



Optimization of aggregate planning of rice husk charcoal production with Fuzzy Goal Programming approach



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Abstract

This study proposes a Fuzzy Goal Programming approach to optimize the problem of aggregate planning of production processes in companies that produce charcoal husks. The application proposed to the company describes the process of Rice Husk Charcoal Production taking into account the uncertain factors involved in the aggregate planning process of Rice Husk charcoal production. Decision-making related to the level of material needs in each type of rice husk charcoal product is considered based on planning for the next 12 months by including weighting value in membership function, determination of membership function of each function objectives with equivalent Crip of fuzzy goal programming. Fuzzification is based on three main objectives with three membership levels for each purpose of Goal Programming. This research provides the results of the proposed adaptive model applied to companies that produce charcoal husks.

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Keywords:

*Aggregate production planning;
Fuzzy Goal Programming;
Charcoal rice husks;*

Article History:

Received: April 26, 2021

Revised: August 28, 2021

Accepted: September 6, 2021

Published: February 1, 2022

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INTRODUCTION

Charcoal Husk Rice husks are one of the main alternative energy sources derived from rice waste in the form of rice husks [1]. Rice husks are obtained from rice milling waste with abundant availability, and their use is not optimal. The use of rice husks into Rice Husk Charcoal as an alternative energy source used for energy sources for household scale and small to medium industrial scale is an effort to reduce the use of energy sources derived from fossils [2].

Rice Husk as a bioenergy source in the form of Rice Husk Charcoal is one of the efforts to support government programs in realizing the energy mix in 2025 [3]. Production planning is important, is the activity of planning and controlling incoming materials in a production system so that demand can be met effectively and efficiently, generally the data used with estimates based on experience [4]. In

production, planning can be separated from aggregate planning, which is all operational activities of the production process for a period of 3 to 18 months to come up with ideas for management. For example, how much quantity of material resources or other to be produced and when to be produced to minimize the total operational costs of the organization in a period [5].

Goal Programming is a decision-making solution technique involving both single and plural goals. The approach used in the Goal Programming method minimizes the deviation between the set goals and the efforts to be made with limited target constraints [6]. The basic approach is to set one specific numerical goal of each goal, formulate one goal function of each goal and look for a solution that minimizes the number of deviations from this goal function to each goal [7]. With the Goal Programming Approach, it is expected that the decision-

making party can easily determine the level of each goal achieved in a condition of uncertainty, which is an integrated part of the Production System [8].

The purpose of the research is to optimize aggregate planning at the operational level of the company as an effort to optimize the limited resources with multiple complex and uncertain objectives to balance the supply and demand of

Rice Husk Charcoal husks. The quantitative approach of aggregate planning to formulate three objectives: Inventory Level Minimization, Employee Working Hours Minimization, and minimization labor level materials. Describe with and formulate fuzzy mixed integer Goal programming Aggregate planning based on three main objectives.

