Analysis of Efficiency of Different Distribution Channels for Select Vegetables – An Analytical Study of Telangana Region

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***Abstract*---The purpose of this paper is to understand the efficiency of different distribution channels for vegetable and propose a model for improvement. Efficiency is the major indicator of the supply chain performance. This analysis was part of a study to find the efficiency of different channels for vegetable supply chain and to find out what are the reasons and how farmers can get the right remuneration for their vegetables. The data was collected based on questionnaires from 410 farmers who use different channels. The data analysis is based on the sample data for four districts of Telangana and three selected vegetables which are assumed to be representative of the overall sample frame. It was observed that there is significant variation of efficiency for different channels. So far, there has been no systematic study to understand the different contributing factors on efficiency and how they vary across different channels. This study will help in understanding the efficiency for different channels from the farmers' perspective. The proposed framework in this article will help in addressing the challenges of vegetable supply chain to improve the situation for farmers by reducing cost and losses across the supply chain and acquiring a better price. The conclusions derived will aid in formulating future policies that will be beneficial to vegetable farmers.**

Keywords: *distribution channel, vegetables, efficiency, supply chain, loss*

1. Introduction

The vegetable supply chain is part of Agri-fresh produce (sometimes referred to as the Perishable food supply chain) and differs from regular supply chain in many ways. Although India is the second largest producer of vegetables in the world, the price realized by the farmers in India is generally only about 1/5th or 1/6th of the final market price. Production and distribution costs and losses at different stages of the supply chain are significant causes of the inefficiency of the vegetable supply chain.

The following are some of the channels for the supply chain network of vegetables.

Channel 1: Local Market

Local markets are one of the most common channels and operate simply by farmers carrying their produce to and selling them at the local markets. They have a semi-permanent structure wherein the producer sells directly to the consumer, though usually in lesser quantities than they would in a wholesale market. They thus receive direct payment in the form of in-hand cash and end consumers benefit simultaneously by being able to purchase fresh vegetables at reasonable prices.

Channel 2: Wholesale Market

This channel facilitates sale of produce in bulk quantities that is purchased from farmers by wholesalers through the process of spot bidding. Commission agents play a significant role in driving the bidding process and arranging for buyers. In turn, they collect commission against the sale. There is an organized market committee that manages the operation of the market and maintains information on the availability, arrival, and pricing of vegetables on a daily basis.

Channel 3: Rythu Bazaar

This channel has been operational in undivided Andhra Pradesh since 1990 with the idea of creating an organized market where farmers can sell directly to end consumers without a middleman.

Channel 4: Super Market

This channel is primarily governed by supermarket chains to collect best quality vegetables directly from farmers. They often create contracts with farmers to purchase different vegetables without any firm commitment and they also work closely with the farmers on product quality.

There can be other variants of the supply chain network that are not considered in this study.

It is important to understand the efficiency of different channels from the farmers' perspective and possible reasons for inefficiency. This will help understand the challenges of the current supply chain and develop a model that can attempt to address farmers' issues.
The objective of this study is to analyze the efficiency of different channels of the vegetable supply chain. The study also aims to propose a model to improve efficiency from the farmers' perspective which in turn can help make vegetable farming more sustainable for them.

2. Literature review

More than 200 peer reviewed papers related to vegetable supply chain were reviewed from international journals and relevant articles related to this specific topic are discussed below.
[4] Study proposed a value chain analysis (VCA) model dividing the whole supply chain into three section as farming company, processing company and supermarket. The individual section's value addition activities are further detailed out to understand the level of value addition in the individual activity.
[1] The paper based on research on vegetables and perishable items tried to analyse the problem of agricultural supply chain. The paper discussed the impact of uncertainties and variabilities of product delivery and quality in vegetable supply chain.
[6] The article tried to provide a framework for performance measurement system (PMS) of agri-food supply chain using Supply Chain Operation Reference (SCOR) model by supply chain council.
[Estimation of post-harvest loss is an important criterion to assess the supply chain efficiency. The study [7] tried to understand the post- harvest losses of fruits at different stages of supply chain.
The research [9] has done a comprehensive study of performance measure on selected vegetable and fruits and proposed an Information and Communication Technology approach for better efficiency of vegetable supply chain.
The article [11] tried to assess the effectiveness of existing sourcing strategy to supply product with appropriate quality and acceptable wastage for international perishable supply chain. The author tried to add the shelf life losses as expected in the ordering policy. The author also tried to derive an effective method of analyzing, evaluating and improving the supply chain model for agricultural products.

