A Goal Programming Model for Solving Environmental Risk Production Planning Problem in Dairy Production System

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ABSTRACT

Environmental risk production planning and decision making is needed to analyze several alternatives in terms of multiple non commensurate criteria which involve conflicting preferences of different stakeholders.

In this paper, a goal programming model for tracking and tackling such environmental risk production planning problem that includes minimization of damages and wastes in the milk production system has been proposed. This model is explained by taking "SARAS" dairy production system in India. An interactive method which combines A.H.P. Strategy has been developed to solve this model.

Keywords: dairy, goal programming, production planning, A.H.P.

INTRODUCTION

Management of dairy and related products is a complex environmental issue. The products can have both positive and negative environmental consequences which have substantial benefits and thus result in severe environmental degradation. Also the rapid growing population and economic development are supplementing to the effects on the environmental degradation.

Due to the uncontrolled urbanization and industrialization, Forest and Agricultural land degradation, Resource depletion (water, mineral, forest, sand, rocks etc.,), Environmental degradation, Public Health, Loss of Biodiversity, Loss of resilience in ecosystems, Livelihood Security for the Poor Ramesha Chandrappa and Ravi.D.R [2] have become the major environmental issues. Conjunction with the growing environmental resources depletion, human toxicity levels and ecosystem quality deterioration have made our governments and corporate sector more attentive towards the environmental damage and they are investing more in the assessment of environmental impact of their products and services to reduce such impacts.

Industrial eco-systems are the environmental friendly systems for industrial waste recycling, resembling the food chains, food webs and the nutrient recycles in natural environment Liu and Shyng, [7]. Because it transforms the harmful component of waste into usable substance and slows down the depletion of primary resources. The win-win solutions for business and the environment seem quite elusive in practice, in particular for considerable reductions on environmental pressure Walley and Whitehead, [14].

Consequently, the dairy industry is facing a potential impact of an individual operation on the environment which varies with animal concentration, weather, and numerous other conditions. Some questions which cropped up:

1. What is the trade-off between the environmental pressure of an economic activity and its costs?
2. How much we need to spend to reduce the wastage produced during the dairy processing?
3. What efforts required to be put in to reduce the environmental impact due to dairy functions and processing?
4. What are the "best" solutions balancing ecological and economic concerns? (Quariguasi Frota Neto [8], [9])

On the normative and qualitative field, these question have led to the concept of trade-offs and efficient frontiers for business and the environment (Huppes and Ishikawa [3]), Bloemhof-Ruwaard et al. [1]) the rationale is to determine the set of solutions towards the reduction wastage and increase environmental quality without much/ any increase in costs. In order to explore the efficient frontier in feasible time (for the intractability of determining all extreme efficient solutions in a multi objective linear program, see Steuer, R.E [13] and Steuer et al. [12].

In every production process, inputs are used to create finished product or commodity. Inevitably, some inputs are not fully used and are released into the environment in forms that may be considered pollutants. Similarly in a dairy production process also, some inputs which are not fully used or wasted during transport and processing are released into the environment in forms that may be considered as pollutants and which specifically are categorized as wastes. Thus, whenever the level of wastage and pollution exceeds the environmental ability to absorb and process dairy discharge, environmental risks develops.

In this paper, a goal programming model has been proposed for managing business environmental risks and wastage thus produced in a dairy products processing organization which consists of making the production process more efficient in such a way to limit its environmental consequences while increasing profitability irrespective of the fact that no production process is 100% efficient.

1. <u>DAIRY PRODUCTION SYSTEM</u>

The dairy production system has two major divisions that further leads to the division of the fragmentation of the dairy industry into two main production areas:

1. Primary sector

2. Processing sector
3. Distribution sector

The Primary sector involves into the following activities:

1. Milking of cows, goats, sheep, buffalos and camels.
2. Feeding these milk producing animals

The processing sector involves in the following activities:

1. Heat treatment of milk (to ensure that milk is safe for human usage and to elongate its preservation period)
2. Preparation of a range of dairy product for the consumption by human being. This includes:
   i. Semi-hydrated dairy products
   ii. Dehydrated dairy products

The distribution sector of the dairy industry includes transportation of milk to the collection centers for various treatments and quality tests and up-gradation. It also includes the distribution of the variety of milk products to the various retail outlets for disbursement to the consumers.

This paper is focused on the dairy production process, the products thus manufactured and the wastage then produced. The primary sector is not considered here in this paper as it is more related to agriculture sector. We do will take into consideration the processing and the distribution sector to identify the actual wastage areas and then will take out the measures to minimize that loss by the use of goal programming.

