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# Mathematical Programming Models in Planning of Optimum Agricultural Production in a Region – A Review

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**Abstract:- Agriculture is essential for human survival, as it serves the basic needs such as food shelter and clothing. A vast majority of the Indian population depends on agriculture for their livelihood. Though, a number of improved high yielding varieties and standard package of practices for cultivation of various crops have been evolved , the production and productivity has not been achieved to the fullest possible extent , due to various factors of which the variations in climatic conditions across crop growing regions is largely responsible. Yield prediction in various crops is an important factor which can help the both in the pre-sowing stage as well as in later stages for the planning of the various farm operations. . Several methods are available to predict the yield and other crop growth parameters which include regression models like Linear, Multiple Linear, Non-linear models, simulation models, Time Series model, Artificial Neural Networks (ANN), Big data analysis, etc. Under Indian conditions mathematical programming models are more reliable and have been validated for yield prediction and other crop related activities.. In this review, an attempt has been made to compile the various prediction methods and their applications in agriculture.**

***Keywords:-*** *Mathematical Programming Models, Linear, Multiple Linear, Non-Linear Models.*

## I. INTRODUCTION

India's is an agrarian country where more than 60 percent of the population depends on agricultural and allied sectors for their livelihood. The continuous population growth and decrease in the availability of natural resources for agriculture, has led to a situation where the nation has to produce more yield per unit area. Forecasting in agriculture at various spatial scales viz., district, state and national levels, is fundamental for providing timely information to the decision makers during the growing season. Therefore, cultural practices and production related forecasts are the key for making food policy decisions. Almost all major food security programmes rely on crop estimations and forecast for strategic planning. In the past, yield prediction was arrived by analyzing the farmer's previous experience in a particular crop. But of late several methods are available to predict the yield and other parameters which includes various regression models like Linear, Multiple Linear, Non-linear models, simulation models, Time Series model, Artificial Neural Networks (ANN), Big data analysis, Agromet data, etc. Among the various methods, mathematical programming models are fairly accurate and have been very well validated under Indian conditions. In this paper, an attempt has been made to compile various mathematical models available to use in the field of agriculture for resource allocation and yield predictions.

## II. REVIEW OF LITERATURE

The process by which a mathematical model can be use to solve real world situations is usually called the mathematical modeling process **(17).**In recent times, mathematical programming models (MP) play an important role for analysis of crop yields and economics of crop production. The basic idea of using mathematical programming models is to optimize the limited resources for maximization of output (**16).** The programming models capture the elements of basic economics and minimize transaction costs. Therefore they have become an important instrument for policy analysis right from the regional level to the global level in the farming sector **(20).** The quantification of the model is challenging as it requires a thorough knowledge model that can be used and a through understanding of the most relevant relationships among the factors.

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## III. CLASSIFICATION OF MATHEMATICAL PROGRAMMING MODELS

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### *A. Mechanistic Mathematical Model*

The unthinking numerical model advancement requires adequate comprehension of the physical, concoction, and organic procedures that happen in a framework and its utilization requests an appropriate approval. These sorts of models are logical models and might be static or dynamic. Also, the examination and depiction of a framework includes two procedures, development of scientific models and numerical arrangement of the arrangement of conditions that portray the conduct of the framework, using an advanced computer (12):.

It is critical to build up quantitative connections among the data sources and yields of the framework (14). One must utilize information about the mechanical, physical, compound, and natural procedures that happen inside in the framework. The numerical programming models are utilized legitimately to the connection the financial components with bio-physical and natural components of the homestead. The connections between the framework factors can be of various types' viz., preservation laws and constitutive connections. Albeit different strategies may likewise take into account consolidation of the joint non item yield creation, Numerical programming models offer one of a kind focal points over different techniques for horticultural part investigation in light of being profoundly interlinked and its capacity to address multivariants (7).

In the economic models, there are three developments that may explain the theoretical evolution such as (i) the switch from price support to other policy instruments with farm-specific ceilings, such as the dairy quotas, set-aside obligations, stock density restrictions. (ii), increased interest in multi functionality and (iii) the possibility of the introduction of restrictions, such as the land balance and animal feeding requirement constraints that prevent the results and thus enhances the credibility of optimization exercises **(5)**.