The article [2] discussed the structure of agri-food sector and tried to examine the different forms of supply chain based on transaction cost economics consideration. Different forms and their transaction cost were analyzed to suggest few research opportunities. Uncertainties at production stage and coupled with demand uncertainty are transmitted across the supply chain and as a result it affects the transaction cost at different stages of supply chain. So, the study concluded by highlighting that it is important to study the different channels of supply chain to have the transaction cost optimized as different chain partner will have different negotiation power which ultimately have the capability to skew or enhance the advantage of the whole supply chain.

The article [5] discussed about the collaboration with supply chain management players. It took a case of organic agriculture produce business opportunity and tried to explore how the player reacts in a new business development.

The article [8] dealt with collaboration aspect of agri-food supply chain and tried to analyze the different ways of collaboration, the challenges, and the outcome of collaboration. The main areas of collaboration where most of the stakeholders opinioned are information sharing, joint planning, and even right supplier selection.

The article [10] suggested through empirical studies that vertical coordination of vegetable supply is necessary to improve the overall supply chain performance. This will enhance the overall yield, demand security, nonseasonal availability, manage price fluctuation. As a result, this will create a transparent supply chain and provide the benefit to the growers and all other supply chain players including the final consumer.

[3] The case study based analysis focused on the interdependence between different supply chain players and the necessary Information and Communication Technology to enhance that relationship both in vertical and horizontal manners. This will help in better collaboration through exchanging information. The study also suggested the need to further analyze the relationship between supply chain performance and the collaboration in both vertical and horizontal ways.

3. Methodology

The hypothesis and relevant research design are explained in this section.

3.1 Hypothesis for the study

The hypothesis tested for the current study is the following:
Null Hypothesis (H01): There is no significant difference in supply chain efficiency for different channels.

3.2 Research Design

The various research design components are discussed below.

Sample selection

The Telangana state was used for the scope of this study. Five years (2012-2016) production data of major crops of the state was collected from Telangana Horticulture department. Accordingly, the top three commonly used vegetables (tomato, brinjal, lady's finger) were selected for study.

Once the vegetables were selected, a multistage area sampling method was used, and each district is considered as a sub-area. The top 4 districts (Medak, Warangal, Mahbubnagar and Ranga Reddy) were selected for sample selection for random sampling.

The district wise distribution of sample for different channels is shown below in Table 1.

Table 1. District wise summary of data for different channels

District/ Channel ->	**1**	**2**	**3**	**4**	**Grand Total**
Mahbubnagar	30	28	51		109
Medak	26	33	11	33	103
Ranga Reddy	25	25	27	23	100
Warangal	24	49	25		98
Grand Total	**105**	**135**	**114**	**56**	**410**

Questionnaire design

A comprehensive questionnaire with the following variables mentioned in Table 2 was designed. The questionnaire was further tested using pilot sample to ensure that we have considered all factors relevant to the variables and also, they are not overlapping.

