Apply Fuzzy Weighted Goal Programming in Sustainable Sugar Supply Chain: A case study of Thanh Thanh Cong Company Viet Nam

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Abstract. Nowadays, when supply chain management is becoming a necessary term in the competitive advantages of company in all industries. In the sugar industry, an effective supply chain plays an essential role. However, the domestic companies are taking a lot of pressure in competition with foreign one about cost and services. As a new trend in supply chain management (SCM), environmental dimension as recently considered as an important factor as the economic factors in the industry. Thus, the new improvements of sugar cane are toward achieving objectives in both dimensions, which is taking great attention in the sugar production. This study has firstly evaluated the sugar life cycle through environmentally friendly production systems. In this concern, the weighted fuzzy goal programming (WFGP) model is developed to determine the optimal production quantities of outputs in order to achieve goals about the amount of waste treatment, logistics, material usage and revenue. As well as this, the CPLEX software package is used as the main tool supported to run the model. The collected outputs are analyzed in different scenarios to generate the optimal solution which compromised the economic and environmental goals of supply chain network.

Keywords: Sustainable supply chain, weighted fuzzy goal programming (WFGP), sugar industry, environment, life cycle, CPLEX.

1. INTRODUCTION

Sugar industry is not advantageous economic sector but sugar is an important raw material in other food industries. That is also an indispensable for people life around the world. Currently, sugar is produced mainly from sugarcane and beets. In worldwide, there has more than 100 countries produce sugar, about 80% of which is made from sugarcane is grown mainly in tropical and subtropical of the southern hemisphere, and the remaining 20% is made from the beets cultivated mainly in temperate regions of the Northern hemisphere. In Vietnam, since 2000, the sugar industry is identified as one of the most important sectors economic sector. However, according to experts, Sugar industry of Vietnam has less competitive in world economic integration. On the other hand, the sugar industry waste resources is the threat of many rivers, polluting water sources, affecting the health of the people along the basin pollution.

Nowadays, most of international companies are forced into a supply chain as competitive advantages. Those are not only for each member in the chain but also for entire supply chain. The strong links of all members in the supply chain together force the flow of materials from suppliers to

customers faster and optimizer. Traditionally, supply chains are designed with the objectives of economic concerns. There are environmental challenges such as: global warming, air, soil and water pollution which created a new awareness of sustainability in supply chain management. Thus, all investments of supply chain are aim to balance between three main dimensions: economy, social and environment. To adapt with the new trend, organizations are designed or redesigned to stimulate the sustainable performance in production and distribution. There are some related works applied new methods improve the performance in supply chain. As (Kulak, Nemecek, Frossard, & Gaillard, 2016) [1] indicated that the function of integrative design and Life Cycle Assessment (LCA) in improving environmental performances, reducing the resources use and emission from Bread Supply Chain in France. The authors just concentrated on agricultural side and this method provides information of environment and improves the ecological efficiency of the value chain. It is also based on Life Cycle Assessment technique, in 2010, Duque, Barbosa-Póvoa, &Novais [11] solved problems in system optimization and determine the transportation schedule.Rommert Dekker and Jacqueline Bloemhof (2011) [7] indicated that, the most remarkable problem of today's environment is the greenhouse effect, which one of the reasons is because emissions during production, transportation and storage and consumption of all products. In this study, they offer an overview model to control the flow of goods in the supply chain management eg: problems about inventory, transportation, production, facility. The ethanol supply chain is evaluated according to economic and environmental terms, while environment is assessed by the life cycle greenhouse gas emissions. In the case of bioethanol production system, (Zamboni, Bezzo, & Shah, 2009) [2] developed MILP model and solved by multi-objective optimization for supply network. As well as this, it approached Well-to-Tank (WTT) to measure the greenhouse gas emissions (GHG). In the paper of (Pinto-Varela, Barbosa-Póvoa & Novais, 2011) [3], two dimensions of economy and environment are considered in the framework of mix integer linear programming model (MILP) and resource-task-network (RTN) methodology. The work aims to maximize profit and reduce environmental impacts. In fuel industry, bioethanol is considered as the most approriated solution for renewable resources. According to (Corsano, Vecchietti, &Montagna, 2011) [4], this study proposed the framework of designing and analysising the behavior for sustainable supply chain, which developed the mix integer nonlinear programming (MINLP). In measure sustainable performance in Argentina 2009, Mele, Guillén-Gosálbez, & Jiménez [12] developed a bi-criteria mix integer linear programming (MILP) aim to minimize cost and reduce environmental impacts in the entire life cycle of sugar and ethanol. In additionally, the supplier selection is also very important role to ensure sustainability in supply chain. Thus, most of organizations become strictly rather than in previous. Recently, there are some research works pay more attention to this issue with new approaches as:

