

Selection of Optimum Farming Strategy Using Multi-Criteria Decision Making Techniques- A Case Study

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Abstract - This paper presents an approach to select the best farming strategy considering various criteria. The goal is to help a farmer to take appropriate decision in farming. Two possible alternatives are considered- Conventional farming and Organic farming. These farming types are evaluated by MCDM technique taking into account three criteria viz. Productivity, Marketing, and Health-Environment Friendliness. Analytical Hierarchical Process (AHP), one of the techniques under MCDM known for its Consistency test, is used to improve the accuracy of result.

Keywords - Farming, Multi-Criteria Decision Making, Analytical Hierarchical Process, Multi Criteria Analysis

1. Introduction

Farming is the cultivation of animals, plants, fungi and other life forms for food, fibre, bio-fuel, medicinal and other products used to sustain and enhance human life [1]. Agriculture is one of the oldest and most areal human activity ever. Since the beginning it has greatly influenced landscape management and environment when people begun to cultivate the soil, grow plants and domestic animals. In the 20th century intensified agriculture begun to affect the environment, bad treatment of animals, decrease in food quality, and degradation of farmer, social security and community health. All the above factors lead to new conception of environment friendly agriculture [2].

Multi-criteria Decision Making (MCDM) methods provide people with a quantitative means to assist with the decision making where there are multiple and conflicting goals measured in different units. Other advantages of MCDM can include- making a decision more transparent to others, providing a focus for discussion and helping people better understand a problem from their own and others view point [3].

2. Types of Farming

Farming can be broadly classified in two types- conventional farming and organic farming.

Conventional farming: - Conventional farming describes any farming not dedicated to alternative

methods. Fundamentally, it is a kind of farming which has dominated in the 20th century and which account for most of today's farming practices. Use of chemicals pesticides, plant protectant, chemical fertilizers and intensive mass animal farming are common in it [4].

Why do farmers use chemicals?

After Green Revolution modern farmland claimed to produce 200 percent more wheat than the same area did 70 years ago and that is basically due to the use of chemicals. If we stop using these due to side effects of chemicals, pesticides on human health environment then it is likely to mean a reduction in output.

With conventional farming it is possible to produce much larger quantities of food, on less land and with less input of (some) resources and manual labour than ever before. With rising food costs and millions of people starving all over the world, it is felt like a moral obligation to use conventional methods to produce large amounts of food at affordable prices [5].

Organic farming: - Organic farming system is not new in India and is being followed from ancient time. It is a method of farming system which primarily aims in cultivating the land and raising crops in such a way so as to keep soil alive and in healthy condition by using organic wastes (crop, animal, and farm wastes, aquatic wastes) and other biological materials along with beneficial microbes (bio-fertilisers). Thus it leads to a sustainable production in an eco friendly pollution free environment [6]. Authors in [7] have concluded that variety of contributions of organic food production appeals to the use of Multi-criteria Analysis. It is pointed in [8] that specific subsidy in organic farming determines the profitability of the average organic farm and has a major and decisive impact on land income, labour income/8hrs and net income; it also increases the return on capital and leads to a reversal of the relation with the other farming systems, as regards gross margin and farm family income. The same concept is valid for Indian subcontinent as well.

Why there is need of Organic Farming?

With the increase in population our compulsion would be not only to stabilize agriculture production but to

increase it further in sustainable manner. Scientists have realized that the Green Revolution with high input use has reached a plateau and is now sustained with diminishing return of falling dividends. Thus a natural balance needs to be maintained at all cost for existence of life and property. The obvious choice for that would be more relevant in present era, when these agrochemicals which are produced from fossil fuel and are not renewable and are diminishing in availability. It may also cost heavily on foreign exchange in future [6]. Hence the need for organic farming is becoming more relevant.

Comparison of Conventional Farming and Organic Farming: -

Table1- Conventional farming vs Organic farming

Conventional Farming	Organic Farming
-Centralisation -Dependence -Competition -Domination of Nature -Specialisation -Exploitation	-Decentralisation -Independence -Community -Harmony with Nature -Diversity -Restraint

3. Analysing the Criteria

In this study, three criteria of high impact relevant to farming strategy are considered, viz. Productivity, Marketing, Health-Environment Friendliness.