3. DAIRY INDUSTRY IN INDIA

"INDIA IS THE WORLD'S HIGHEST MILK PRODUCER"

Dairy is a place where handling of milk and milk products is done and technology refers to the application of scientific knowledge for practical purposes. Dairy technology has been defined as that branch of dairy science, which deals with the processing of milk and the manufacture of milk products on an industrial scale.

In India, dairying has been regarded as a rural cottage industry profession since the remote past. Semi-commercial dairying started with the establishment of military dairy farms and co-operative milk unions throughout the country towards the end of the nineteenth century. During the earlier years, each household in the country maintained its 'family cow' or secured milk from its neighbor who supplied those living close by. As the growth of urban population, fewer households could keep a cow for private use. The high cost of milk production, problems of sanitation etc., restricted the practice; and gradually the "family cow" in the city was eliminated and city cattle were all sent back to the rural areas. Gradually farmers within easy driving distance began delivering milk over regular routes in the cities. This was the beginning of the fluid milk-sheds which surround the large cities of today. Prior to the 1850's, most milk was necessarily produced within a short distance of the place of consumption because of lack of suitable means of transportation and refrigeration.

The Indian dairy industry has made rapid progress since independence. A large number of modern milk plants and product factories have since been established. These organized dairies have been successfully engaged in the routine commercial production of pasteurized bottled milk/ packed milk and various western and Indian dairy products. With modern knowledge of the protection of milk during transportation, it became possible to locate dairies where land was less expensive and crops could be grown more economically.

In India, the market milk technology may be considered to have commenced in 1950, with the functioning of the central dairy of array milk colony, and further the country stepped into milk product technology in 1956 with the establishment of Amul Dairy, Anand. To fulfil the national objective of making India self sufficient in milk production, a small step was taken in March, 1975 when Jaipur Zila Dugdh Utpadak Sahakari Sangh Ltd., Jaipur (popularly known as Jaipur dairy) was registered under cooperative act 1965 to work in Jaipur district. Initially this union did not have the processing facilities. It started with a modest beginning of procuring 250 liters of milk per day, which has increased manifolds with the passage of time.

3.1 **HISTORY OF INDIAN MARKET MILK INDUSTRY**

Beginning in organized milk handling was made in India with the establishment of military dairy farms. Handling of milk in co-operative milk unions established all over the country on a small scale in the early stages. Long distance refrigerated rail-transport of milk from Anand to Bombay since 1945

Pasteurization and bottling of milk on a large scale for organized distribution was started at Aarey (1950), Calcutta (Haringhata, 1959), Delhi (1959), Worli (1961), Madras (1963) etc.