Table 2. Variables Considered for Questionnaire Design

General Demographic Information		**Storage Efficiency**	
1	Name	25	Storage facility requirement
2	District	26	Storage facilities availability
3	Taluka	27	Approximate loss during storage
4	Village	28	Reasons for storage losses
5	Contact no.	29	General Remarks on Storing
6	Age	**Transportation Efficiency**	
7	Annual Income	30	Distance of nearest market where produce is sold
8	What is the proportion of agricultural income out of total income	31	Mode of transport used
9	Source of investment	32	Road/infrastructure condition
10	Educational background	33	Transportation availability
11	No. of years in the profession	34	Approximate loss during Transportation
12	Number of family members	35	Approximate loss during loading/unloading
13	Total area of land used for farming	36	Reasons for transportation loss
14	Total area (%) used and quantity produced in Quintal for selected produce	37	General Remarks on transportation, loading/unloading
15	Infrastructure available	**Marketing Efficiency**	
Channel Efficiency		38	Price information availability in advance
16	Channel selection	39	Approximate price received from different channels in last one year (High/Low/Average)
17	Reason for channel selection	40	Approximate loss during Market handling
18	Channel selection satisfaction	41	Reasons for marketing losses
19	General Remarks on Channel selection	42	General Remarks on Marketing
Harvesting Efficiency		**Demand Efficiency**	
20	Harvesting plan and practice	43	Demand information availability in advance
21	Approximate loss during harvesting	44	General Remarks on Demand
22	Approximate loss during sorting/grading	**Cost Methods and Components**	
23	Reason for harvesting and sorting loss	45	Method used for calculating the price?
24	General Remarks on Harvesting/Sorting/Grading	46	Cost components for different channels

4. Discussion

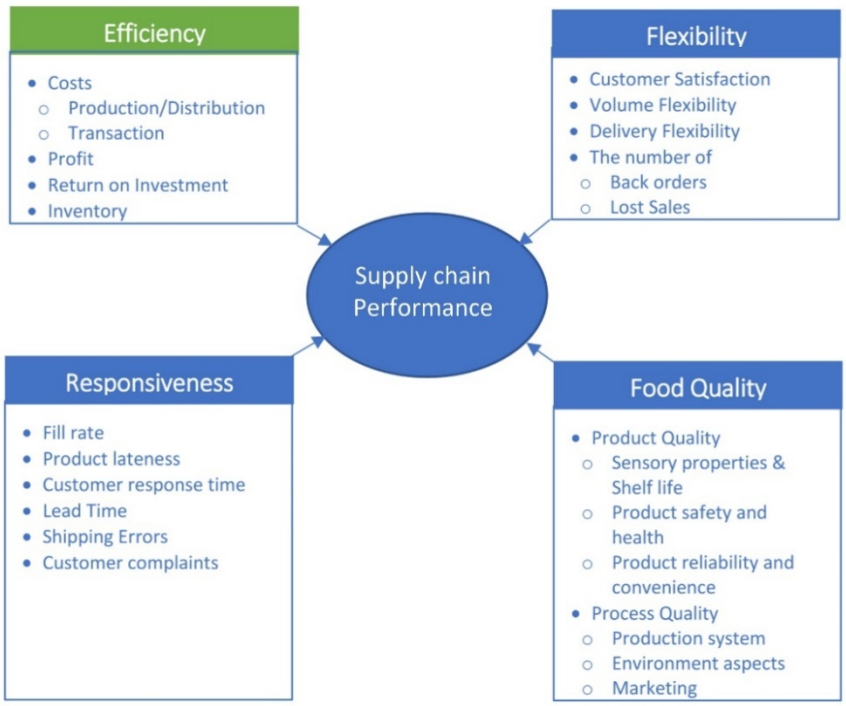
4.1 Vegetable Supply Chain Efficiency Framework

Performance of any supply chain is an important measurement to enable the different stakeholders throughout the chain to make more informed decision. Measuring the performance of vegetable supply chain is equally important to ensure course correction and channel selection decision for farmers. But it is equally difficult to measure the performance due to diverse characteristics of vegetable supply chain.

The different components of performance measurement are explained in the Figure 1 below from [6]. The identified

box in green, the efficiency, is one component of the overall supply chain performance which will be the focus of our study.

