		
15	*Impatiens balsamia(IB)* Balsaminaceae			15	*Pothoscandens(PS)* Araceae		
16	*Impatiens walleriana(IL)* Balsaminaceae			16	*Protulacagrandiflora(PG)* Protulacaceae		
17	*Kaempferiagalanga(KG)* Zingiberaceae			17	*Rubusniveus(RN)* Rosaceae		
18	*Leucasaspera (LA)* Lamiaceae			18	*Thunbergiaalata(TA)* Acanthaceae		
19	*Menthaarvensis*(MA) Lamiaceae			19	*Thunbergiafragrans(TF)* White gem		
20	*Mimosa pudica*(MP) Fabaceae			20	*Tinosporacordifolia(TC)* Menispermaceae		

Since the number of plants (62) selected initially for the study was found to be high with respect to the area and layout of the study site (field location of the garden-both outdoor and indoor) considered presently, the number of plants had to be reduced further. Under such a circumstance a judicious decision had to be made regarding the choice of plants (herbs, climbersand shrubs) for the garden. The weighted product method was thus adopted to screen out the more suited plants.

As an example, the procedure adopted to select a small group of climbers from the total has been represented below

Selection of climbers:

The list of 22- [morphological (16) and medicinal (6)] characters that were used for the selection of climbers (11/ 20) from among the total (20 climbers selected initially) has been described. The characters, character states and their scores are provided. The characters, character states and scores were slightly different for the herbs and shrubs but the procedure adopted for selection was similar.

Table II. Characters and character states with scores for climbers

Sl N0	Characters and its codes	Character states / scores				
		1	2	3	4	5
1	Habit	Perennial (PL)	Annual (AL)			
2	Availability of material	Very scarce (VS)	Scarce (S)	Moderate (M)	Prevalent (P)	Most prevalent (MP)
3	Method of propagation	Sucker (SR)	Off shoot (OS)	Stem cutting (SC)	Rhizome (RM)	Seeds (SD)
4	Ease of propagation	Very difficult (VD)	Difficult (D)	Moderate (M)	Easy (E)	Very easy (VE)
5	Presence of thorns/spines	Yes (Y)	No (N)			
6	Leaf type	Simple (SM)	Compound (CD)			
7	Foliage colour at emergence	Dark green (DG)	Green (G)	Light green (LG)	Variegated red (VR)	Variegated yellow/white (VYW)
8	Presence of flower / inflorescence	Flower (F)	Inflorescence (IF)			
9	Colour of flower or inflorescence	Light coloured (LC)	Bright coloured (BC)	Variegated coloured (VC)		
10	Size of flower or inflorescence	Very small [<5mm] (VS)	Small [5-10mm] (SM)	Medium [10-20mm] (MD)	Large [20-50mm](L)	Very large [>50mm] (VL)
11	Aromatic property	Unpleasant smell (US)	No smell (NS)	Pleasant smell (PS)		
12	Foliage and floral contrast	No (N)	Yes (Y)			
13	Fruit edibility	No (N)	Yes (Y)			
14	Fruit taste	Bad (B)	Bland (BD)	Sour (SR)	Sweet (ST)	Very sweet (VST)
15	Fruit size	Very small [2-5mm] (vs)	Small [5=10mm] (SM)	Medium [10-15mm] (MD)	Medium large [15-20mm] (ML)	Large [20-50m] (LG)
16	Fruit shape	Long (LN)	Oval (OV)	Round (RD)		
17	Medicinal components reported	No (N)	Yes (Y)			
18	Medicinal parts	Root/Rhizome (RTR)	Stem (ST)	Flower (FL)	Seed/fruit (SF)	Leaf (LF)
19	Used as nostrum	No (N)	Yes (Y)			
20	Poisonous nature	Yes (Y)	No (N)			
21	Mode of application	Topical (TL)	Oral (OL)			
22	Air purifying property	No (N)	Yes (Y)			

Thus from the sixty two medicinal plants listed (herbs-29, climbers 20, shrubs-13) a total of 30 most suited plants (herbs-14/29, climbers-11/20 and shrubs-5/13) were selected for the study sites.

The selection was based on high scores in the analysis using the weighted product method. Each of the thirty listed plants were scored as shown below using the character weight, character score and weighted score to get the final weighted score.

A model of the scoring table for a particular climber, ***Clitoriaternatea*** is as shown below. The codes provided for the characters in the Table III can be traced back to the previous table (Table II).