No	Author	Methods	Result
1	(Tsai & Hung, 2009) [2]	AHP and fuzzy goal programming approach	Generating and solving the problem with multi objectives. Supporting companies select a sustainable supplier
2	(Kuo, Hsu, & Chen, 2015) [5]	Supplier performance assessment with integrating fuzzy ANP and fuzzy TOPSIS	Provide the hybric method to assess the carbon management of suppliers
3	(Chaharsooghi & Ashrafi, 2014) [15]	Neofuzzy TOPSIS for sustainable supply chain management	Proposed model for the best supplier selection follow triple bottom line (TBL) with economic, society and environment
4	(You & Snyder, 2012) [10]	Multi-objective mix-integer linear programming with ε-constraint method, pareto analysis	Selected the location with lowest transportation cost to material sources, suggest the technology to overcome the barrier of ethanol commercial.
5	(Shen, 2013) [14]	Propose fuzzy multi-criteria model (fuzzy	The proposed method is used to aggregate the

	TOPSIS) to evaluate suppliers in two dimensions: economy and environment	ratings and evaluate an overall performance score on each supplier's performance

Using other mathematical techniques such as statistical analysis and optimization, operation research offer an optimal solution or near optimal for complicated decision of problem. In 2016, Wladimir E.Soto-Silva [6] presents some articles using OR models for fresh fruit supply chain. It is focused in tactical and operational decisions and less considered strategic decisions. Moreover, Nelson Chibeles-Martins and Tânia Pinto-Varela (2015) have presented the way to choose a suitable technology installed in production facilities and define the location and capacities for elements of supply chain (plants, inventories, distribution centers, retailers). Based on this research, economy and environment play an important role when designing and planning supply chain management aim to balance between revenue and environment effect. According to Dr Peter W Rein (2011) [16], recommended components of sustainability and the main problems producers have to face with. This paper also mention about the aspects of sustainability and its effect with economy, environment and social development. In 2007, C.N. Bezuidenhout [17], used Simulation model reporting about the development of operational crop forecasting system. An optimal design using multi-objective mixed-integer linear program is proposed by Fernando D. Mele [8] in 2011. The objective of the study is to launch a quantitative tool to help authorities in the strategic policies analyzation in the field of agriculture and energy, support decision-making in the field of optimal design of the supply chain (SC) for sugar cane production with ethanol. P.W. Gerbens-Leenes (2003) [9] has mentioned about Sustainable Corporate Performance (SCP),this paper introduces the discoveries of a study about the environmental indicators using and proposes a measuring strategy for sustainable environment in producing food. The last result is communicated in three major indexes: the aggregate area, energy and water requirement per kilogram of available food. Company use these data to compare and against with other companies in the same market. In 2015, Sebnem Yilmaz Balaman [10] has represented fuzzy mathematical programming to develop a decision model in order to optimize multi-objectives for economic aspects. The government and private financial specialists can utilize this model to examine the relationship between vitality crop usage and operational expenses on inventory network structure so as to propose tax strategies and finance for renewable energy sector.

However, there are not many papers which support to improve the supply chain performance in sugar cane industry toward sustainable development. In developing countries, this field is putting potential goals in fuzzy environment which is not only enhancing value-added for main products but also becoming friendlier to environment.

2. METHODOLOGY

2.1 Framework

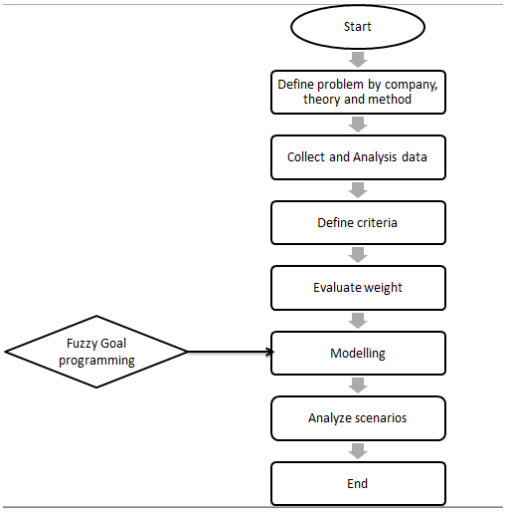

Figure 1: Research process

Step 1: Identify the problem of company and choose methodology

Step 2: Collect data from departments of company and analysis.