Table 1. State of the art

No	Title	Methods	Result
1	A Fuzzy Goal Programming Approach for Solid Waste Management Under Multiple Uncertainties [9]	Fuzzy Goal Programming	minimize the cost of cleaning systems and maximizing revenue obtained from different management facilities present a better model when compared to the previously applied model
2	A hybrid probabilistic fuzzy goal programming approach for agricultural decision-making [10]	Hybrid approach consisting of Monte-Carlo simulation and Genetic algorithm	proposed problem-solving technique taking into account the planning of agricultural planning development block in Paschim Medinipur district of West Bengal
3	A multi-objective model for cleaner production-transportation planning in manufacturing plants via fuzzy goal programming [11]	fuzzy goal programming and heuristic algorithms	extensive computing, as well as real case studies, are considered to be able to evaluate the quality of the proposed model
4	Approach based on fuzzy goal programming and quality function deployment for new product planning [12]	Quality function deployment (QFD) and new product planning (NPP)	minimizing additional costs and technical difficulties to obtain optimal satisfaction from all objectives resulting in numerical examples used to demonstrate the implementation of the proposed model.
5	Solving multi-objective facility location problem using the fuzzy analytical hierarchy process and goal programming: a case study on infectious waste disposal centres [13]	Fuzzy AHP, goal Programming (FAHP-GP)	account the total cost objectives and final priority weights resulting in a model novelty that is a simultaneous combination of relevant factors that are difficult to interpret and cost factors that require resource allocation
6	Optimizing renewable energy portfolios under uncertainty: A multi-segment fuzzy goal programming approach [14]	multi-segment fuzzy goal programming (MS-FGP), multi-criteria decision-making issue (MCDM)	the methodology could assist 25 decision-making in determining portfolios on the most sustainable renewable energy sources for 26 power plants in uncertain conditions and an uncertain environment.
7	A preemptive fuzzy goal programming model for generalized supplier selection and order allocation with incremental discount [15]	fuzzy goal programming	minimizing total cost and purchase value with the result of research that the proposed model is better (superior) than other methods
8	A fuzzy goal programme with carbon tax policy for Brownfield Tyre remanufacturing strategic supply chain planning [16]	fuzzy goal program	methods on strategic planning on the tire remanufacture supply chain
9	A Fuzzy Goal Programming Model for Production Planning in Furniture Company [17]	fuzzy purpose programming	form of application programs for problem-solving decision making about the amount of production and application programs that have been made able to facilitate user performance
10	Analysis of a wastewater treatment plant using fuzzy goal programming as a management tool: A case study [18]	Linear mathematical programming methods	reduction in economic costs by comparing optimal solutions with deterministic solutions with energy reductions of 803 KWh/year and theoretically reducing greenhouse emissions by 586.2 tCO ₂ /year
11	Weighted-additive fuzzy multi-choice goal programming (WA-FMCGP) for supporting renewable energy site selection decisions [19]	The fuzzy programming model of multi-purpose additives – new additives (WA-FMCGP), multi-attribute decision-making model (MADM)	objective functions that minimize the summation of weighted additives from deviations that have been nominalized so that this study provides a different additional method to the application
12	Optimizing sustainable and renewable energy portfolios using a fuzzy interval goal programming approach [20]	Multi-criteria method, multi-choice inspiration level (MCALs), multi Choice goal Programming (RMCGP)	model on the selection of the optimal energy portfolio as a power plant in Italy, the relevant renewable energy is biomass
13	Multi-objective flexibility-complexity trade-off problem in batch production systems using fuzzy goal programming [11].	Fuzzy goal programming.	the flexibility of production systems with promising results and proposed models capable of regulating strategic, tactical, and operational variables of batch production systems
14	Modified two-phase fuzzy goal programming integrated with IF-TOPSIS for green supplier selection [21].	fuzzy goal programming integrated with IF-TOPSIS	green supplier selection model
15	Academic staff planning, allocation and optimization using genetic algorithm under the framework of fuzzy goal programming [22].	genetic algorithm under the framework of fuzzy goal programming	academic staff planning model
16	A solving approach for fuzzy multi-objective linear fractional programming and application to an agricultural planting structure optimization problem [23].	Fuzzy multi-objective linear fractional programming	post-harvest handling optimization research

Formulation of Multi-Objective Goal programming as an effort to overcome the problem of uncertainty in aggregate planning based on data sets processed is to obtain deterministic models related to decision-makers who have limited information related to different criteria. Previous research related to goal programming methods in several research areas is presented on state of the art in [Table 1](#).

The research position using fuzzy goal programming approach on the application of aggregate planning is expected to determine the resources needed to achieve a set of objectives with available resources to obtain the best destination solution with various resources and priority main objectives.

MATERIAL AND METHOD

Material

Rice Husk Charcoal Husk Rice is an energy source used in the industry and for households, Rice Husk Charcoal is produced by utilizing rice husks whose supplies are abundant, with the utilization of rice waste is expected to provide added value for farmers and industry actors Charcoal Husk Rice, Rice Husk Charcoal production process includes the first process is rice husks as the main raw material is dried and burned so that it becomes charcoal. The next process is mixing rice husk charcoal with mixing materials and adhesives, the third step is the printing process following its shape and size and the last step is the process of drying rice husks that have been printed. The production process of rice husks is in [Figure 1](#).

