Study of Select Issues in Agri - Fresh Produce Supply Chain Management

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In recent years, there has been a significant rise in the prices of agri-fresh produce such as fruits, flowers, and vegetables, etc. This price rise is mainly due to the demand supply mismatch, i.e., an increase in demand and shortage in supply. In emerging economies like India, this problem is often attributed to the changing consumption patterns and post-harvest waste owing to inefficient storage and distribution infrastructure. Such waste reduces the overall availability of the agri-fresh produce in the market. Therefore, to effectively deal with the current situation, we have identified the major causes of these wastes from an operational perspective and then proposed appropriate solutions.

A comprehensive literature review was undertaken to identify the major causes of waste. The literature review revealed that revenue maximization is the prime objective for the researchers while post-harvest waste reduction being a secondary objective. An in-depth analysis of the literature suggests that the major causes of wastes are due to:

- Lack of demand visibility for an individual agri-fresh produce especially at a disaggregate level.
- Lack of an appropriate harvest schedule to reduce the waste by matching the market demand with the farm supply.
- Lack of an efficient inventory policy for continuously deteriorating agri-fresh produce.
- Lack of an efficient transportation to reduce the waste of agri-fresh produce.

In order to fill the identified gaps in the literature, we first conducted time series modelling by applying Auto Regressive Integrated Moving Average (ARIMA) technique to forecast the demand of agri-fresh produce at a disaggregate level. Next we proposed mathematical models taking into consideration profit maximization (cost reduction), waste reduction and customer satisfaction. Therefore, the objective of the proposed models are: (i) to determine an optimal harvest schedule that can maximize the profit by reducing the waste due to demand supply mismatch, (ii) to find an optimal replenishment policy that can minimize the cost incurred in managing the inventory, losses due to deterioration and loss of sales, and (iii) to decide the vehicle routes in such a way that the cost incurred in transportation, loss due to deterioration and penalty for late delivery is minimized. Business constraints such as variable demand, fluctuating prices, limited capacity, stringent dead-lines and significant lead-time as well as the product characteristics such as plant maturation and agri-fresh produce deterioration are incorporated into the models.

For the purpose of modelling and validation, we collected data from the stake-holders and secondary sources such as the website of Ministry of Agriculture. ARIMA models were built using onion sales data from Ahmedabad wholesale market and validated taking sales data of the same commodity from Azadpur wholesale market, New Delhi. The proposed mathematical models were validated using data

from the real-life instances generated from Azadpur wholesale market. These models were complex in nature, and finding all possible solutions was computationally prohibitive. Therefore, to obtain the results within feasible time limits, a meta-heuristics, Artificial Immune System (AIS) based solution methodology was applied.

The major contributions of this research are:

- A comprehensive literature review that highlights the operational issues in agri-fresh produce supply chains
- An ARIMA model that can efficiently forecast the daily demand of an agri-fresh produce in an unorganized wholesale market
- A harvest schedule that can reduce the waste due to demand supply mismatch
- Replenishment policy that can facilitate the wholesaler to efficiently manage the agri-fresh produce inventory
- Vehicle routes to efficiently transport the agri-fresh produce with considerable reduction in the overall cost

The outcome of this research work will facilitate the managers and researchers in dealing with the operational issues of agri-fresh produce supply chains. ARIMA models for forecasting can be used by the farmers, farm co-operatives and wholesalers in effective decision making. Advance information of the market demand will facilitate the farmers to better schedule the harvest. Demand information coupled with an efficient harvest schedule will facilitate the farmers in managing the required resources for harvesting and transportation. Managers handling the procurement in the food and beverages organizations can use the harvest schedules to ensure sufficient and reliable supply. The proposed replenishment policy can be valuable for the wholesaler as it reduces the cost, time and efforts in managing the inventory. Wholesalers will be highly motivated to use the proposed vehicle routes as it reduces the overall cost of transportation and the loss due to deterioration. In a nutshell, the implementation of the proposed models can make a significant reduction in the overall waste across the agri-fresh produce supply chains.

Keywords: Agri-fresh produce, Post -harvest waste, Demand forecasting, Harvest scheduling, Replenishment policy, Vehicle routing, Artificial Immune System (AIS).