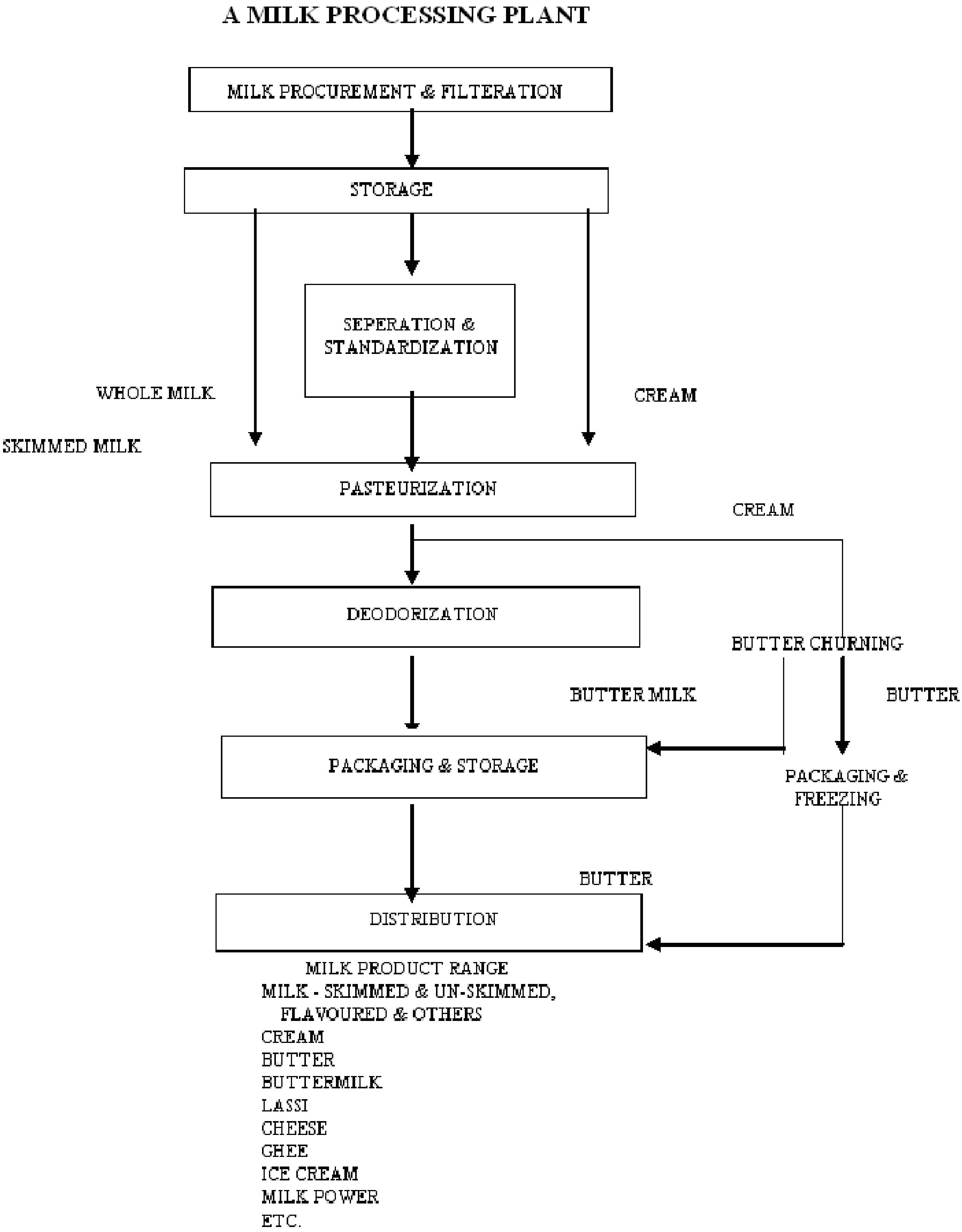
Establishment of milk plants under the five-year plans for dairy development all over India. These were taken up with the dual object of increasing the national level of milk consumption and ensuing better returns to the primary milk producer.

The main aim has been to produce more, better and cheaper milk which was possible only when the wastage was minimized and the available milk is packaged and distributed so that it could be made usable even after a considerably longer gestation period.

4. **PRODUCTION PROCESS OVERVIEW 'SARAS' DAIRY PRODUCTS**

This production process has been classified into following steps:

1. Milk procurement
2. Processing – this includes chilling, seperation & standardization, pasteurization, sterilization and deodorisation
3. Production of milk product range :
   i. Ghee
   ii. butter (salted / unsalted)
   iii. Skimmed milk powder(SMP)
   iv. Indigenous fresh milk products (paneer, shrikhand, chhach (plain / salted), lassi, mawa (khoa)& dahi (plain / mishti) and aseptic milk (which was handed over to Jaipur dairy only in 1997-98), ice-cream, shakes, etc.
4. Packaging
5. Storage (includes before and after storage both)
6. Distribution



Similar plants have been developed for the processing of butter, cheese, ghee and the various other products of the SARAS dairy.

5. **WASTAGE ANALYSIS AT EACH LEVEL**

THE FOLLOWING WASTES TO BE DISPOSED:

In the associated milk processing factories, most of the waste is washing water that is treated, usually by composting, and returned to waterways. This is much different from half a century ago, when the main products were butter, cheese and casein, and the rest of the milk had to be disposed of as waste (sometimes as animal feed).

In many cases, modern farms have very large quantities of milk to be transported to a factory for processing. If anything goes wrong with the milking, transport or processing facilities it can be a major disaster trying to dispose of enormous quantities of milk. If a road tanker overturns on a road, the rescue crew is looking at accommodating the spill of 5 to 10 thousand gallons of milk (20 to 45 thousand litres) without allowing any into the waterways. A derailed rail tanker-train may involve 10 times that amount. Without refrigeration, milk is a fragile commodity, and it is very damaging to the environment in its raw state. A widespread electrical power blackout is another disaster for the dairy industry, because both milking and processing facilities are affected.

1. Water wastage- water is used for cleaning, cooling and maintaining hygine standards
2. Solid wastes- include plastic bags, bottles, packs, cartons, etc.

