REVIEW OF LITERATURE
CHAPTER 2

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There is a need for making the detailed review of literature on the present study to know the existing status of the research problem. So that the researcher would be able to make an improvement over the existing studies and also expand the horizon of investigation on the subject matter. The review would also help in refuting, the concepts and statements made in the earlier studies as well as support the findings of the present study.

Next to field crops, dairying forms an important subsidiary occupation in agriculture, which has the largest employment potential. So it is necessary to study the economics of dairy farming, the production functions on input and output data.

Many research workers have estimated the resource use efficiency using several types of production functions like Cobb-Douglas, Quadratic and square root to data to measure the resource use efficiency, allocation efficiency and impact of use of dummy variable in dairy production function have been reviewed.

References of the types of production functions used in the analysis of animal science, whether for a cow or buffalo or for mixed flock were included in the thesis because analytical method does not depend on types of animals. To review the various analytical methods the references were viewed and added in the chapter.
Jocob et al. (1969) tried linear, quadratic and Cobb-Douglass type of production function with Paragrass, concentrate mixture, groundnut cake and ragi straw as the independent variables and milk production as the dependent variable of the three types of production function, the quadratic function was preferred for further analysis on grounds of logic although on statistical grounds the Cobb-Douglas production function was more suited. The percentage of the variation explained by the Cobb-Douglass production function was 78. The regression coefficient for concentrates (0.78) and Paragrass (0.28) were statistically significant while those for groundnut cake and ragi straw were not significant.

Kumar et al. (1975) used Cobb-Douglas type of production function in milk production for Hariana cows in Hissar district of Hariana. The fitted production equation revealed that the value of $R^2$ ranged from 0.43 to 0.66 implying thereby that the dairy inputs namely feed, labour, depreciation and miscellaneous explained about 43 to 66 per cent of the total variation in the milk yield. At the overall, the regression coefficient of feed (0.39) was highly significant followed by miscellaneous expenditure (0.24). The regression coefficient of depreciation owns positive (0.19) while the regression coefficient of labour was negative (-0.06) but not significant. The elasticity of production was highest for feed implying nearest feed was the major and the most significant factor influencing milk yield.
Sankhayan and Joshi (1975) studied the resource productivity in milk production of crossbred and indigenous cows in the area of Ludhiana district. Cobb-Douglas type of production function was selected for further economic analysis. Age, number of lactations, stage of lactation, quantity of concentrate and quantity of green fodder formed independent varieties. The milk yield as dependent varieties. The total variation in milk production in the case of indigenous (82 per cent) and crossbred (51 per cent) cow were influenced by the various factors. On an average the regression coefficient for concentrate (0.59) was highly significant as compared to other input factors. The marginal value product of concentrate, dry and green fodder were positive in all the cases for both the breeds and amounted to Rs. 1.81, 0.03 and 0.24, respectively in case of indigenous cows and Rs. 1.48, 0.59 and 1.44 in case of crossbred cows.

Singh and Jha (1975) tried linear, Cobb-Douglas, quadratic and square root forms of production functions in Elah district of Uttar Pradesh. Cobb-Douglas type of production function was chosen for presentation of economic analysis on the basis of inherent conformity to production logic and also the significant levels of variables. Functions were fitted for Murrah and local buffaloes separates, seasonwise, coefficient of multiple determination indicated that the independent variable like green fodder, concentrates and human labour explained about 60 to 77 per cent of variation in the milk yield in case of Murrah buffaloes.
The highest and lowest being for the equation for rainy and winter seasons, respectively for non-descript buffaloes the range was 78 to 82 per cent. Maximum being for winter and minimum for summer season equation. In case of Murrah buffalo regression co-efficient of labour in rainy (1.89) and winter (0.83) were highly significant. In case of non-descript buffalo the regression coefficient of labour in rainy (1.220) and winter (0.99) were also statistically significant.