a) Agriculture productivity- Agriculture productivity is measured as the ratio of agricultural output to agricultural input. The productivity of a region/ farm is important for many reasons. Apart from increase in production, productivity of farm affects the regions prospects for growth and competitiveness on agricultural market, income distribution, savings and labour migration. Agriculture productivity is becoming increasing important as world’s population continues to grow. India, one of the world’s most populated countries, has taken steps in the past decades to increase its productivity. Forty years ago, North India produced only wheat, but with the advent of the earlier maturing high yielding wheat and rice, the wheat could be harvested in time to plant rice [9].

b) Agricultural Marketing - Agricultural marketing covers the services involved in moving an agricultural product from the farm to the customer. Numerous interconnected activities are involved in doing this such as planning production growing and harvesting, grading, packaging, transport, storage, agro and food processing, distribution,

advertising and sale. Some definitions would even include the act of buying supplies, renting equipment, and paying labour, arguing that market is everything a business does. Such activity cannot take place without the exchange of information and are often heavily dependent on the availability of suitable finance. Marketing systems are dynamic, they are competitive and involve continuous change and improvements in business that have lower costs are more efficient and can deliver quality products. Those that have high costs, fail to adopt changes in market demand and provide poorer quality is often forced out of business [10].

c) Health-Environment Friendliness - Every kind of agriculture has an impact on the environment. It is the belief of the Organic farming community that organic farming minimises the need for chemical inputs thereby limiting damage to health and the environment. Intensive farming is said to destroy the fertility of land, but with Organic farming and sustainable crop rotations, soil health is improved. Use of chemicals and pesticides for farming persist in environment. This persistent element then comes to our body through food, water and air. This results in physical disorder, breathing complications, skin problems and various other complications. Such kind of farming also affects the life style of animals.

4. Use of MCDM

Whenever we have to take any decision, the aim is to have a good or wise enough decision. Usually there are many criteria required to be considered for choosing the best alternative. This type of decision making problem is basically a problem categorized as an MCDM problem. MCDM has the potential to do more than this, and the other benefits need to be promoted in advocating the use of MCDM. This may be difficult since these benefits may not be recognised until completion of the process. Promotion of MCDM may best be achieved as part of other extension or consultation activities by someone who has used the process [3].

With the help of an example an attempt is made to choose the best alternative farming strategy. To select a certain method of MCDM, a comparison table is used, analysed in [11]

Table.2: Comparison of AHP, ELECTRE, SAW, and TOPSIS (methods in MCDM)

	AHP	ELECTRE	SAW	TOPSIS
Consistency	Yes	Yes	No	No
core process problem	hierarchy Principle	Pair wise Compression Principle	Weighted avg. Principle	Distance Principle
Structure	Few criteria & alternatives	Plenty criteria	Many criteria & alternatives	Many criteria & alternatives

Concept	Scoring modal	Concordance modal	Scoring modal	Compromising model
Final results	Global net ordering	Partial Pre-order	Global net ordering	Global net ordering

From the above table it is very clear that SAW and TOPSIS method do not have any consistency test and ELECTRE method has partial pre-order for final results. AHP method seems to be the most suitable one and hence is selected for this research work as a MCDM technique. The only drawback with AHP method is that of using few criteria and alternatives. But by appropriate grouping of the criteria and alternatives, this drawback can be minimized.

5. Methodology

The following steps must be followed for the solution of problem using AHP technique as explained in [12].

- Step1-** Generating pair-wise comparison matrix for all criteria and alternatives.
 - Step2-** Measuring inconsistency in every judgement.
 - Step3-** Calculate the Local Priority for all matrices
 - Step4-** Calculate the global priority
- $[A'] = [A][x] \dots \dots \dots 1$
 Where $[A]$ = Global matrix
 $[x]$ = Local Priority for all Criteria
- Step5-** Alternative of highest global priority is selected as best and most suitable.

Data collection-

The researcher is himself a farmer and has got ample experience in the relevant area. And after discussing amongst the fellow farmers and analyzing about the farms management, the researcher reached to the following conclusions-

- a) Marketing may be considered 2 times as important as Productivity
- b) Health-Environment Friendliness may be

n	1	3	4	5	6	7	8	9
RI	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45

- assumed 2 times as important as Marketing
- c) Health-Environment Friendliness may be 4 times as important as Productivity.

The above conclusions are hypothetical in the sense that they are identified only on the basis of farming experience of researcher and his co-workers and some of critical factors are neglected.