### *B. Direct Relapse*

Models of this sort may be basic, yet they speak to a helpful apparatus with a decent guess to comprehend the worldwide connections among plants and biosphere. This model can be utilized for the estimation of photorespiration at the biochemical entire plant and environment levels. It settles the fitting of oxygen (O2) and carbon dioxide (CO2) gas trades, staying away from complex conditions and uncovering the principle elements of guideline of photosynthesis with its indistinguishable relationship with photorespiration.

### *C. Different Straight Relapse*

By and large, yield will rely upon a few free factors, for example, x1; x2; x3; . . .; xn. This case can be treated by the numerous straight relapse (MLR) techniques. This strategy is most generally utilized technique in climatology and harvest yield expectation. This Different Direct Relapse (MLR) strategy is connected where the predictant is the generation and there are seven indicators to be specific year, precipitation, temperature, relative mugginess, territory of sowing, yield and manures (Nitrogen, Phosphorous and Potassium). This model builds up the straight connection between a needy variable and at least one autonomous factor. The needy variable is some of the time named as predictant and autonomous factors are called indicators.

### *D. Nonlinear Relapse*

The non straight relapse capacities will depend in a nonlinear manner on the relapse coefficients. Nonlinear relapse models are significant apparatuses the same number of yield and soil forms are preferred spoken to by nonlinear over by straight models.

### *E. Logistic Sort*

These kinds of models have been utilized in nature, demography, science and medication, for the investigation of the development of microscopic organisms, tumours, and a few types of creatures and plants.

### *F. R2 and Root Mean Square Mistake*

This is a general proportion of the quality of relationship to autonomous variable with the reliant variable. R2 somewhere in the range of 0 and 1 demonstrates the degree to which the needy variable is unsurprising. For instance, if R2=0.90 implies that 90 percent of the difference in yield is unsurprising from climate variable, etc. An examination of the level of incident among re-enacted and watched values was done by utilizing Root Mean Square Mistake. The RMSE has been generally utilized as a rule for model assessment and has been registered as:

$$RMSE(\%) = \left\{\frac{1}{n}\sum\left(O_i - S_i\right)^2\right\}^{1/2} \times \frac{100}{\overline{O}}$$

Where,

O and S are the watched and mimicked values for the ith perception. it the mean of watched esteems and N is the quantity of perceptions inside every treatment. The lower is the estimation of RMSE, higher is the precision of the model forecasts. A zero esteem is perfect. Standardized RMSE gives a measure (%) of the overall contrast of mimicked versus watched information. The re-enactment is viewed as brilliant with a standardized RMSE under 10%, great if the standardized RMSE is more prominent than 10% and under 20%, reasonable whenever standardized

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RMSE is more noteworthy than 20 and under 30%, and poor if the standardized RMSE is more noteworthy than 30% ( 10).

*G. Summed Up Relapse Neural Systems*

This technique is utilized for anticipating of horticultural harvest creation (2) and has been observed to be appropriate for forecast of grain generation in provincial territories. It was accounted for that model is reasonable for non-direct, multi-goals and multivariate estimating (19).

*H. Yield Creation Models*

This model is relies upon harvest type yet by and large include a succession of regular tasks. In arranging crop creation, ranchers must consider the regular idea of the tasks and the related types of gear and work necessities; reaping requires specific consideration in light of the fact that most yields must be collected amid generally brief periods. Yield at reaping relies upon climate conditions and the impact of bugs and ailments. The utilization of composts to improve the supplement supply, and synthetic substances to control bugs and illnesses, can diminish the variety in harvest yield. The yield creation models can be isolated into four areas: (I) the assurance of editing arrangement; (ii) techniques for arranging collecting tasks; (iii) procedures for assessing capital speculations; and (iv) strategies for assessing irritation and sickness control systems. Trimming strategy arranging includes the assurance of the harvests to be developed, the territory to be utilized for each yield, the compost application arrangement and the harvest turn approach. Various systems have been utilized to design crop generation while representing known operational requirements. Numerical programming models have been broadly utilized around there (7) The LP models that are more sensible than Overwhelming's model have been utilized as the premise of yield arranging frameworks. Most LP-based yield arranging models include amplifying a benefit work subject to impediments on assets and different necessities, for example, crop pivot.