Figure 1. Conceptual Framework of Agri-food Supply Chain Performance



Source: [6]

As mentioned above, following are the different components important for agri-food supply chain and the relevance in current context is discussed below:

Cost: The cost in a vegetable supply chain consists of production cost (Agri-input, Land utilization, labor, irrigation etc.), harvesting cost, grading cost, various distribution cost (storage, loading/unloading, transportation etc.) and also the market transaction fees. One of the effective means of reducing the production cost is to increase the yield apart from the reducing the other components of cost mentioned above. Objective of any supply chain will be the optimize the cost to increase the efficiency.

Profit: The profit of vegetable supply chain is measured as difference of realized price and combined effect of cost and losses. The losses associated with vegetable supply chain at different stages namely harvesting, storage, grading, loading/unloading, transportation etc. play an important role in deriving the efficiency. The objective of vegetable supply chain is always to maximize the profit by increasing the price realization and reducing the loss and cost effectively.

Return on Investment: Vegetable farming is labor intensive farming and most of the farmers are small and marginal. There is no significant capital investment other than the petty loan from market which are recoverable in the same year through supply of vegetable. Also, even if required, they do not have the capital to invest in acquiring the necessary infrastructure. So, return of investment will not be a significant parameter for the current discussion to calculate the efficiency of vegetable supply chain from the farmers' perspective.

Inventory: Due to perishable nature of vegetable supply chain, inventory is not maintained by the farmers at different stages. The current infrastructure also does not allow to hold the inventory for a period even when it is necessary to hold the inventory. So, cost of carrying inventory will not be a major consideration for the current study as the scope of the study is to analyze the efficiency from farmer's perspective. Inventory losses will be considered as discussed above due to different inefficiency across the supply chain.

So, the above framework will be used for the efficiency calculation of the vegetable supply chain. The primary focus for measuring the efficiency for the current study will be to analyze price, cost and losses to arrive at the efficiency of a particular supply chain.

4.2 Data analysis

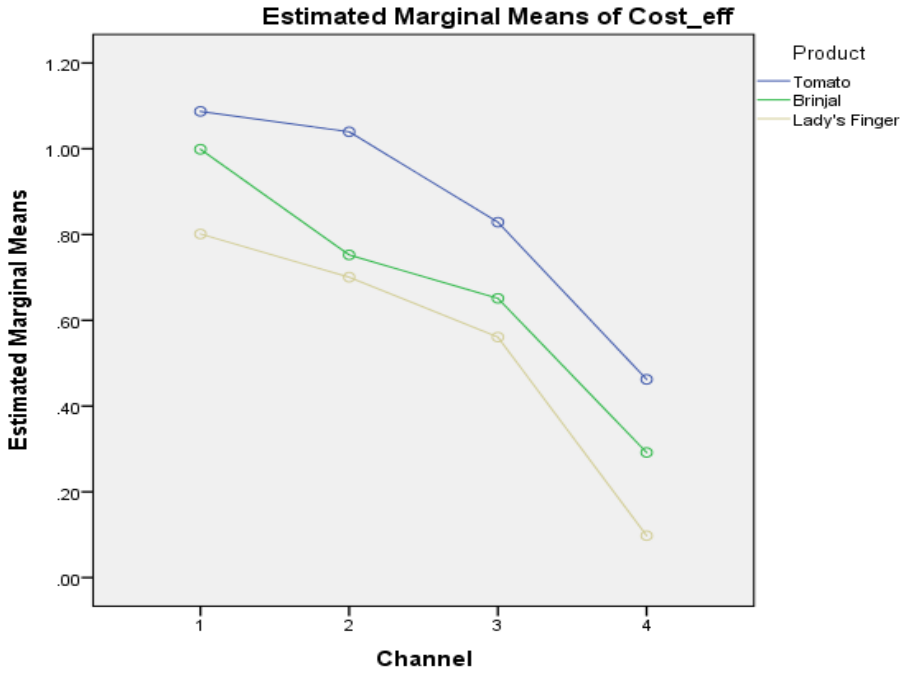
The cost efficiency of any channel is defined as the margin a farmer gets in respect to the cost they have incurred and can be defined based on the formula below:

$$\text{Cost Efficiency} = \{(1-\%\text{Loss}) * \text{Price} - \text{Cost}\}/\text{Cost}$$

This will be considered as the supply chain efficiency of the channel from farmer to market.