Step 3: Identify the criteria affect to the problem.

Step 4: Evaluate the weights for each criterion by interviewing experts, manager of the company.

Step 5: Apply Fuzzy Goal Programming to solve the problem

2.2 Life Cycle Assessment

This work evaluates the effects and consequences impact on the environment of the sugar production process by using Life Cycle Assessment (LCA) method on a cradle-to-grave basis.

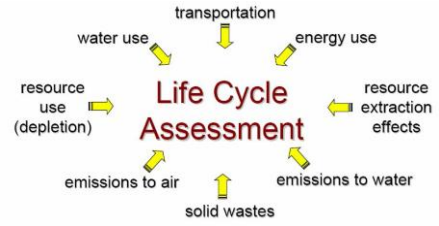

Figure 2: The issue is evaluated by LCA

The Life Cycle Assessment (LCA) is a technique evaluated the impacts and consequences on the

environment though out product's life from cradle to grave. Evaluate a product, a system under analysis life cycle assessment (LCA) including the exploitation of raw materials and energy sources from the environment, turning these into the desired product, using this product by consumers and finally discarded, reused or recycled products after using.

LCA includes the objectives and scope identification, statistical information and data collection, evaluation and environmental impact assessment and result analysis.

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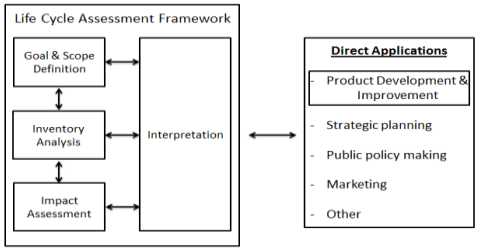

Figure 3: Life Cycle Assessment Framework

2.3 Fuzzy Weighted Goal Programming:

Goal Programming was appeared in study of Charnes and Cooper in 1961, but until 1955 this method was first used by Charnes, Cooper and Ferguson, goal programming support to find compromise solutions with multi-objective problems. This method is measured by the goal or target value which the company expects to achieve and the weighted score of each goal and constraints. Goal Programming (GP) can handle large numbers of objectives, variables and constraints. The major advantage of GP is very simple and easy to use.

Fuzzy Goal Programming considers the problems in the fuzzy environment with the aspiration levels or goals as precise and deterministic.

Membership function

According to Zadeh (1965), fuzzy set theory is based on the development of the basic definition of a set.

Definition 1: A fuzzy set A in X is defined by:

$$A - \{(x, \mu_A(x)) / x \in X\}$$

where $\mu_A(x) : X \to [0,1]$ is the membership function of A and $\mu_A(x)$ is the degree of membership to which x belongs to A:

Definition 2:

$$\mu_c(x) = \max[\mu_A(x), \mu_B(x)], \qquad x \in X$$

Definition 3:

$$\mu_c(x) = \min[\mu_A(x), \mu_B(x)], \qquad x \in X$$

Solution approach:

$$M_g(x) = \begin{cases} 1 & f_g(x) \geq L_g \\ [f_g(x) - (L_g - u_g)]/u_g & L_g - u_g \leq f_g(x) < L_g \\ 0 & f_g(x) < L_g - u_g \end{cases}$$

$$M_g(x) = \begin{cases} 1 & f_g(x) \leq L_g \\ [(L_g + u_g) - f_g(x)]/u_g & L_g < f_g(x) \leq L_g + u_g \\ 0 & f_g(x) > L_g + u_g \end{cases}$$

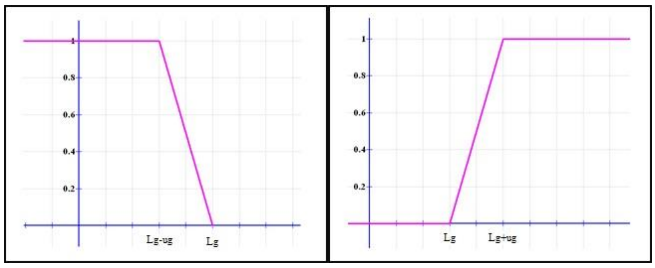

Figure 4: The membership function

2.4 CPLEX software

IBM ILOG CPLEX Optimization Studio (often informally referred to CPLEX) is an optimize software which is the main tool for solving Fuzzy Weighted Goal Programming to get the best solution. CPLEX help the company seek compromise solution by achieving their goals as: maximum the material usage and revenue, minimum the quantity wastewater and fertilizer as well as minimum the logistic cost.

