ABSTRACT

Rajasthan is the largest state in India located at western part of country between 23°30’ and 30°11’ north latitude and 69°29’ and 78°17’ east longitude. The state shares its boundary with 5 other states. The western part of the state is bounded by the stretches of Thar Desert and the Aravalli Range**.** The Aravalli Range acts as a barrier causing variation in climatic conditions. Based on agro climatic parameters; rainfall, temperature and topography the state has been divided into 10 zones. The state’s arid topography, varying weather conditions and inadequate availability of irrigational water resources makes the agricultural scenario complex.

Traditionally, being practiced from years the growers in every cultivating season face challenge to overcome the constraints for generating optimized farm revenues. To subdue these losses a mathematical model is being formulated. The formulation supports the decision maker to evaluate the niche regions such that the variations would be incorporated to improve the feasibility of decision space. Mathematical tools and techniques will come up with the problem output that will provide a scientific basis to the decisions. However, there are bounteous farm parameters that are difficult to represent in mathematical form posing a challenge to formulate/construct a mathematical model. Thus, the research work conducted is an effort to develop a mathematical model to improvise the farm revenues and reduce the risk involved in sector. Therefore, the study is taken up to identify the farm parameters in Rajasthan that impact the crop yield and hence the revenues.

For the formulation of mathematical model selection of decision variables to evaluate the optimality of objective function is quite a challenging task. For determining the optimal crop output there are several controllable and un-controllable farm parameters impacting the crop productivity making it difficult for the decision makers to choose the variables that greatly influence the output.

Different crop-combinations and cropping pattern is being practiced in districts of Rajasthan. Multiple cropping, mono cropping, crop rotation and mix cropping are some of the most common cropping patterns adopted by farmers in the region. Due to inadequate availability of irrigational water resources some of the farmers prefer mono-cropping. Such a crop pattern is associated with risk and uncertainties. Consequently, farmers with sufficient availability of resources prefer to cultivate multiple crops. Multiple cropping is bourgeois crop pattern adopted by famers since it allows to hedge the loss caused to any one crop failure, offsetting it

with the crop that doesn't fail. Hence, a case study is being discussed practicing multiple crop pattern. A set of constraints and challenges faced by the growers is formulated to determine the solution optimality and feasibility. For model formulation cost parameters were posed as a constraint. A crop-mix model is developed to reduce the input cost and maximize the farm revenues. Hence, Multi-Objective Linear model is explored to illustrate the challenges and to evaluate the optimal values of decision variables. LINGO 18.0 and EXCEL SOLVER is used for analysis. Further, to select optimal crop combinations among the available alternatives different MCDM techniques were employed that evaluates a set of an optimal crop combination by comparing MOORA and TOPSIS ranking output with that of crop order ranking obtain by (Qureshi et al., 2018) applying Fuzzy-TOPSIS. Lastly, 10 different MCDM techniques were compared to evaluate the best technique to determine the optimal set of crop combination. The results of the mathematical techniques indicate that the MCDM techniques adopted provide approximately the same crop combination as practiced by growers to optimize the farm revenue. However, the crop preference by applying Multi-Objective Linear Programming approach is quite different from that of MCDM technique. The cost coefficient in case of MOLP model and the weights assigned to the attributes in decision space in MCDM formulation causes a variation in results. The constraints, criteria and alternatives defined; restrict the optimal value of decision variables within a convex region providing an optimized result.

The variations in climatic conditions impact the ecological system, economy and agriculture to a great extent. The fluctuating climatic conditions and uncertainty of available resources leads to grave challenges faced by the farmers who has to risk his finances and efforts on a particular crop based on his rule of thumb forecasting. This has motivated the author to explore and provide a scientific basis for decision making made by farmers of Rajasthan. The research work is conducted to investigate the "optimal crop allocation" & crop practice that can be adopted by growers depending on availability and accessibility of resources.

To avoid the uncertainties involved in sector, some of the farm parameters such as soil, market fluctuations and operational farm activities in a particular season were kept consistent. To investigate the impact of climatic parameters; rainfall and temperature on mean crop yield and variability Just and Pope production function is used for estimation. Since climatic data consists of both cross-sectional as well as time series data thus, panel data model is applied to illustrate a function output. Maximum likelihood estimation is employed for evaluation. STATA is used

to maximize the Likelihood Function. The results reveal that the varying climatic conditions influences the crop productivity.

Though many researchers have explored different mathematical techniques to improve the farm revenues and minimize the operational cost but no such study has been conducted for Rajasthan scenario. Thus, study contributes to determine the feasibility and optimality of decision variables for Rajasthan farm scenario to support the growers to increase the productivity with scientific basis. The mathematical model developed is an effort to support the decision made by growers in every season with scientific basis.

Keywords: Multi-Objective Linear Programming, Rajasthan, MCDM techniques, mathematical model, Just & Pope production function, crop productivity, farm revenue, cropping pattern, crop mix, regional feasibility, Maximum likelihood function.