As seen above, Cost efficiency is dependent upon Price recovered by the farmer from the channel, cost incurred within the supply chain and the losses in the supply chain. The cost-efficiency analysis for different channels were done using ANOVA and depicted below in Figure 2.

Figure 2. Two-way ANOVA Graph for Cost Efficiency with Different Channel and Product



The above figure shows a difference of efficiency for different channels and it can be observed that the pattern for all vegetables is the same.

The significance of the difference is further reviewed from the univariate test result as shown in Table 3 below.

Table 3. ANOVA Results for Effect of Channel on Cost Efficiency (Univariate Tests)

Dependent Variable: Cost_Efficiency

	Sum of Squares	df	Mean Square	F	Sig.
Contrast	14.177	3	4.726	30.322	0.0000
Error	45.039	289	0.156		

The "F" tests the effect of Channel. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

Further deep dive to identify the channels where the cost efficiency is different were conducted and the p-values are mentioned in the Table 4 below.

Table 4. Cost Efficiency Difference Between Channels Significance (p-value) Based on ANOVA Results

Channel comparison		Tomato p-value	Brinjal p-value	Lady's finger p-value
Channel A	Channel B			
1	2	0.63	0.020*	0.359
1	3	0.013*	0.001**	0.031*
1	4	0.0001**	0.0001**	0.0001**
2	3	0.032*	0.334	0.199
2	4	0.0002**	0.0003**	0.0002**
3	4	0.004**	0.006**	0.0001**

* p-value significant with 0.05 significance
** p-value significant with 0.01 significance

The observation from the above Table 4 and Figure 2 and other relevant information from ANOVA results are following:

- Channels 1 and 2 have similar efficiency and there is significance of difference in efficiency between other channels.
- Channel 1 has highest efficiency followed by channel 2 and channel 3. Efficiency of channel 4 is lowest.

The above analysis clearly shows that there is a significance in the difference of efficiency for different channels and the null hypothesis is rejected, and the alternative hypothesis is accepted that there is significant difference of efficiency for different channels.

The efficiency was further reviewed for different districts and it was observed that there is significant difference of efficiency between districts. Analysis of difference with p-value shows that Medak and Warangal have better efficiency than Ranga Reddy and Mahbubnagar and the reasons observed can be tied to the better price and less cost.

Regression analysis of efficiency was done for price, cost and losses and following are some of the regression results:

Impact of price, cost and losses on Efficiency:

The impact on efficiency was separately analyzed for price, cost and losses using regression analysis. The following dependent and independent variables were considered:

- The dependent variables (Y1, Y2, Y3) are the total supply chain efficiency of tomato, brinjal and lady's finger respectively for all analysis
- For price analysis, independent variable (P1, P2, P3) are price of tomato, brinjal and lady's finger respectively
- For cost analysis, independent variable (C1, C2, C3) are cost of tomato, brinjal and lady's finger respectively
- For loss analysis, independent variable (L1, L2, L3) as loss of tomato, brinjal and lady's finger respectively

Regression equations are shown in Table 5. In all cases below the p-value is less than 0.0001.

Table 5. Regression equation for Efficiency for Price, Cost and Loss

Impact Analysis	Product	Equation	Adjusted R^2
Price on Efficiency	Tomato	Y1= -1.391 + 0.001 x P1	0.548
	Brinjal	Y2= -1.581 + 0.001 x P2	0.497
	Lady's finger	Y3= -1.412 + 0.001 x P3	0.394
Cost on Efficiency	Tomato	Y1= 3.470 – 0.003 x C1	0.479
	Brinjal	Y2= 3.096 – 0.003 x C2	0.684
	Lady's finger	Y3= 2.772 – 0.002 x C3	0.664
Loss on Efficiency	Tomato	Y1= 1.905 – 3.512 x L1	0.309
	Brinjal	Y2= 1.576 – 3.020 x L2	0.276
	Lady's finger	Y3= 1.450 – 3.050 x L3	0.428

With the Adjusted R^2 shown in Table 5 and low p-value, above equations can be good predictor for Efficiency with price, cost and loss.