Chandrappa (1977) studied the economic analysis of milk production in Chitradurga district of Karnataka state. He used the Cobb-Douglas type of production function in order to determine the relationship between the milk and a set of inputs contributing to it. The regression coefficients are also the efficacies of production and the surus of these regression coefficients indicated the returns to scale. The production functional model was as the following type

\[ Y = a \cdot X_1^{b_1} X_2^{b_2} X_3^{b_3} X_4^{b_4} \quad \text{and} \quad Y = X_1^{b_1} X_1^{b_2} X_1^{b_3} X_1^{b_4} \]

Where,

\[ Y = \text{ Milk yield liters per animal per year.} \]
\[ X_1 = \text{ Roughages per animal per year .} \]
\[ X_2 = \text{ Concentrates per animal in Kg. per year } \]
\[ X_3 = \text{ Value of animal in Rupees.} \]
\[ X_4 = \text{ Lactation period in years.} \]
The coefficient of multiple determination was higher in crossbred cow (0.94) than the local cow (0.89). The elasticity coefficients for concentrates in case of crossbred cow (0.87) and local cow (0.30) were significant. It implied that an increase in quantity of concentrates to crossbred and local cows by one per cent holding the other inputs constants their milk yield increased respectively by 0.87 and 0.30 per cent.

Singh (1979) studied the economics of milk production and bovine livestock composition in a growing economy in Delhi. He considered two milk production technologies viz. cows and in buffaloes and used Cobb-Douglas form of production function to study the impact of different factors viz. green fodder, dry fodder, concentrates and the number of animals per farm in milk production. It was revealed that coefficients of multiple determination for cows and buffaloes were 0.26 and 0.43 which implied that the variation in milk production due to explanatory variable was 26 and 43 per cent, respectively. Regression coefficient of concentrate in case of buffalo (0.34) was higher than the regression coefficient for concentrates in case of cows (0.08) which indicated the positive impact of concentrates on milk yield indeed dry fodder appears to be fed in excess by the farmers of Delhi region.

Sambasiva Rao (1985) studied the factors affecting milk production in the command area of Nagarjun Sagar project, in
Andhra Pradesh. Forty she-buffaloes were taken sampled out. Linear and Cobb-Douglass types of production functions were tried but the Cobb-Douglass type of production function was chosen for presentation of the analysis because it gave a better fit to the data. The first zero order correlation matrices were worked out and the correlation coefficients were examined to detect the multi co-linearity problem. If the value of correlation coefficient between any two explanatory variable is less than the value of the coefficient of multiple determination, then it can be treated as problem of multi co-linearity. Thus explanatory variables considered near values of dry fodder, green fodder, concentrates, number of lactations and labour hours. The values of milk per, animal per day was dependent variable. The coefficient of multiple determination was 0.78 which indicated the regression coefficient of concentrate (0.62) was highly significant followed by labour (0.27), dry fodder (0.22) and green fodder (0.32). But it was negative for number of lactations (0.28).

Singh and Singh (1988) studied the resource management on commercial dairy herd in Karnal town (Haryana) and fitted both linear and Cobb-Douglass type of production functions and found that the Cobb-Douglass equation was more suited as it give a better fit with more value of coefficient of determination and more number of significant and logical regression coefficients. They considered annual return per milch animal (Rs.) as dependent variable and the independent variable
such as size of herd, annual expenditure on green fodder, dry fodder, concentrate, labour and miscellaneous expenditure per milch animal. The explanatory variables found to contributes 77 per cent in the milk yield per milch animal. The regression coefficient on all resources were statistically significant on small farm.

Sharma and Singh (1993) revealed that before employing Cobb-Douglass production function for resources productivity and allocation efficiency in milk production, in Himachal Pradesh zero order correlation matrices were worked out and the correlation coefficient were examined for multi co linearity. In order to capture the effect of different resources on milk production the dummy variables representing D₁ for summer and D₂ for rainy season were incorporated in the production functions. The coefficient of multiple determination \( (R^2) \) values were 0.75, 0.87 and 0.71 for crossbred cows, non descript cows and graded Murrah buffaloes, respectively. The regression coefficient of green fodder (0.07), dry fodder (0.03), concentrate (0.08) and labour (0.04) were significant. In case of non-descript cow the regression coefficient of green fodder, dry fodder, concentrate and labour were non significant. In case of Murrah buffalo, the regression coefficient of green fodder (0.06) dry fodder (0.05), concentrate (0.11) and labour (0.05) were significant. The dummy variables for summer and rainy season had negative regression coefficients. It indicated that milk yield was higher in winter as
compared to the summer and rainy season in all breeds of animals. The MVP of concentrate was positive and significantly higher than its price for all breeds of animals.