LEVEL WASTE ANALYSIS

1. At milk procurement level – poor drainage of tankers, spilling any leakage in pipes and tankers, foaming of milk, wastage in cleaning operations
2. At pasteurization and heat treatment level – leaking, deposits on the equipment, foaming, cleaning operations
3. At separation and filtration level – foaming, cleaning operation, spilling, cleaning operation, left over
4. At deodorization level – vacreation, cleaning operations
5. Miscellaneous wastes – start-up and shut-down process loss, damaged packaging, overfilling, plant malfunctioning, manhandling losses, bagging losses, incomplete separation of whey from curd, etc.

6. MODELING MULTI-OBJECTIVES OPTIMIZATION OF THE PRODUCTION

Quariguasi Frota Neto [8] was the first approach to define the theoretical frontier of Huppes And Ishkawa [3]. A cradle to grave approach is used to determine the eco-efficient frontier regarding business and the environment for the design of sustainable logistic networks. In this work, the diverse phases of a product: raw material, extraction, manufacturing, transportation, use and end-of-use alternatives are accounted determine the optimal solutions. In order to assess the trade-offs and determine the optimum configurations, multi-objective programming is used.

A multi objective programming is denoted by (Steuer et al. [12]):

$$\mathrm{Min}\{c'X = z_1\}$$

$$\ldots.$$

$$\mathrm{Min}\{c^k x = z_k\}$$

$$\text{s.t. } \{x \in R^n \mid AX \le b, b \in R^m, x \ge 0\}$$

where,

k is number of objectives

a point $x \in SR^n$ is efficient iff there is no $x \in S$ such that $c^i \geq x^i$ and there is atleast one $c^i x < x^i$

The efficient set or efficient frontier is the set of all efficient solutions.

In our formulation, c^1x represents total cost of a certain economic configuration, c^2x the cumulative impact to the environment, c^3x the respective wastage.

The economical objective function is the sum of the cost of the following activities:

1. minimized wastage
2. waste processing
3. reuse of the industrial wastage
4. production based on clean technology

The constraints towards attainment of the functional objectives are:

1. capital required
2. labor handling
3. flow conditions
4. storage conditions
5. time lag during transportation
6. quality of raw material

6. DESCRIPTIONS

1. GOAL PROGRAMMING – The goal programming technique is an analytical framework that a decision-maker can use to provide optimal solutions to multiple and conflicting objectives. The GP and its variants have been applied to wide-ranging problems (Ignizio, [4]; Ijiri, [5]; Lee, [6]; Romero, [10]). it is a branch of multi-objective optimization, which in turn is a branch of Multi-Criteria Decision Analysis (MCDA), also known as Multiple-Criteria Decision Making (MCDM). This is an optimization programme. It can be thought of as an extension or generalization of linear programming to handle multiple, normally conflicting objective measures. Each of these measures is given a goal or target value to be achieved. Unwanted deviations from this set of target values are then minimized in an achievement function. This can be a vector or a weighted sum dependent on the goal programming variant used. As satisfaction of the target is deemed to satisfy the decision maker(s), an underlying satisfying philosophy is assumed.

2. A.H.P. - ANALYTIC HIERARCHY PROCESS (AHP), as one of multi-attribute decision making (MADM), is a structured technique for dealing with complex decisions. AHP provides the decision maker an approach to find results that best suits their requirement and their understanding of the problem, i.e. rather than prescribing a "correct" decision, the AHP helps the decision makers to find the decision most suitable to him. A.H.P was proposed by Saaty [11] 20 year ago and therefore referred as ‘Saaty’ method. It is a widely used technique for MADM, which is based upon pair wise subjective judgment of element used to complete a matrix. The Eigen value for each element is then used to asses the contribution of that element to the overall component.

In the context of this paper, a dairy production system on the basis of several criteria such as cost and wastage can be taken as a typical example. We would need to determine the relative contribution of cost and wastage to the overall decision and also the relative degree to which dairy manufacturer processes each criterion.

Assume that there are n elements, then we require (n (n-1))/2 pair-wise judgments to complete the matrix, where each judgments reflects the perception of the ratio of the relative contributions of elements i & j to the overall components be assessed so $a_{ij} = (w_i / w_j)$, subject to the following constraint:

$a_{ij} > 0$, $a_{ij} = 1$ when i = j elsewhere $a_{ji} = (1 / a_{ij})$.

Saaty argues that each of these judgments assign a number on a scale. A basic and reasonable assumption is that if attribute A is absolutely more important than attribute B and is rated at 9, then B must be absolutely less important than A and is valued at 1/9. The technique can only be effectively used where the elements are homogenous, that is with in the same order of magnitude, and hence the ratio must range from 1/9 to 9.