3. MATHEMATICAL MODEL

It has firstly defined the notations used in the FGP model and then presents the model.

Indices

i: product n = 1,2,…n

j: customer m = 1,2,…n

Parameters

L_i The amount of product i when the plant pressed 1 ton sugarcane (ton)

S_{hj} The logistic cost of product i to customer j (vnd/ton)

P_i The selling price of product i (1,000vnd)

Q_{min} The minimum order quantity of product i to one customer annually

Q_{max} The maximum order quantity of product I to one customer j annually

W_f The weights of the deviation variables

L_1 The aspiration level of total material usage for next season

L_2 The aspiration level of total quantity of wastewater for next season

L_3 The aspiration level of quantity of fertilizer for next season

L_4 The aspiration level of logistic cost

L_5 The aspiration level of revenue

d_k^+ Amount of deviation above the goal

d_k^- Amount of deviation below the goal

Decision variables

X_i The quantity of product i (ton)

K_{hj} The quantity of product h to customer j (ton)

$d_k^+ > 0$, k = 1, 2, 3, 4, 5

$d_k^- > 0$, k = 1, 2, 3, 4, 5

Objective functions

$$Z = \sum_{f=1}^{K} \sum_{g=1}^{4} E_f \left(w_{fg} d_g + w_{fg}^- d_g^- \right)$$

Goal constraints

The constraints is considered in Goal Programming of Tsai in 2009 [16]. The constraints of this paper are including:

- Maximum the material usage and revenue of TTC Tay Ninh (constraint 1, 5)
- Minimum the quantity wastewater and fertilizer (constraint 2, 3)
- Minimum the logistic cost (constraint 4)

Then the detailed of the model is given below:

Maximize the total material usage

$$\left[\sum_{i=1}^{4} L_i X_i - (L_1 - u_1) \right] \Big/ u_1 + d_1^- - d_1^+ = 1 \qquad [1]$$

In Tay Ninh, the material resources of TTC Tay Ninh based on the farmers therefore input of company always unstable. Output X_i of sugar production process include: sugar, molasses, wastewater and fertilizer. Fertilizer is product of bagasse handling production. Each product has its own quantity L_i when the plant presses 1 ton sugarcane. This constraint is help company increase the input.

Minimize the total quantity of wastewater

$$\left[\alpha X_3 - (L_2 - u_2) \right] \Big/ u_2 + d_2^- - d_2^+ = 1 \qquad [2]$$

$$X_3 \geq X_1 \qquad [3]$$

Wastewater of sugar production has a high value of pollution index, contaminates water resource of local area and affects the human life. Therefore, TTC Tay Ninh tries to minimize this as much as possible.

Minimize the total quantity of fertilizer

$$\left[\beta X_4 - (L_3 - u_3) \right] \Big/ u_3 + d_3^- - d_3^+ = 1 \qquad [4]$$

$$X_4 \geq X_1 \qquad [5]$$

After pressing sugarcane, bagasse is the remainder of sugarcane. TTC Tay Ninh reuses this part become fertilizer for agriculture purpose. But the amount of bagasse too large, the company cannot handle it all therefore this constraint is expected to minimize the amount of bagasse as well as fertilizer.

Minimize the logistic cost

$$\left\{ (L_4 + u_4) - \sum_{j=1}^{8} S_{1j} K_{1j} \right\} \Big/ u_4 + d_4^- - d_4^+ = 1 \qquad [6]$$

Transportation cost is also a concerned problem of TTC Tay Ninh. Each year, the company has to spend lots of money for logistic company to delivery products to their customers. Thus, this constraint is minimizing the total logistic cost of product 1 (sugar) to customer j.

Maximize the revenue

$$\left[(P_1 \times X_1 + P_2 \times X_2 + P_4 \times X_4) - (L_5 - u_5) \right] \Big/ u_5 + d_5^- - d_5^+ = 1 \qquad [7]$$

All of companies always want to increase profit so this constraint is expected to do that. This constraint concerned the cost of sugar, molasses and fertilizer.