Padmanaban (1994) employed a Cobb-Douglas type of production function to evaluate the resource use efficiency among the three size groups of sheep farms in Tamil Nadu. The functional form of the production function was $Y = a \cdot X_1^{b_1} X_2^{b_2} X_3^{b_3} X_4^{b_4} e^u$ were $Y$ is annual income from sheep in Rs. is constant b's are elasticity's of production, $X_1$ is number of cows, $X_2$ is maintenance cost excluding labour in Rs. per year, $X_3$ is labour cost in Rs. per year, $X_4$ is average value of sheep in Rs. and $e^u$ is error term. The coefficient of multiple determination ($R^2$) values were 0.59, 0.49 and 0.51 for marginal, large and small farms respectively, which implies that 59.49 and 51 per cent of the variation in the income from sheep were explained by the included explanatory variables. In marginal farm, regression coefficient of labour (2.7) and value of sheep (1.18) were significant. In large farms, regression coefficient of ewes (7.3) was significant. The sum of regression coefficient for marginal (27) and small farms (1.80) indicated the increasing returns to scale. For large farm it was (0.77) decreasing return to scale indicating that increased use of variable inputs does not add to income from sheep.

Notter et al. (1979) used a deterministic computer simulation model to study the effects of milk production and body

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size on the biological and economic efficiency of beef production for a Midwestern cow-calf-feedlot management system. If forage digestibility and availability were high, relatively high milk levels could be tolerated in suckler cows without extreme depression in reproductive performance. However, if weaned calves were assumed to go directly into a feedlot on a 79% total digestible nutrient, the efficiency of conversion of TDN due to Empty Body (EB) or Fat-Free Weight (FFW) was maximized at relatively low milk levels associated with maximum cow fertility. Increase in body size produced more than proportionate increases in the optimum and maximum feasible milk levels. Economic efficiency (cost / 100 Kg) corresponded to biological efficiency if all TDN had the same cost, but if the price of feedlot TDN increased in relation to cow herd TDN, the optimum milk level also increased. Calf capacity, heifer condition and feed quality all affected the maximum feasible milk level, but changes in the optimum level were small. Progeny of high-milking cows were predicted to be fatter than progeny of low-milking cows when slaughtered at a constant weight. Slaughter at a constant EB fat content did not change the optimum milk level for economical EB weight production but did increase the optimum milk level for FFW production. Increase in milk level that increased weaning rate by increasing calf survival generally increased economic efficiency, whereas increases in milk level that reduced weaning weight per cow exposed by decreasing pregnancy rates reduced efficiency. Between these limits the
optimum milk level varied with the price ratio of feed lot to cow herd TDN and with the emphasis placed on EB fat content.

Cartwright (1979) in his article "The use of systems analysis in Animal Science with emphasis on Animal Breeding" mentioned the application of system Analysis in livestock production. The units of livestock production are individual animals, the units of livestock breeding are male, female and progeny. These units of production systems interact with the environment and mating systems often in a cryptic nonlinear manner so that all the inputs and outputs of the entire system must be simultaneously considered in order to evaluate the production or breeding value of individuals within a bounded production system. System analysis is defined as a method of conceptualizing a production system and modeling it in mathematical terms so that animal functions and responses across time and space are closely simulated or predicted.

System analysis provider a method of more systematically organizing knowledge including ad hoc research in animal science.

Oltenacu et al. (1981) tried mathematical modeling and dynamic simulation to evaluate relative economic merits of three heat detection rates and three conception rates. Reproductive performance is determined by the interplay of a large number of
management factors that can be controlled by the farmer and biological factors intrinsic to cow in a given environment.