In this study, the data used comes from the company and is based on literature studies. Rice husk charcoal produced consists of 4 models of rice husk charcoal by their respective functions and uses.



Figure 1. Production Process of Making Rice Husk Charcoal

Charcoal husk rice is also used as a household scale fuel charcoal Husk Rice is widely used by the industrial-scale among others for barbecue shisha fuel with a share of both domestic and export scales.

One of the advantages of using optimization with a fuzzy goal programming approach is that it is possible to extract a meaningful set of information related to the problem to be analyzed using an approach that uses the concept of membership [24]. Fuzzy's set theory is helpful in an uncertain environment.

Membership function

1. Inventory Level Minimization

Based on the first goal to minimize delivery delays, the company strives to have adequate inventory levels and safety supplies (Shortage) to meet the needs of long-term consumers.

2. Employee Hours Minimization

The second goal based on the preference of the company management is to minimize the waiting time and interrupt (Idle time) and overtime employee work time.

3. Minimization of Labor Change Rate

The third goal is to minimize changes in the labor rate. The labor rate can be adjusted to the needs. The Fuzzy logic design is shown in [Figure 2](#).

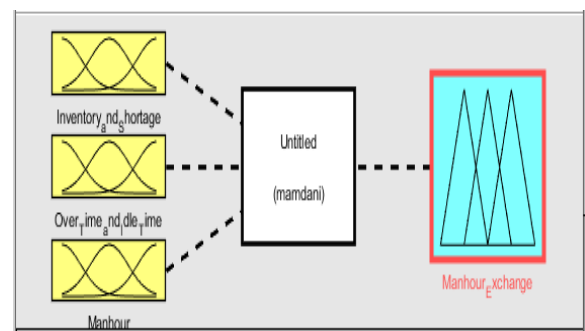


Figure 2. Fuzzy logic design

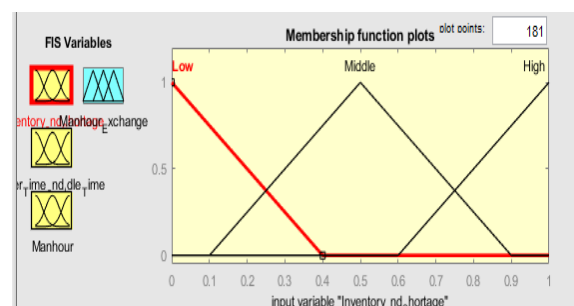


Figure 3. Membership function destination 1

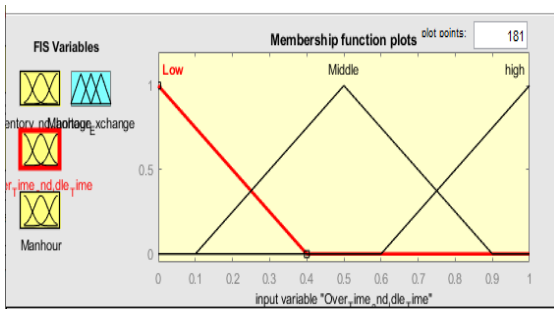


Figure 4. Membership function destination 2

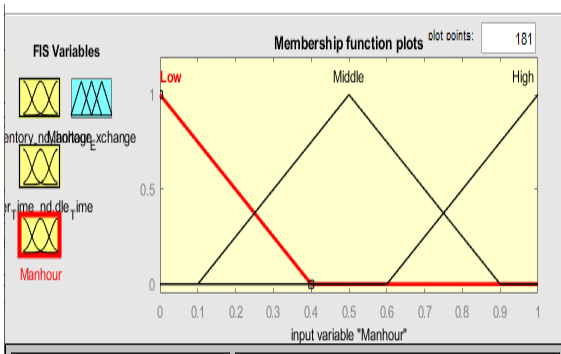


Figure 5. Membership function destination 3

The membership function for each Purpose function is shown in Figure 3, Figure 4 and Figure 5.

