Chapter 8
CONCLUSIONS AND DISCUSSION

The concept of crop pattern, crop combination and allocation of farm resources has been practiced by growers based on their instincts and thumb rule forecasting. Therefore, the decisions made by growers sometimes results in low crop productivity and even the crop failure. Since country's economy is majorly driven by the agriculture sector hence the need to evaluate the basis of the decisions, laid a foundation to formulate a mathematical model. The mathematical model is developed for Rajasthan scenario owned with arid physiographical features. The model presented, is an effort to support the decision makers in this direction. The model formulated is focussed to improve the crop productivity by reducing the operating cost hence improving the farm revenues.

8.1 Crop-Mix and Crop Combination

The research conducted with an aim to develop a mathematical model for a crop-mix and crop combinations pattern for Rajasthan farm scenario. The model constraints are formulated from the data collected during survey and by using secondary data, provides an overview of the challenges faced by farmers in every growing season. As the model is formulated from the real data collected from farmer's thus, the research significantly contributes to provide a skills approach. The case study is being discussed to validate a mathematical model so that the variations can be incorporated in the decisions taken by the growers to improve the yield on scientific basis. Different statistical and operations research tools and techniques is applied to carry out an analysis.

Literature reviewed so far does not provide an imprint of such an analysis for Rajasthan agriculture sector. (Meena, 2014; Patodiya, 2015) focusses on the crop distribution in particular districts of Rajasthan. None of the study conducted so far provides a mathematical model of cropping pattern for Rajasthan agriculture. Rajasthan being a state with arid topography faces inadequate irrigational water issues with fluctuating climatic conditions. Consequently, most of the cultivation in a region is rain-fed thus, making water as one of the major constraints of the model.

However, development and formulation of mathematical model for farm scenario pose a question regarding a need for such an analysis. Traditionally, agriculture sector depends on

grower instincts and their thumb rule forecasting to choose an optimal crop combination and their allocation. Technological development, increase in population, fluctuating climatic conditions, enforces the need to develop a mathematical model to identify the constraints that leads to crop failure, low production and other parameters that influences the farm revenue. In addition, such a formulation supports the policy and decision makers to adapt a crop based on topographical, climatic and geographical features of a region. The mathematical approach of representing the farm constraints laid a basis to have scientific view of decision making.

As we are dealing with the challenges faced by the farmers, this adds a skill approach to the proposed research work. It's a skills and technological advancement that makes the growers to adapt a change in the sector and increase the productivity with improved quality by changing the cropping pattern, crop combinations or their allocation.

To get an insight about the cropping scenario questionnaire as a tool is developed. The questionnaire is developed to get an overview of the constraints, the cost and the problems faced by the farmers while allocating their field. Though there are many parameters and factors that affect the mean crop yield and its variability one of parameter that is briefly reviewed by the researcher is, to evaluate the impact of soil on crop growth. Different mathematical and statistical tools used by statisticians, economist and mathematicians is discussed. In recent studies stochastic model is being implemented by researchers to evaluate the value of decision variables but Winnie (1998) argues that deterministic model is more informative than stochastic models.

A mathematical model formulated investigate the effect of crop yield for a mix-crop and for the combination of crops cultivated in Rajasthan. A set of constraints such as land allocated under each crop, labour, harvesting and cultivation cost are considered. Multi-Objective Linear Programming is employed for the evaluation. Further, multiple regression analysis is applied to determine how different crops when cultivated with each other; with respect to area, temperature and rainfall will respond to climatic conditions. Graphs are presented to illustrate the parameters trend. The graphs show the variations of crop yield with respect to average change in temperature and rainfall. The scatter graph plotted between yield vs rainfall and temperature shows that the data points are scattered randomly in decision space indicating that there are numerous other parameters that impact the yield. EXCEL SOLVER, LINGO 18.0 and STATA software are used for analysis.

The formulated model evaluates a grower's choice for crop allocation across a wide spectrum of climatic changes and other farm factors. The study finds that the crop choice is highly sensitive to temperature and rainfall. Thus, farmers adapt the crop choice based on the local conditions faced by them. The topographical features, inadequacy of water resources and crop pattern adopted by the farmers motivates to carry out an analysis to evaluate the parameters and variables that effect the crop productivity and thus the farm revenue.

The climatic variations impact the ecological system, economy and agriculture to a great extent (McCarl et al., 2008; Adam et al., 1999). To determine the impact of crop yield variability, a Just and Pope production function is applied to investigate the spatial crop distribution due to climatic fluctuations. The impact of climatic parameters on four majorly cultivated crops namely: wheat, mustard, maize and pearl millet in Rajasthan is analyzed. The state being arid with erratic rainfall often face a fluctuation in crop production, and hence the profit of growers gets impacted. The function proposed is the sum of two functions; first one deals with the output level i.e., mean crop yield and second one explains the crop variability. The function can be linear and non-liner. The reason behind explaining the linearity and non-linearity nature of the function is to explain the fact that the effect of input on output is not prior to the effect of input on the variability of output. To determine the value of the parameter vectors δ and β Maximum Likelihood Function is applied. The model results conclude that the crop with high mean yield and less variability is preferred by growers.

Thus, the research work conducted will support the farmers in arid-region to determine the feasible crop combination based on the set of constraints faced by growers. Further, the results of the model will show a variation if the set of crops were altered.

8.2 Contribution

- A mathematical model to illustrate the optimal crop combination has been formulated.
- A model develop will support the decision makers to evaluate the expected crop output based on the defined set of constraints
- The analysis conducted to determine the impact of climate parameter on crop yield make it amenable for the decision makers to opt for a feasible crop combination with high mean crop yield and less variability.
- Different farm parameters impacting the productivity has been identified and formulated as model constraint.

- Different MCDM techniques has been presented to evaluate the feasible crop based on defined set of criteria in decision space.
- Different criteria that influence the crop choice were identified and defined as a criterion in decision space.
- Statistical analysis conducted will help to evaluate how parameters and which parameter greatly influence the productivity.
- A comparative analysis of mathematical technique will provide an overview to illustrate the feasible crop combination that will support the growers to take the decision based on defined set of constraints and criteria.

8.3 Directions for Future Work

- The deepening relationship between the agricultural activities and economy offers a skills base job opportunity such as management and maintenance, agri-logistics and agro-processing. The Agriculture Skill Council of India (ASCI) is working in this direction. The research work proposed would be further elaborated for the skills enhancement in allied sector. The study conducted focuses only to develop a mathematical model for the Rajasthan farm scenario.
- More climate parameters such as humidity, evatranspiration and CO_2 can be included to elaborate a model.
- By including the soil parameter, the developed mathematical model can be elaborated.
- The mathematical model for organic crop pattern would be formulated that will support the decision makers to reduce the cost since in organic crop production cost is one of the major challenges faced by growers.
- The concept of agri-logistics and ware-housing will give a further direction to the future work.
- Topographical parameters such as slope elevation, terrain can be incorporated in model.