Table III: Scoring of *Clitoriaternatea* (climber no. 4) [CW – Character weight; CT- Character type; Scr- Score of each characters; WS- Weighted score]

Sl No	Characters	CW	CT	Scr	WS	Sl No	Characters	CW	CT	Scr	WS
1	Habit (H)	2	AL	2	**4**	13	Fruit edibility (FEY)	1	N	1	**1**
2	Availability of material (AOM)	5	MP	5	**25**	14	Fruit taste (FTE)	1	-	1	**1**
3	Method of propagation (MOP)	4	SD	5	**20**	15	Fruit size (FSZ)	1	MD	3	**3**
4	Ease of propagation (EOP)	4	VE	5	**20**	16	Fruit shape (FSP)	1	LN	2	**2**
5	Presence of thorns/spines (PT/S)	5	N	2	**10**	17	Medicinal components reported (MCR)	1	Y	2	**2**
6	Leaf type (LT)	1	SM	1	**1**	18	Medicinal parts (MPT)	1	Whole	5	**5**
7	Foliage colour at emergence (FCE)	1	LG	2	**2**	19	Used as nostrum (UAN)	3	Y	2	**6**
8	Presence of flower / inflorescence (PF/I)	3	F	1	**3**	20	Poisonous nature (PNR)	5	N	1	**5**
9	Colour of flower or inflorescence (CF/I)	2	BC	2	**4**	21	Mode of application (MOA)	3	OL	2	**6**
10	Size of flower or inflorescence (SF/I)	2	MD	3	**6**	22	Air purifying property (APP)	4	N	1	**4**
11	Aromatic property (APT)	5	NS	2	**10**	**TOTAL**		**60**		**52**	**150**
12	Foliage and floral contrast (FFC)	5	Y	2	**10**						

Weighted score = CW ×Scr

Category score = Total WS ÷ Total CW = 150 ÷ 60 = ***2.5***

Final weighted score = Category score × Category weight = 2.5 × 4 = ***10***

A summary sheet of the scores and ranks assigned to the thirty selected plants based on the scoring model is provided below. The score of the selected climber is highlighted.

Table IV. List of selected plants for the construction of healing gardens

Sl no:	List if selected plants	Garden	Score	Rank
	HERBS			
1	*Aloe vera*	Both	14.0	3
2	*Catharanthusroseus*	Outdoor	13.1	4
3	*Chlorophytumcapense*	Both	12.2	6
4	*Chrysanthemum moriflorum*	Outdoor	14.1	2
5	*Costusspeciosus*	Outdoor	12.1	7
6	*Curcuma longa*	Outdoor	14.0	3
7	*Dendrobium species*	Both	12.0	8
8	*Impatiens balsamia*	Both	12.0	8
9	*Impatiens walleriana*	Both	12.0	8
10	*Kaempferiagalanga*	Outdoor	12.0	8
11	*Ocimumbasilicum*	Both	14.5	1
12	*Ocimum sanctum*	Both	14.0	3
13	*Plecranthusamboinicus*	Both	12.5	5
14	*Sanseveriatrifciata*	Both	12.5	5
	CLIMBERS			
15	*Asparagus recemosus*	Outdoor	9.2	4
16	*Centellaasiatica*	Outdoor	9.5	3
17	***Clitoriaternata***	**Outdoor**	**10.0**	**1**
18	*Epipremnumaureum*	Both	8.0	6
19	*Hemigraphisalternata*	Outdoor	8.0	6
20	*Ipomoea quamoclit*	Outdoor	9.2	4
21	*Jasminumofficianale*	Outdoor	9.7	2
22	*Jasminumsambac*	Outdoor	9.7	2
23	***Pipperlongum***	**Outdoor**	**10.0**	**1**
24	*Protulacagrandifolia*	Both	8.0	6
25	*Thunbergiafragrans*	Outdoor	8.4	5
	SHRUBS			
26	*Hamelia patens*	Outdoor	7.9	1
27	*Hibiscus rosasinensis*	Outdoor	7.6	2
28	*Lawsoniainermis*	Outdoor	7.3	3
29	*Murrayakoenigii*	Outdoor	7.2	4
30	*Tabernaemontana divaricate*	Outdoor	7.2	4

DISCUSSION AND CONCLUSION

The present study was intended to help the botanists to make use of a mathematical method as a selection criterion. The same procedure can be extended for any similar application. However, it should be kept in mind that the parameters identified for a particular experiment and weights to be provided for specific parameters can be changed according to the situation and are likely to affect the final scores. However, the utility of the weighted product method in making appropriate decisions is evident.

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