Sethi and Nagarcenkar (1987) suggested the buffalo production model which simulates all the activities and accounts for each simulated variables. Similar model can be used for evaluating other livestock production system. System analysis is seldom feasible in actual animal production system therefore models are used. Modeling in system research consists of developing a mathematical model of system suitable for operation on computer. Economists generally use "Monto Curlo" model for simulation problems where as for specific systems analysis such as "dairying" the possible types of models used one are as follows.

i)  Simulation models (using differential equation live table)

ii) Optimization models (using linear programming)

iii) Statistical models (using regression models)

Oltenacu et al. (1980) tried the modeling reproduction in a heard of dairy cattle. A dynamic stochastic model to simulate the productive process in a heard of dairy cattle has been constructed. The next event scheduling approach was utilized with four events being specified, parturition, ovulation, embryonic loss and replacement.

Balaine et al.(1981) studied profit functions frowzy cow performance : to establish the relationships among profit functions and to determine effects of prices on characteristics of the
functions and on rank of cows. Data were one to three lactations of 182 cows in the Beltsville Hostein herd. Three subsets of data were used 1) complete data set (182 cows) 2) cows with an opportunity for three lactations (192 cows) and 3) cows that completed three lactations (47 cows). Four profit functions were computed from income and expense for each cow. The correlation between per day and expenses was 98 the changes in selective price had little effect on sae of cows. Income variables milk yield, protein yield and fat yield had the highest simple correlations with profit per day (7.44). Expense items feed intake (0.27) mastitis treatments (- 0.21) and herd life (0.19) has the highest consolations with this profit function.

Brown et al. (1981) worked on the nutritional modeling and its impact on managerial goals in diary production. Various types of linear and curvilinear regression models were evaluated. Nutrition intake and the factors like stage of lactation, milk production, age, body weight / size, feeding frequency, feed type, season, concentrate amount, genetic feasibility, length of dry period etc and discussed critically. A definite interaction between the ideal body size and production potential were reported along with several environmental factors.

Freeman (1981) tried linear programming application in the breeding decision when goals of selection have been specified semen can be purchased at minimum cost to meet them
by linear programming application. Primary selection emphasis should be on production, predicted difference for dollars for most payment plans. Other traits that may deserve emphasis for sire selection are dystocia, satiability and type. Aids to cow culling included in a system model, with inputs from herd. Considerations of exported income and variance of income or size are described.

Kundu and Basu (1988) studied production functions namely linear Cobb-Douglas and quadratic were fitted separately for both Holstein Friesian (HF), crossbred cattle and Murrah buffaloes for optimization of resource utilization. Quadratic form of production function was found to be the “Best fit”. On the basis of marginally principle it was found that an adult HF crossbreed cattle annually needed 5.550 tons of hay fodder, 2008 kg of concentrates, 0.22 unit of labour, 0.27 acre of land and Rs. 1184.89 as operation cost. Likewise, an adult Murrah buffalo needed 6.32 tons of hay equivalent, 1346 Kg of concentrates, 0.19 unit of labour, 0.30 acre of land and Rs. 773.87 operational cost per year. Through optimal allocations of inputs, income from milk increased by 1.80% in HF crossbreed and 26.34% in Murrah buffaloes, which suggests a better possibility in buffaloes for obtaining higher milk yields through rationalized input / adjustments.

Sharma and Singh (1993) used the production function analysis as an analytical tool for achieving of the study. Linear,
Cobb-Douglas and Semi-log types of production functions were used to express the relationship between milk output per animal and various factors influencing it like green fodder, dry fodder, concentrate, labour cost, age of animal, order of lactation, stage of lactation and miscellaneous expenditure. The analysis indicated that the concentrate is the most important input affecting milk production. The regression coefficients of this input were positive and statistically significant in all the equations fitted. The regression coefficient of green fodder and dry fodder were also positive and significant in all the equation fitted. The coefficient of stage of lactation was significantly positive.

Reyes et al. (1981) were studied multistage linear programming representing 13 and 15 No calving intervals (production cycles) of Holstein cows in Northeast Texas, was used to estimate income over feed cost for 5900, 6800, 7700 and 8600 kg of 3.5% milk per lactation and six calving Deacons. The linear program model directly accounted for loss - or gain by stage of body weight during calving interval. The response of income over feed cost to increased milk yield was essentially linear. Income over feed cost for each milk yield did not differ between 13 and 15 month calving intervals indicating that the immediate penalty of extending calving interval can be hedged by multistage management.
Basu and Kundu (1988) applied technique of linear programming for maximizing net income from dairy farming. Optimum utilization of resources to increase net income of seven large and small dairy farms were developed by linear programming technique which revealed that Murrah buffaloes did not occur in the optimum plan pertaining to efficient use of resources in production of milk yield from mixed herd of cattle and buffaloes. Only Holstein - friesian crossbreed cattle with 4.5 cows per man and dry matter consumption at the rate of 9 tons per animal unit per year were achieved. More intensive use of the land per fodder cultivation and lesser member of man power were also envisaged in the optimal plan which showed considerable increase in the net income of five farms.