Nomenclature-

Productivity=P, Marketing = M,
 Health-Environment Friendliness= H-E,
 Organic Farming= OF, Conventional Farming= CF

Calculations-

Step1- Generating the pair-wise matrix

For all criteria (P, M, H-E)

	P	M	H-E
P	1/1	1/2	1/4
M	1/1	1/1	1/2
H-E	4/1	2/1	1/1

For criteria P (Productivity)

P	OF	CF
OF	1/1	1/4
CF	4/1	1/1

For Criteria M (Marketing)

M	OF	CF
OF	1/1	1/2
CF	2/1	1/1

For Criteria H-E (Health-Environment Friendly)

H-E	OF	CF
OF	1/1	4/1
CF	1/4	1/1

Step2- Measuring Inconsistency in all judgements

As explained in [12] we can calculate Consistency Index as,

$$CI = (\lambda_{max} - n)/(n-1)$$

Where,

λ_{max} = Principal Eigenvalue of matrix and

n = size of matrix

Then calculating Consistency Ratio

$$(CR) = CI/RI$$

The value of RI is given in following table,

Table.3 RI table

Where, RI = Random Index,
 Judgements are acceptable if,

$$CR < 0.1$$

In the present work, value of consistency ratio for all matrices is found to be zero i.e. all the judgements are consistent

Step3- Calculate the Local Priority for all matrix

Local Priority for PMH-E or [X]

0.1428

0.2857

0.5714

Local Priority for P

0.2

0.8

Local Priority for M

0.3333

0.6667

Local Priority for H-E

0.8

0.2

Generate the Global matrix, [A]

	P	M	H-E
OF	0.2	0.3333	0.8
CF	0.8	0.6667	0.2

Step4- Calculate the global priority

From equation 1

$$[A'] = [A][x]$$

Global priority is

OF	0.58090
CF	0.41899

Step5- Alternative of highest global priority is selected as best and most suitable

The global priority shows very clear that Organic Farming is best alternative than Conventional Farming [13].

6. Result and Discussions

The data acquired in this research work are examined by AHP method to calculate local priority and global priority scores. Local priority scores shows the relative importance of individual factor in the same group where as global priority scores represents the relative importance of them across the global matrix. The consistency ratios are maintained $CR=0 < 0.1$ during our analysis. Calculated global priority score for Organic Farming **0.58090** and Conventional Farming **0.41889**, indicate that Organic Farming is a better alternative.

7. Conclusions

In this research paper, the selection of farming strategy is studied. An optimal farming strategy can improve farmers profit as well as satisfy consumer's demands. It is seen that farmers are not interested to produce products having poison for their consumers, but they have some limitations of marketing, productivity, loans and availability of resources. Lots of research work is required to make sustainable and easy organic farming for farmers. On the other hand government need to provide subsidy and establish organic markets. The consumers can also encourage farmers for organic farming by demanding organic products.

Biography

At present the researcher is a PG scholar, specialisation in production engineering at BIT Durg and also the local farmer of Chhattisgarh, India.

References

1. Safety and health in agriculture, international labour organization 1999
2. Jan; Konvalina, Petr and Sramek, Jan (2009) Major problems of organic farming—experience transmission. *Lucrări Ştiinţifice, Seria Agronomie*, 52 (2009), pp. 327-333.
3. A.E. Dooley, G.W. sheath, D.Smeaton 2005, Multi-criteria decision making method selection and appropriate to three contrasting agricultural: case study at NZARES coferece New Zealand
4. www.coextra.edu/glossary/word672.html
5. www.appropedia.org/conventional_farming
6. www.agritech.tnau.ac.in/org_farm_introduction.htm
7. Tove Christensen, soren boye olsen, alex dubgaard and neils kaerrgard, organic farming and multi-criteria decisions:an economic survey
8. Athanasios theocharopoulos, stamatic, panaraia, Katrina and evangelos 2012 sustainable farming systems vs conventional agriculture: a socioeconomic approach ISBN 978-953-51-0116-1
9. www.en.m.wikipedia.org/wiki/agriculture_productivity
10. www.en.m.wikipedia.org/wiki/agricultural_marketing
11. Jureen Thor, Siew-Hong Ding, Shahrul Kamaruddin, Comparasion of Multi-Criteria Decision Making Methods From The Maintenance Alternative Selection Perspective, 2013, ISSN(e):2319-1813, ISSN(p):2319-1805
12. Maria Socorro Garcia-cascales, Maria Teresa Lamata 2009, Selection of a cleaning system for engine maintenance based on the analytic hierarchy process, 1442-1451
13. Thomas L. Saaty, Decision making with the analytic hierarchy process, Int. J. Service Science, Vol. 1, No. 1, 2008