Constraints

$$Q_{\min} \leq \sum_{j=1}^{8} K_{1j} \leq Q_{\max} \qquad [8]$$

TTC Tay Ninh is only delivery the number of containers per working day (242 working days per year) and each area can storage maximum 300 tons of sugar. Thus, this constraint is limiting the capacity transported to a customer annually.

$$\sum_{j=1}^{2} K_{1j} = 0.5 \times \sum_{j=1}^{8} K_{1j} \qquad [9]$$

$$\sum_{j=1}^{8} K_{1j} \leq X[1] \qquad [10]$$

The total quantity of sugar delivery from TTC Tay Ninh to Dong Nai province and Binh Duong province take 50% of total produced quantity. Most of produced sugar is consumed by all customers.

$$d_g^-, d_g^+ \geq 0, \forall g \qquad [11]$$

Non-negative integer variables: Z, K_{hj}

Non-negative variables: d_k^+ , d_k^-

Non-negative integer parameters: L_i, S_{hj}, P_i

4. CASE STUDY

TTC Tay Ninh is one of leading companies in Vietnam Sugar industry in output and product quality. Although products of the company only appear on market only for about over 10 years, the company also retains a stable position. Products of the company are consumed by the majority of confectionery and beverage manufacturers. The current market share of the company's refined sugar accounts for about 18% of Vietnam and sugar productivity accounted for 4.6% of total national output.

Main product of TTC Tay Ninh is refined sugar (R.E) which is manufactured according to European standards, for personal consumption and industry. Besides, TTC Tay Ninh also produce commercial electricity connect to National power grid and self-used electricity from bagasse. From 2008, TTC Tay Ninh also launched microbiological fertilizers for Tay Ninh farmers.

4.1 Problem statement

TTC Tay Ninh has developed with sustainable oriented in economy and environment term. Actually, company still remains some problems about unstable raw material resources and other related cost as: logistic, revenue.

The relationship between sugar production company and sugar cane growers to develop material areas not reached the desired effect. Sugarcane growers registration status is slowly, even not getting the support from businesses has also occurred in some localities;

mechanisms purchasing of corporate at some places that have not been done in accordance with the contract. After cutting, sugarcane is not shipped immediately to company that has reduced sugar concentration and reduced the trust on the sugar cane growers. Other reason is farmers just sign contract with company in one season. These are factors have negative effects to the raw material area development annually.

In production, TTC Tay Ninh has invested in upgrading machine and equipment, specifically as improve wastewater treatment systems capacity and recycle bagasse to fertilizer. These are also considered as revenue therefore company desire to increase the quantity of water and waste treatment.

TTC Tay Ninh pays logistic cost for logistic company to distribute products to their wholesalers and retailers. Currently, company has many strategic customers as: Pepsico, Coca cola, Kinh Do Group, Vinamilk, Unilever and delivery for 8 major areas: Ho Chi Minh city, Binh Duong, Dong Nai, Hung Yen, Ha Noi, Vung Tau, Can Tho, Long An. Besides, the total capacity of products transported to Ho Chi Minh City and Binh Duong province account for 50% the total capacity of production output while logistic cost is quite high. Revenue goal is also play an important role in managing the company.

4.2 Data collection

Table 1: Basis data for the quantity of each product when the plant press 1 ton sugarcane (ton) L_i

1 (Sugar)	2 (Molasses)	3 (Wastewater)	4 (Fertilizer)
0.09	29	0.95	0.75

Table 2: Logistic cost of products to customers (vnd/ton) S_{1j}

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	180	180	350	340	200	700	340	300

Table 3: The capacity of product is transported to a customer in 1 year (ton)

Q_{min}	7260
Q_{max}	72600

Table 4: The amount of wastewater and fertilizer

The quantity of		Wastewater	Fertilizer
Wastewater when produce 1 ton sugar	α	0.95	
Fertilizer when produce 1 ton sugar	β		0.12

Table 5: Goal of TTC TayNinh for next season

No.	**Content**	**Unit**	**Goal**
1	Sugarcane	Ton	950,000
2	Molasses	Ton	49,963
3	Wastewater	m3	1,173,000
4	Fertilizer	Ton	12,000
5	Revenue	1000vnd	2430000