Shah and Singh (1994) tried linear and Log-linear mathematical models to examine input-output relationship in milk production for crossbreed cows in rural and urban areas of Bareilly district revealed that crossbred cows were maintained with better breeding efficiency by urban cattle keepers. Green fodder, concentrate and dry fodder were the inputs which hold significant and positive impact on returns from milk in all the three seasons in rural areas. However, in Urban area there feed input had positive and significant influence only in winter season. The marginal value product of green fodder in winter season indicated that the use of there resources should be increased further in rural areas so as to make rational resource adjustments. In urban area in
some cases the use of green fodder and concentrate should also be enhanced for higher milk production and profits.

Kumar and Agarwal (1998) studied the resource productivity and resource use efficiency of milk production at NDRI farm, Karnal during 1986-87. Linear and Log-linear milk production functions, using daily milk yield (y) as dependent variable and roughage (X₁) and concentrate (X₂) as explanatory variable were tried. The roughages and concentrate together explained total variation ranging from 71 to 88 per cent for indigenous cows, and from 79 to 95 per cent in crossbred cows, in different months. The regression coefficients of roughage were found negative in all the months both for indigenous and crossbred cows, while regression coefficients of concentrates were found positive and highly significant for both the breeds of cows. The MVP of inputs and returns to scale indicated excess use of roughage and importance of concentrate in increasing milk production for both the breed of cows.

Tozer (2000) tried four mathematical programming models developed to formulate rations for large breed replacement dairy heifers in each of 11 different weight classes from 50 to 550 kg and daily growth rates of 600, 700 and 800 g, with the objective of achieving a final calving weight of 600 kg. First, a base linear programming model was developed; then, to account for variability in the crude protein content of ration ingredients three
other methods were used: right-hand side adjustment, incorporation of a safety margin, and stochastic programming. The average daily cost to calving, given a daily gain of 600,700 and 800 g, was $, .62 , $.64 and $.68, respectively. The total feed cost to 600 kg was $89.87 more for a growth rate of 600 over 800 g/d. The stochastic programming model performed better, on the bases of cost and protein feeding, than did the right-hand side adjustment or the safety margin methods. The stochastic programming model over-adjusted crude protein by 5% and cost an average of 3.5% more than the linear programming solution for a dairy heifer growing at 800 g/d with a desired probability of 80% of crude protein intake achieving the NRC minimum. The other two methods over-adjusted crude protein by 10 and 13% and cost an extra 5.5 and 7.6%, respectively, for the right-hand side adjustment and safety margin methods.

Mourits et al. (1997) studied mathematical models to maximize herd profits. Dairy farmers are faced with the complex dilemma of minimizing costs that are associated with rearing heifers while ensuring or enhancing lifetime economic productivity. Decisions about heifer management interact with underlying biological aspects of growth, thereby influencing future profitability. A thorough understanding of these biological interactions is lacking. Studies based on models could be useful in the evaluation of various rearing strategies. Currently available models for dairy cattle primarily focus on the dairy cow. In a dairy
farm production system, management decisions concerning the rearing of livestock and the replacement of dairy cows strongly influence each other. In a model that describes the dairy herd as a multiple component system, opportunity is greater to coordinate rearing and replacement policies. Expected benefits of such a model are discussed.