A few scientists have proposed numerical programming strategies that consolidate vulnerability in arranging crop generation. Fokkens and Puylaert proposed the limiting mean outright pay deviation as a direct option in contrast to the quadratic programming approach (6). Different scientists (14, 7) have utilized game hypothesis models fathomed by LP (14) to manage vulnerability in ranch arranging, however again it is hard to relate the outcomes to down to earth basic leadership. Scientific programming models that consolidate vulnerability require progressively computational exertion and are more hard to translate than the relating deterministic model. Deterministic and stochastic powerful programming (DP) models have given another way to deal with assessing editing arrangement. The stochastic DP model (1) was utilized with soil dampness content as the state variable, to decide the harvest pivot framework in the dry cultivating locales of the US. Fisher and .Lee built up a deterministic DP model to decide the harvest turn strategy for malady and weed control in an Australian wheat crop, utilizing soil dampness content, sickness level and weed populace as the state factors (5). Taylor and Burt stretched out this way to deal with fuse stochastic components by de-forming the issue into three separate DP issues, yet the legitimacy of the methodology is hazy (21). The employments of different MPM are given in Table 1.

| S. No | Methodology/model | Issues addressed | Authors |
|---|---|---|---|
| 1 | Stochastic dynamic programming | Crop rotation | **(1)** |
| 2 | Stochastic Linear Programming | Crop yield uncertainity | **(3)** |
| 3 | Simulation | Harvesting capacity | **(3)** |
| 4 | Linear Programming | Daily harvest operations | **(6)** |
| 5 | Linear Programming | Land use for two crops | **(7)** |
| 6 | Linear Programming | Farm land use | **(9)** |
| 7 | Stochasting Linear Programming | Yield and price uncertainity | **(12)** |
| 8 | Linear Programming | Grain and farm land use | **(13)** |
| 9 | Linear Programming | Farm growth | **(18)** |

## IV. COMPARISON OF VARIOUS MATHEMATICAL PROGRAMMING MODELS

The base year or an average over several years is generally calibrated in the mathematical programming models. Several policy analyses were based on normative models that show a wide divergence between base period model outcomes and actual production patterns. The positive mathematical programme approach is developed for the majority of models which are lacking an empirical justification, data availability, or cost. The linear programming solution is an extreme point of the binding constraints. In contrast, the positive mathematical programming approach views the optimal farm production as a boundary point, which is a combination of binding constraints and first-order conditions. Prasad (2004) employed LP approach in determining the optimum herd size for different size groups of farms and to assess the income and employment potential of buffalos in the existing and alternate farm situations in Ranga Reddy district of Andhra Pradesh. Sekar and Palanisami (2000) used Minimisation of Total Absolute Deviation (MOTAD) model to develop optimal farm plans to minimize risk and to study the effect of changes in net income and resource use and its availability on risk efficient farm plans. Barry and Willman (1976) developed a multi-period quadratic risk programming model to evaluate contract and other financial choices for producers subject to external credit rationing.

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## V. CONCLUSION

Research, extension and developmental activities in agriculture have led to increase in agricultural production and productivity. Further, the innovations have led to new concepts like digital agriculture; smart farming, precision agriculture etc have also further helped farmers to achieve the production in various crops. However, the use of prediction models are very well accepted for yield prediction as well as forecasting of various activities pertaining to the agriculture, horticulture and forestry. The yield prediction is very helpful to the farmers in various ways by providing the record of previous crop yields so that they can plan the area and other agricultural operations. It is also helpful for policy makers to formulate the crop insurance policies, supply chain and operation policies. Since, the use of information technology is showing emerging trend in agriculture, the mathematical programming models can be used to their fullest possible as tool so that the problem of yield prediction could be solved effectively for enhancing the livelihood enhancement of farmers.

## FUTURE SCOPE

In addition to the yield prediction and resource allocation. The mathematical modelling can be further used to identify constraints which contribute maximum to decide the production and productivity in a resource constrained environment.

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