Table 6: Fuzzy goals of the illustrative sugar GSC

Goal	**Aspiration levels** (L_g)	**Lower tolerance limits** $(L_g - u_g)$	**Upper tolerance limits** $(L_g + u_g)$	**Range** (u_g)
Goal 1 (ton)	950000	855000		95000
Goal 2 (m3)	1173000	1055700		117300
Goal 3 (ton)	12000	108000		1200
Goal 4 (1000vnd)	51600000		56760000	5160000
Goal 5 (1000vnd)	2430000	2187000		243000

Sugarcane is the main raw material of sugar production therefore this paper focus on this side. There are totally five main criteria to be considered by TTC Tay Ninh: material usage, the quantity of wastewater recycling and fertilizer, logistic cost and revenue. Each criterion is managed by different departments as: Raw Material and Agricultural Technology Department, Production Department, Logistic Department and Accounting Department. Each department has one manager and other 2-3 experts who has long experiences. Additionally, the suppliers for TTC Tay Ninh is primarily from many districts of Tay Ninh province and about 30% from Campuchia, the long-time customer of TTC Tay Ninh is from many areas in our country as: Pepsi, Cocacola, Kinh Do group,etc. ,which is mainly in Ho Chi Minh city, Dong

Nai province, Binh Duong province.

Then, the surveys were conducted within 1 week from July 3th to July 8th and interview 5 managers about their opinion in their offices. They were required to give a rating for each company's objectives. The manager would score points for each goal by using judgment to determine the importance level of the goals and then use mathematical to figure out is weight for each priorities of goal programming model in Table 7.

Table 7: weight for each priorities of goal

w1	w2	w3	w4	w5
0.5	0.03	0.02	0.15	0.3

4.3 SCENARIOS ANALYSIS

The first scenario follows the priorities of TTC Tay Ninh, while scenarios can change together for decision maker have more options to choose. The company has five priorities which can have 120 ways generating, many of them will have the same result. Therefore, this paper concerns on the cases that different from others in table 8 below.

Table 8: Analysis of scenarios

Priorities					
Scenarios	**A1**	**A2**	**A3**	**A4**	**A5**
1	MU	WR	F	L	R
2	WR	F	L	MU	R
3	F	R	MU	L	WR
4	WR	L	MU	F	R
5	WR	F	L	R	MU

Note: Material usage (MU), Water recycling goal (WR), Fertilizer goal (F), Logistic cost goal (L), Revenue goal (R).

5. RESULT

After solving Goal Programming by using CLPEX software, the results is showed below:

Table 9: The flow quantity of products

Sugar (X1)	Molasses (X2)	Wastewater (X3)	Fertilizer (X4)
280000	7131	1234738	280000

Table 10 The quantity of product 1 (sugar) to customer j

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	72600	13866	7260	7260	7260	50166	7260	7260

Table 11 Goal achievement

Priorities	**Goals**	**Objective**	**Result**
1	Material usage	Min d_1^+	$d_1^+ = 0$
2	Water recycling goal	Min d_2^-	$d_2^- = 0$
3	Fertilizer goal	Min d_3^-	$d_3^- = 0$
4	Logistic goal	Min d_4^+	$d_4^+ = 0$
5	Revenue goal	Min d_5^-	$d_5^- = 0$

6. CONCLUSIONS

The main purpose focuses on two techniques, namely Life Cycle Assessment (LCA) and fuzzy goal Programming. Firstly, LCA shows the life cycle of sugarcane in sugar production and evaluate the emissions (water, gas, bagasse) impact the environment. The fuzzy goal programming help company achieves goals about: material, desirable outputs (sugar, molasses, water recycling, fertilizer), logistics cost and revenue. By running model, the optimal result is suggested to company decision-makers to be:

Table 9: The best solution

Goals	**Pre-emptive Priorities**	**Weights**
Material usage	1	0.5
Water recycling	2	0.03
Fertilizer	3	0.02
Logistic	4	0.15
Revenue	5	0.3

Applying these methods, the problem of TTC Tay Ninh is solved. This thesis also concern many different scenarios by exchange priorities that help the company has more options for their best solution.

To overcome disadvantages of apply goal

programming in improving the supply chain performance. This paper is not only suggest the company decision makers an optimal solution but also prioritized in the potential goals. The main contribution of this paper is support decision-making in the integration of multi-objective and fuzzy environments. In additionally, the view of experts are play an important role in problem solving. This is a modern technique to improve or assess the supply chain performance toward sustainability. In future work, this frame work support to be extended as well combination of up-to-date multi criteria decision making (MCDM) methods which can ensure the quality of collected data and fuzzy goal programming. It is able to solve in large scale problems.