1. Membership function destination 1
2. Membership function goals 2
3. Membership function Destination 3

Method

The stages of the research are presented in Figure 6.

- a. Problem Identification, Identification of the company's problems that produce rice husk charcoal is a medium-scale business, and chaff charcoal is produced as biobriquette raw material. Focus research on the production process from milling to being a charcoal product.
- b. Data collection is conducted internally with interview techniques with staff members and supervisors of production operators.
- c. The multi-objective mathematical modelling developed in this study combines the season and period of rice harvesting, accounting for 48 weeks of activity after rice milling.
- d. The experimental data collected is used to model problems with Matlab R2017b software devices as well as to find the most optimal solution.
- e. Validation is done by involving experts in the field of bioenergy. Experts analyze the results of model solutions and compare them with real conditions for harvesting in later periods to

check the results of coherence and consider the application of model results.

- f. Implementation, this phase depends on the company's decision by emphasizing adequate consideration for all technical aspects.

Fuzzy goal programming is defined as a set of fuzzy numbers defined over several features governed by membership functions. Three fuzzy programming objectives are presented in Figure 7, consisting of upper, lower, and middle limits for k . The determination of membership values at each boundary is objectively selected by decision-makers and expert opinions, especially concerning tolerance levels in technical processes. Tolerance limits are very important because they will directly affect the performance of model optimization.

Fuzzy Goal Programming is identified as a set defined above the set feature containing several membership functions. The most widely used function is the linear membership function applied in theoretical and practical works. The linear membership functions for all three types of blurred destinations are as shown in (1), (2), and (3).

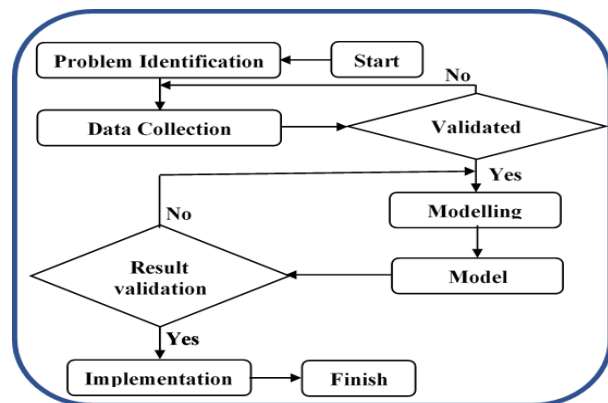


Figure 6. Stages of the research

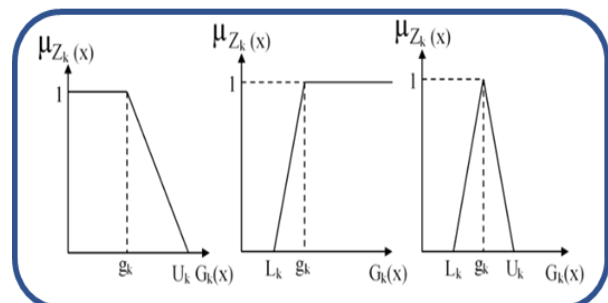


Figure 7. Fuzzy goal $G_k(x)$

$$(x) = \begin{cases} 1 & \text{if } G_k(x) \leq g_k \\ \frac{U_k - G_k(x)}{U_k - g_k} & \text{if } g_k \leq G_k(x) \leq U_k \\ 0 & \text{if } G_k(x) \geq U_k \end{cases} ; k = 1, \dots, m \quad (1)$$

$$\mu_{Z_k}(x) = \begin{cases} 1 & \text{if } G_k(x) \geq g_k \\ \frac{G_k(x) - L_k}{g_k - L_k} & \text{if } L_k \leq G_k(x) \leq g_k \\ 0 & \text{if } G_k(x) \leq L_k \end{cases} ; k = m + 1, \dots, n \quad (2)$$

$$\mu_{Z_k}(x) = \begin{cases} 0 & \text{if } G_k(x) \leq L_k \\ \frac{G_k(x) - L_k}{g_k - L_k} & \text{if } L_k \leq G_k(x) \leq g_k \\ \frac{U_k - G_k(x)}{U_k - g_k} & \text{if } g_k \leq G_k(x) \leq U_k \\ 0 & \text{if } G_k(x) \geq U_k \end{cases} ; k = n + 1, \dots, l \quad (3)$$

Model Goal Programming

Following this study's index set notation, Parameters, and Variables, the same notation was used for the fuzzy goal programming model.