4.3 Findings

Based on the efficiency analysis shown in section 7 and the other similar analysis conducted for price, cost, losses, the Table 6 below summarizes the performance of all channels under different parameters.

Table 6. Ranking of Channels on Different Performance Parameters

Channel	Price Realized	Supply chain cost	Supply chain Losses	Cost Efficiency
1	1	4	3	1
2	4	3	4	2
3	3	2	2	3
4	2	1	1	4

Note: 1 is highest and 4 is lowest

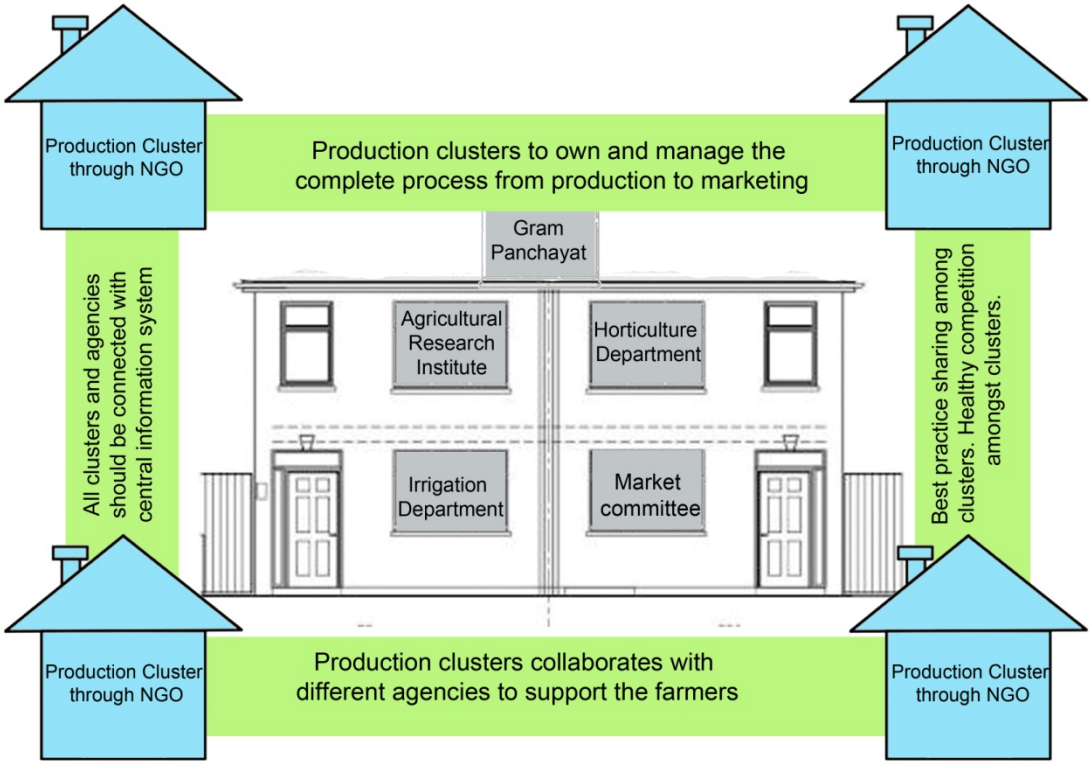
It was observed that different channels have different price, cost, losses and efficiency. There is no focused approach to reduce the cost and losses with improved infrastructure. Also, the price can be better realized through better demand-supply planning and exploring alternate market opportunities. Reducing cost and losses and improving price realization can improve the efficiency of vegetable supply chain. There are significant opportunities to improve the supply chain performance of the vegetables and a holistic view of the overall supply chain can make farming attractive for the farmers.