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REFERENCES

[1] M. Kulak, T. Nemecek, E. Frossard, and G. Gaillard, "Eco-efficiency improvement by using integrative design and life cycle assessment.The case study of alternative bread supply chains in France," *Journal of Cleaner Production*, vol. 112, pp. 2452-2461, 2016.

[2] W. H. Tsai and S.-J. Hung, "A fuzzy goal programming approach for green supply chain optimisation under activity-based costing and performance evaluation with a value-chain structure," *International Journal of Production Research*, vol. 47, pp. 4991-5017, 2009.

[3] T. Pinto-Varela, A. P. F. D. Barbosa-Póvoa, and A. Q. Novais, "Bi-objective optimization approach to the design and planning of supply chains: Economic versus environmental performances," *Computers & Chemical Engineering*, vol. 35, pp. 1454-1468, 2011.

[4] G. Corsano, A. R. Vecchietti, and J. M. Montagna, "Optimal design for sustainable bioethanol supply chain considering detailed plant performance model," *Computers & Chemical Engineering*, vol. 35, pp. 1384-1398, 2011.

[5] R. J. Kuo, C. W. Hsu, and Y. L. Chen, "Integration of fuzzy ANP and fuzzy TOPSIS for evaluating carbon performance of suppliers," *International Journal of Environmental Science and Technology*, vol. 12, pp. 3863-3876, 2015.

[6] W. E. Soto-Silva, E. Nadal-Roig, M. C. González-Araya, and L. M. Pla-Aragones, "Operational research models applied to the fresh fruit supply chain," *European Journal of Operational Research*, vol. 251, pp. 345-355, 2016.

[7] R. Dekker, J. Bloemhof, and I. Mallidis, "Operations Research for green logistics – An overview of aspects, issues, contributions and challenges," *European Journal of Operational Research*, vol. 219, pp. 671-679, 2012.

[8] F. D. Mele, A. M. Kostin, G. Guillén-Gosálbez, and L. Jiménez, "Multiobjective Model for More Sustainable Fuel Supply Chains. A Case Study of the Sugar Cane Industry in Argentina," *Industrial & Engineering Chemistry Research*, vol. 50, pp. 4939-4958, 2011.

[9] P. W. Gerbens-Leenes, H. C. Moll, and A. J. M. SchootUiterkamp, "Design and development of a measuring method for environmental sustainability in food production systems," *Ecological Economics*, vol. 46, pp. 231-248, 2003.

[10] S. YilmazBalaman and H. Selim, "A decision model for cost effective design of biomass based green energy supply chains," *BioresourTechnol*, vol. 191, pp. 97-109, Sep 2015.

[11] Duque, J., Barbosa-Póvoa, A. P., & Novais, A. Q. (2010). Design and planning of sustainable industrial networks: application to a recovery network of residual products. *Industrial & Engineering Chemistry Research* , 4230-4248.

[12] Mele, F. D., Guillén-Gosálbez, G., & Jiménez, L. (2009). Optimal planning of supply chains for bioethanol and sugar production with economic and environmental concerns. *Comput Aided Chem Eng* , 997-1002.

[13] F. You, L. Tao, D. J. Graziano, and S. W. Snyder, "Optimal design of sustainable cellulosic biofuel supply chains: Multiobjective optimization coupled with life cycle assessment and input-output analysis," *AIChE Journal*, vol. 58, pp. 1157-1180, 2012.

[14] L. Shen, L. Olfat, K. Govindan, R. Khodaverdi, and A. Diabat, "A fuzzy multi criteria approach for evaluating green supplier's performance in green supply chain with linguistic preferences," *Resources, Conservation and Recycling*, vol. 74, pp. 170-179, 2013.

[15] Chaharsooghi, S. K., &Ashrafi, M. (2014). Sustainable Supplier Performance Evaluation and Selection with Neofuzzy TOPSIS Method. International Scholarly Research Notices .

[16] Rein, P. W. (2011). Sustainable production of raw and refined cane sugar, Zuckerindustrie-Sugar Industry , 734.

[17] C. N. Bezuidenhout and A. Singels, "Operational forecasting of South African sugarcane production: Part

1 – System description," *Agricultural Systems*, vol. 92, pp. 23-38, 2007.
[18] Ministry of Natural Resources & Environment
[19] http://ttcsugar.com.vn
[20] http://cem.gov.vn