Hall et al. (1998) used a new application of an optimization tool, dynamic programming (DP), is described to model the economics of animal health control programs. To demonstrate the value of this technique, a model is applied to determine optimal net benefits of controlling East Coast fever (ECF) in Malawi Zebu cattle in the Lilongwe plateau. The objective function was the present value of net benefits due to treatment, defined as mortality savings minus treatment costs. Mortality savings were based on decreased mortality from ECF following treatment. Model constraints included herd size, animal (herd) nutritional requirements, and program budget. Treatment options were tank dipping in acaroids and vaccination. Secondary data from a dipping trial of 1800 Malawi Zebu cattle conducted from 1991 to 1994 were used to determine probabilities of mortality. Total optimal net benefits of long-term treatment (25 years, i = 10%) from vaccination (Malawi Kwacha (MK) 21 069) exceeded benefits for treatment with chlorfenvinphos acaricide (MK15 203).

Aloelija (1998) manure phosphorus (P) is a major pollutant in many ecologically sensitive areas today. Reduction of
manure P in the dairy industry is critical for environmental sustainability. Optimum ration management is one way of minimizing excess manure. The objective of the article is to present nutritionally satisfying rations that result in the elimination of unwanted P in a dairy farm by using an optimization-based nutrient balance (NBD) model. The NBD model shows that nutritionally satisfying rations that lead to zero-excess manure are characterized by high P contribution from crops, low in excess dietary N and P, high corn-to-alfalfa silage ratio, and high plant biomass content. Rations low in excess dietary N and P lead to low fecal excretion of P and high utilization of P and vice versa for rations high in excess dietary P. Rations formulated for high milk-yielding cows (25 kg d^{-1} or more) result in the most efficient utilization of P and zero-excess manure P. On the other hand, dairy systems with low milk yields (20 kg d^{-1} or less) have low utilization efficiency for P and, consequently, high unwanted manure P.

Mourits et al. (1999) studied dynamic programming technique in economic optimization of dairy heifer management decisions. A farmer exercises control over the heifer rearing unit in two main areas: nutritional plane of growth and the moment of insemination. The two management controls interact with biological aspects of growth thereby influencing future profitability of the dairy heifer. A dynamic programming model was developed to optimize these decisions for individual heifers, using the
hierarchic Markov process (HMP) technique. HMP provides a method to model a wide variety of heifer calves, differing in age, season, body weight, reproductive status and pubertal growth level. Under Dutch conditions the optimal rearing strategy resulted in an average calving age of 22.6 months at a calving weight of 564 kg. faced with the scarcity of exact information on the interrelationships of rearing strategies with the productivity of the dairy replacement, the strength of this heifer model lies in the field of the sensitivity analyses by providing valuable information regarding the critical components of heifer rearing.

Tedeschi et al. (2000) used linear programming technique in predicting feed biological values for diet optimization. The CNCPS model is intrinsically nonlinear, and feed biological values vary with animal and feed characteristics. To allow linear diet optimization, we first used the CNCPS model to generate biological values to characterize the energy and protein content of each feed for the specific group for which the diet was being formulated. The biological values used were metabolizable energy (Mcal/kg), metabolizable protein (% dry matter (DM)), passage rate (%/h), bacteria yield efficiencies (g/g), and degradation rate of the carbohydrate B2 fraction (%/h). In addition, the ruminal balances for nitrogen and peptides were included in the optimizer to optimize ruminal degradation of fiber. The objective function was to minimize diet cost subject to animal requirement and feed availability constraints. The animal constraints were set by
requirements for DM intake (kg/d), metabolizable energy (Mcal/kg), metabolizable protein (%DM), and effective neutral detergent fiber (%DM) for a given level of production. Data from a dairy farm were used to evaluate this linear diet optimizer. Across all classes of dairy cattle, the CNCPS 4.0 model typically obtained a solution in less than six iterations that met the requirements with nearly 100% accuracy. We conclude this linear optimizer can be used to accurately formulate least-cost diets with the CNCPS model.