Recommendation

A model is proposed to improve the efficiency of the vegetable supply chain. The complete state is proposed to be divided into production cluster. It is required to have a group of people dedicated to that production cluster responsible for building an effective supply chain operation starting from agricultural planning and operation to appropriate marketing. The Telangana horticulture department has a progressive horticulture mission with multiple scheme to improve the vegetable farming. It is physically impossible to implement and bring the advantage of the mission to the farmers by the government official only. As a result, farmers do not have information and access to the plans aimed to improve the current vegetable farming.

The proposed model of multiple production clusters entrusted to NGOs with close collaboration with different government agencies is shown below in Figure 3.

Figure 3. Proposed Model for Multiple Clusters



The key elements of the proposed model are as under:

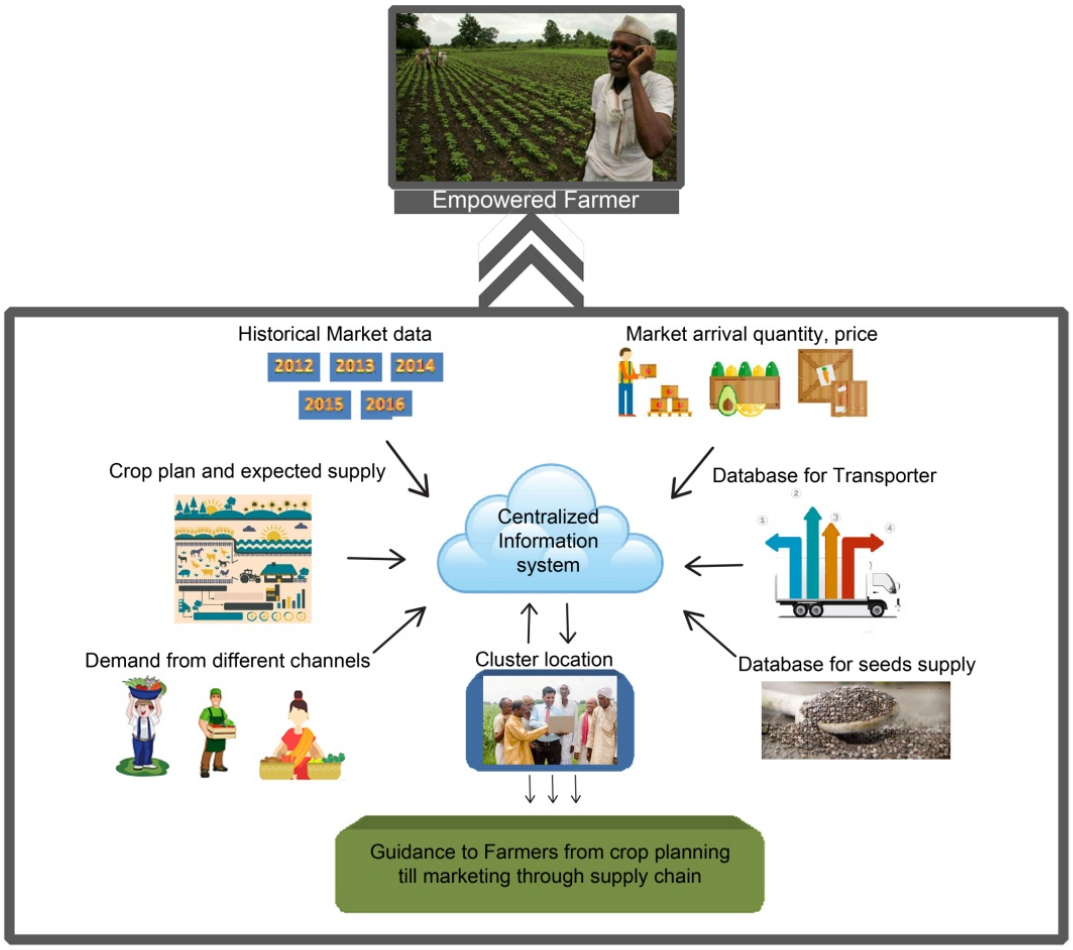
- Create multiple production clusters considering the logical geographical and agricultural consideration.
- These clusters will be owned jointly by a group of NGOs and Horticulture department aimed to improve the vegetable supply chain.
- The group will be responsible for the complete process from providing production guidance till market guidance through an effective supply chain support across the line.
- The group will work as a conduit between the farmers and different agencies like horticultural department, agricultural research institute, irrigation department and different market committees.
- The group will also work with Gram Panchayat closely to ensure the confidence of the farmers.
- The group will analyze the different plans of government bodies and help in implementing this at farmers' level working as an extended arm of the Horticulture Mission.
- The different clusters should have periodic meets to share best practices and should identify champions from their respective clusters.
- A healthy competition between clusters should be encouraged to assess the performance periodically and reward the best performers in different stages of supply chain.
- In the short term, the group should identify the different data required (e.g., market arrival and price data, historical demand data, production data, seed performance, soil testing results, transporters in the region etc.) to have a seamless information system to help the overall supply chain of vegetables.
- In the medium term there should be a sustainable integrated information system which will help to drive an efficient supply chain through appropriate information flow.
- The different roles and responsibilities of the cluster group with the possible input points are described in Table 7 below.