Through the literature review, we analyzed that Some researchers attach semantic labels such as "equal" where ratio is 1 ,"Slightly more important " where it is 2 and so forth for instance, if we considered wastage to be "Slightly more important " than cost , one would assign the value to the appropriate cell in the matrix. In this case matrix would be completed as follows:

	Wastage	Cost
Wastage	1	2
Cost	0.5	1

Each component has a priority scale that is derived ratio scale, to measure the contribution of each element to that component. This is based upon the approximate Eigen value (i.e. divide the sum of the row by n) of each element.

One problem that can occur, especially since the judgments are subjective is that the values assigned are inconsistent. For example, one would expect to observe transitivity. Consistency can be measured as a deviation of the principle Eigen value of the matrix from the order of the matrix.

The consistency index, CI, is calculated as follows.

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

Where λ_{max} is the maximum principle Eigen value of the judgment matrix. The nearer CI is to zero the more consistent the judgments. The CI can be compared with the consistency index of a random matrix (RI). The ratio CI/RI is known as the consistency ratio (CR) Saaty suggest CR should be less than 0.1, although one should be cautious about attaching undue significance to this value.

GP Model as follows :

Minimize : $\sum_{k=1}^{4} P_k(\eta_k + \rho_k)$

Subject to :

$\sum_{j=1}^{n} C_{j\ wastage} X_j - \eta_1 + \rho_1 = G_W$ **}wastage target (P1)**

$\sum_{j=1}^{n} C_{j\ waste\ processing} X_j - \eta_2 + \rho_2 = G_{WP}$ **}waste processing target (P2)**

$\sum_{j=1}^{n} C_{j\ reuse\ of\ the\ industrial\ wastage} X_j - \eta_3 + \rho_3 = G_{RW}$ **}reuse of the industrial wastage target (P3)**

$\sum_{j=1}^{n} C_{j\ production\ based\ on\ clean\ technology} X_j - \eta_4 + \rho_4 = G_{CT}$ **} clean technology target (P4)**

$\sum_{j=1}^{n} C_j X_j \leq B_{cr}$ **}capital required constraint**

$\sum^{n}_{j=1} C_j X_j \leq B_{lh}$ **}labor handling constraint**

$\sum^{n}_{j=1} C_j X_j \leq B_{fc}$ **}flow conditions constraint**

$\sum^{n}_{j=1} C_j X_j \leq B_{sc}$ **}storage conditions constraint**

$\sum^{n}_{j=1} C_{ij} X_j \leq B_{tl}$ **} time lag during transportation constraint**

$\sum^{n}_{j=1} C_{ij} X_j \leq B_{qm}$ **} quality of raw material constraint**

$\eta_i, \rho_i, X_j \geq 0$ **} non–negativity constraint**

$\eta_i * \rho_i = 0$ **} complementary constraint**

$i = 1,2,3,\ldots\ldots..8 , j = 1,2,3,\ldots\ldots..n$

We use Analytic Hierarchy Process to determine the level of priority. A hierarchy of importance among goals is established by assigning to each of them a pre-emptive priority factor, Pj These pre-emptive priority factors reflect the hierarchical relationships in such a way that P1 represents the highest priority, P2 the second highest, and P3 third highest, P4 forth highest priority. A positive deviational variable (η_i) represents overachievement of the goal. A negative deviational variable (ρ_i) represents underachievement of the goal. If the desire is not to underachieve the goal, d should be driven to zero. To the contrary, if d is driven to zero, the overachievement of the goal will not be realized. Deviational variables are mutually exclusive.

Where X1,X2,…….,Xn represent decision variable, (Cij) represent the contribution coefficientof each decision variable. GW ,GWP ,GRW ,GCT represent the goals for the minimized wastage ,waste processing , reuse of the industrial wastage , production based on clean technology respectively.

7. RECOMMENDATIONS

Feeding to increase productive life by reducing culling rates, improving herd health status, maintaining fertility, reducing mastitis and somatic cell count, and increasing milk production are possible goals on dairy farms. Dairy managers, veterinarians, and nutritionists can review the following outline of key points and nutrient guideline table for phase feeding.

1. Monitoring dry matter intake
2. Optimizing rumen fermentation
3. Strategies with transition feeding program
4. Balancing and meeting nutrient requirements
5. Benchmarking cow performance

8. CONCLUSION

The purpose of the paper was to suggest another method for the minimization of the wastage during the dairy products' processing in the SARAS dairy. We suggest the use and the application of goal programming method for the reduction of the wastage of the milk and its products or by-products. The goal programming model for managing the wastage during the dairy processing consists of making the production process more efficient in such a way as to limit the wastes in the processing.

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