Heyes et al. (2000) developed a method to derive optimum composite genotypes when the proportion of a specific breed (or combination of breeds) in the composite is constrained to a desired level. The method allows development of composites that balance net merit according to available parameters and reflects the production system and/or risk preference, particularly when traits in the breeding objective do not represent all traits important for production. The method can also be used to evaluate the cost of constraining breed use. For example, when the true optimal composite is difficult to obtain in the time frame available to the producer, the predicted merit of the composite with breed proportion restricted to those that are obtainable in practice can be compared with the predicted merit of the true optimum composite. In a case study the method is used to optimize a tropical composite using Brahman, Charolais, and Belmont Red breeds. The proportion of Charolais is to be
constrained to 50%. Using growth parameters from a tropical crossbreeding experiment, the unconstrained optimum composite was 32.5% Brahman, 11.1% Belmont Red, and 56.3% Charolais. When the proportion of Charolais in the composite was constrained to 50%, optimum proportions of Brahman and Belmont Red were 33.9% and 16.1%, respectively. In the case study net merit (annualized profit per cow exposed, $), as defined by the growth parameters, was 0.2% less than that of the unconstrained optimum composite.

Tozer and Stokes (2001) tried multiple objective programming used to examine the effects various objectives had on the optimal portfolio of sires chosen for a given breeding problem in a Jersey cow dairy herd. It was assumed that the dairy producer had the following three objectives in the breeding decision: to maximize net merit, to minimize inbreeding, and to minimize total expenditure on semen. Integer programming models of these three single objectives were estimated to provide the ideal and anti-ideal values for use in several multiple-objective programming models. The integer multiple-objective models examined the interactions and costs of tradeoffs between the three single objectives in a model framework designed to minimize the maximum deviations from the single-objective optima. A model with equal weights on each objective resulted in a decrease of 3% in average inbreeding but also reduced average net merit by $170 from the single-objective optima. A second model, where the
weight on net merit was twice that of inbreeding and semen cost, decreased net merit by $100 and reduced inbreeding by 2% from the single objective optima. The results of the multiple-objective programming models show that reducing the inbreeding coefficient for a group of sires purchased will decrease the net merit. However, the results generated also demonstrate that the weights placed on each objective by the dairy producer substantially affect the optimal levels of each objective within the multiple-objective model.

Amer et al. (1996) used a systems model to assess optimal breed and management choices for Swiss cattle farmers under alternative pricing systems. The model combines biological prediction functions parameterized using experimental results with least cost ration linear programming methods. Results for individual animals are aggregated to farm level according to equilibrium population theory with a constraint on either total roughage fed or total milk production. With the current pricing system, where milk payments and quota are based on milk volume, farm gross margins were FS 15618, -10616 and 1316 for Holstein Friesians, Jerseys and Simmentals, respectively. However, with component pricing and a fat quota, the breed gross margins were FS 14659, 18528 and 7598, respectively. Maximization of crosses with beef sires and reductions in voluntary culling are shown to have favorable effects on gross margins. Results indicate the extent to which levels of support prices and changes in
payment systems can influence technology decisions at farm level. Furthermore, it is argued that the future evolution of environmentally sound farming systems will be equally dependant on economic signals at farm level.

Gottardo (1978) developed a general plan for a cattle operation is given, then nine different but interconnected processes are distinguished within such a plan. The relationships that are found are fed into a linear programming matrix which considers the following problems: size of the breeding operation; average herd size at any given time; sales authorization; income; fixed and variable costs. The results can be applied to the analysis of groups of farms and are useful both for study and for technical assistance purposes.

Gasparetto (1994) studied optimization of milk production costs analyzed in a sample of 66 farms in 5 regions of Belluno, Italy. A marked variation in costs was found depending on the type of establishments involved. Factors related to farm structure, and not easily modified in the short term, included the number of cattle, farm area, availability of buildings and workforce. More easily modified factors were management choices such as feed composition and milk productivity/head. It is concluded that only large establishments can introduce economics on a scale sufficient to optimize production costs.
Kolajo and Martin (1994) studied cow-calf operations have traditionally been the mainstay of the beef cattle industry in southern USA, and Alabama ships feeder calves to feedlots in more than 30 states of the nation. On-farm cattle finishing is, however, gaining producers' interest in the south, and particularly in Alabama. This study evaluates the risk/return trade-offs of alternative production and marketing phases of vertically integrated grazing and cattle feeding programs in Alabama. A MOTAD model was developed to analyze alternative scenarios of cattle production and marketing systems. The results indicated that forage-finishing light steers produced the optimum net return with relatively lower risk level. Greater costs relative to returns were incurred on grain-finishing all feeder cattle activities. Thus, the economic feasibility of finishing stockers in Alabama lies in producing forage-fed beef.