Table 7. Roles and Responsibilities of Cluster Groups and the Suggested Input

Stage	Roles/Responsibility	Input	Input source
Pre-Harvesting	Prepare crop plan based on previous demand/supply data	Demand data, Supply data, Price data for last 3 years	Market committee, Horticulture Department.
	Review current irrigation capability and work with Irrigation department for additional infrastructure proposal	Total cultivation land. Current irrigation capability Irrigation department proposal form	Irrigation Department
	Support and guide agricultural activities through proper soil test, seed supply, best agricultural practice	Research result on soil test. High yield seed from horticulture dept. Agricultural best practice.	Agricultural research institute, Horticulture Department
Harvesting	Harvesting plan with proper staggering based on market situation	Market Demand Price fluctuation information. Alternate market situation	Market committee, Horticulture Department
Grading/Sorting	Review the current grading/sorting capabilities and work with government body for additional infrastructure	Infrastructure data. Budget approval from Horticulture Department	Horticulture Department
Storage	Review the current storage facility near farming point, Local market, Rythu Bazaar	Infrastructure data. Budget approval from Horticulture Department	Horticulture Department
Transportation	Create pool transportation plan and execute the plan	Demand plan Supply plan Transporter database	Market data. Harvesting plan. Proposed Central data base for transporter
Market	Select appropriate channel Co-ordinate on alternate channel Propose appropriate market reform	Demand from different channel. Price information from different channel. Alternate channel information	Proposed centralized database

As discussed above the effective collaboration will enhance significantly with the implementation of an integrated information system. The proposed information system landscape is shown in Figure 4 below.

Figure 4. Proposed Centralized Information System Landscape



The key element in this model is the clusters will be able to access all relevant data captured at different transaction points and can guide the farmers throughout the production and supply chain life cycle. The centralized information system should have historical market data of demand, supply and price from different markets, demand from different markets, crop plan and possible supply plan, market arrival, transporter and seed supply information. The cluster representatives should be able to access the data to provide necessary guidance.

5. Conclusion

This study will help in understanding the differences of efficiencies for different channels and districts of Telangana for select vegetables. It highlights the difference of different components of efficiency (price, cost, loss) for different channels. The proposed cluster model and the integrated information system can address some of the inherent gaps in the current supply chain. This will help in implementing some of the progressive mission of central and state Horticulture departments and can help in increasing the efficiency of vegetable supply chain and thus improve the current condition of vegetable farmers.

The study can be utilized to build a framework of effective supply chain for vegetable farming and also help in formulating horticulture policies for the benefit of the farmers.

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