Index Set:

- M set of Rice Husk Charcoal Products
- T Set for the period in the month
- Set of parameters
- Pj Priority Destination To jth
- pi Sales Profit from Rice Husk Charcoal Productsith
- ci Production Costs for products ith
- li0 Inventory level for Rice Husk Charcoal products i
- dit Demand for Charcoal Husk Padi i products in the period
- ki Employee working hours required to produce one unit of product i
- W0 Provisions for employee working hours
- WM Maximum employee hours for each period required by the company
- r Maximum employee overtime
- si Changes in product inventory levels ith
- crt Average rate of change in periods t
- Ei mean change ith product.
- Set of Variables
- Xit Total Product production on it h Period t
- D_{it}⁺, D_{it}⁻ Total loss on product sales i in the period tth
- R_t⁺, R_t⁻ deviation of variables to the second destination function each period the tth
- L_t⁺, L_t⁻ deviation of variables to the third destination function in the tth
- C_t⁺, C_t⁻ deviation of variables to the fourth destination function in the i
- Wt ability of labor hours in the period t

Here's a model of programming the basic purpose, which in this model is integrated into one function of purpose based on the given priority.

$$\begin{aligned} \text{Min } Z = & P_1 \times \sum_{t=1}^T \sum_{i=1}^N p_i \cdot D_{it}^- \\ & + P_2 \times \sum_{t=1}^T (L_t^+ + L_t^-) \\ & + P_3 \times \sum_{i=1}^N (C_i^-) \\ & + P_4 \times \sum_{t=1}^T (1.5R_t^+ + R_t^-) \\ & + P_5 \times \sum_{t=1}^T \sum_{i=1}^N C_i \cdot D_{it}^+ \end{aligned} \quad (4)$$

With Purpose Function:

$$I_{i0} + X_{i1} - D_{i1}^+ + D_{i1}^- = d_{i1} \quad \forall i = 1, \dots, M \quad (5)$$

$$\begin{aligned} D_{i,t-1}^+ - D_{i,t-1}^- + X_{it} - D_{it}^+ + D_{it}^- = \\ d_{it} \quad \forall i = 1, \dots, M; \forall t = 1, \dots, T \end{aligned} \quad (6)$$

RESULTS AND DISCUSSION

Data collection is grouped into two primary data obtained from companies and secondary Data obtained from previous literature and research.

Data demand for rice husk charcoal products for 12 months (January-December 2019) is listed in Table 2.

Table 2. Demand for rice husk charcoal husks for 12 months

Months	A (Beam /Cube)	B (Hexagonal)	C (Pillow)	D (Tablet Form)
January	5	0	0	0
February	28	0	0	5
March	45	0	0	5
April	37	0	0	0
May	21	8	4	0
June	12	17	4	0
July	17	22	4	0
August	10	11	0	0
September	2	10	0	2
October	0	5	1	7
November	0	5	1	7
December	0	0	1	2

The data information and labor needs for each Rice Husk Charcoal Product are in Table 3.

Table 3. Labor Needs data

Type of Rice Husk Charcoal	Production Cost/Kg	Sales Profits	Labour	Expected savings from the change
A	14200	9600	795	170000
B	34100	12770	802	84000
C	54000	18320	1370	47000
D	46700	14630	1360	70000

Here data forecasting the average rate of change with the value of maximal labor needs capability is $T_k = 8,000$ and $T_{km} = 40000$, and correlation rate $r = 0.3$ in Table 4. Based on Table

4, there are fluctuations in forecasting changes over one year in Figure 8. Results Based on goal Programming model in Table 5.

Table 4. Average Forecasting Results need Rate of Change

Months	1	2	3	4	5	6	7	8	9	10	11	12
Average Change	0.980	0.970	0.982	0.975	0.984	1.001	0.985	0.979	0.989	1.004	1.005	1.000

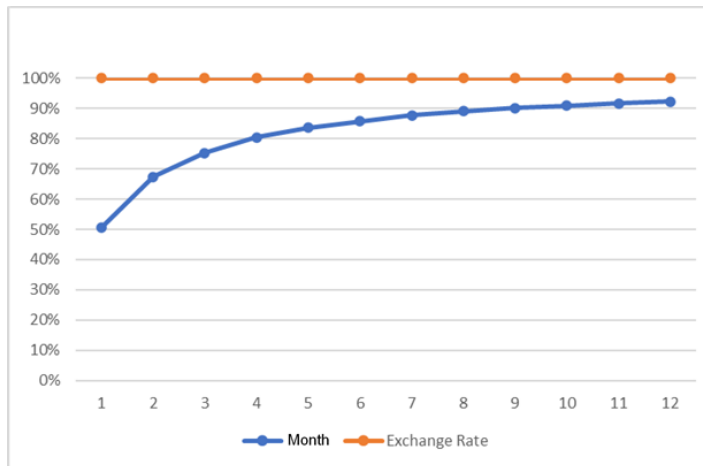


Figure 8. Forecasting Fluctuations of Change

Table 5. Results based on the goal programming model

Months	X_{At}	X_{Bt}	X_{Ct}	X_{Dt}	W_t	L_t^+	L_t^-	R_t^+	R_t^-
1	14	0	0	0	20000	11000	0	0	0
2	42	0	0	8	50000	20000	0	15000	0
3	45	0	0	16	50000	0	0	15000	0
4	32	0	0	0	34839	0	15161	10452	0
5	4	23	7	0	34839	0	0	10452	0
6	11	15	7	7	34839	0	0	10452	0
7	26	18	7	0	42879	8040	0	12864	0
8	12	27	0	0	42879	0	0	6130	0
9	5	0	0	11	42879	0	0	0	24126
10	0	11	4	4	18855	0	24024	5657	0
11	0	5	5	10	18855	0	0	56576	0
12	0	0	3	5	26799	7944	0	0	16799

Based on the three function objectives, results from the goal programming model are obtained results in Table 6. The amount of inventory needed for 12 months on aggregate planning is presented in Table 7. The purpose of aggregate planning with Fuzzy goal programming method in Table 8 for each element of constraint function and resources for aggregate planning.

Table 6. Results on destination functions

	A	B	C	D
Rice Husk				
Charcoal				
C_i^+	220.4	3718.6	2127.7	1164
C_i^-	0	0	0	0

Tabel 7. Net Inventory

Months	Net Inventory			
	I_{At}	I_{Bt}	I_{Ct}	I_{Dt}
0	0	0	0	0
1	9	0	0	0
2	26	0	0	0
3	18	0	0	8
4	17	0	0	0
5	0	12	0	0
6	0	7	0	7
7	0	0	0	7
8	0	13	0	7
9	0	0	0	13
10	0	3	0	7
11	0	0	1	7
12	0	0	0	7

Table 8. Objective Achievement Results

Membership Function	Results	Weighting Value
Inventory level	0.05	0
Safety Supplies	0.3	1
Overtime	0.1	0
Annoying Time	0.15	1
Increased Number of Workers	0.2	0
Decrease in The Number of Workers	0.2	1

CONCLUSION

Aggregate Planning of Rice Husk charcoal production begins with reviewing literature related to friends Aggregate planning optimization research with Multi-Objective Fuzzy Goal Programming approach with reduced purpose function based on three main objectives namely Storage Level and Safety inventory level, Employee overtime work time and Waiting Time and Third goal is Labor change rate. The planning for the next 12 months membership function on Fuzzy Goal programming based on the three function goals to be achieved. Data processing results obtained results that can be effective to be applied in the company based on the model and the proposed approach.

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