Ind. Jn. of Agri. Econ.
Vol.67, No.3, July-Sept. 2012

Enabling Efficient Supply Chain in Dairying Using GIS: A Case of Private Dairy Industry in Andhra Pradesh State

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INTRODUCTION

The Indian dairy industry has been through an evolution in India and many innovations in agricultural field has been successful in dairying first. It has come a long way over the years from milk production of 21.2 million tonnes in 1968-69 to 121 million tonnes in 2010-11. Steadily and firmly, it has cruised to become *numero uno* in the list of milk producing countries and this success story has been scripted by the small holder milk producers. Today, the Indian dairy industry stands at a mammoth size of US$ 70 billion. Moreover, the estimated milk demand in India is 128 million tonnes by 2020 (Alagh, 2012).

The industry had been recording a growth of 3-4 per cent annually during the period 1991-2011, which is almost three times the average growth rate of the dairy industry in the world. According to the Ministry of Food Processing Industry, milk processing in India is around 35 per cent, of which the organised dairy industry account for 13 per cent of the milk produced, while the rest of the milk is either consumed at farm level, or sold as fresh, non-pasteurised milk through unorganised channels. Milk is processed and marketed by 170 Milk Producers' Co-operative Unions, which federate into 15 State Cooperative Milk Marketing Federations.

The top ten milk producing states of Uttar Pradesh, Rajasthan, Punjab, Andhra Pradesh, Gujarat, Maharashtra, Madhya Pradesh, Bihar, Tamil Nadu, and Haryana account for more than 80 per cent of India's milk production. Dairy production is an important direct and supplementary source of income for around 75 million rural families (mainly comprising small farmers and landless labourers), which accounts for around 98 per cent of total milk production. Andhra Pradesh, among other major milk producing states is milk surplus state in India. However, the dairy sector is still facing daunting challenges of low productivity of dairy animals, lack of effective quality and hygienic control systems, and inefficient network of cold chain infrastructure from the producer to the consumer. The present paper highlights the issues related to inefficient supply chain in dairying in Andhra Pradesh state and recommends the Geographic Information System (GIS) to improve the efficiency.

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DATA AND METHODOLOGY

Secondary data on production and prices has been collected from different published sources. Besides, information related to a specific dairy company in Andhra Pradesh, i.e., Creamline Dairy was collected from the company's record and also by conducting interviews of different stakeholders during 2011-12.

Geographic Information System (GIS) is an organised collection of computer hardware, software, geographic data and appropriately designed to efficiently capture, store, update, manipulate, analyse and display many forms of geographically referenced information *(ESRI website)*. The word geographic implies that location of the data items are known in terms of geographic co-ordinates (Latitude and Longitude). The word information implies that the data in a GIS are organised to yield useful knowledge, often as coloured maps and images, but also as statistical graphics, tables and various onscreen responses to interactive queries. The word system implies that a GIS is made up from several interrelated and linked components with different functions. Thus GIS has functional capabilities for data capture, input, manipulation, transformation, visualisation, combination, query, analysis, modeling and output.

The capabilities of the GIS system are expected to bring transformations in a business organization, ranging from the way routing decisions are planned to the decisions related to opening of new facilities.

The three different views in GIS enable its use for different purposes:

1) The Database View (Non-Spatial Information), also known as the geo database, describes the world in geographic terms.
2) The Map View (Spatial Information), also known as the geo visualisation view, includes interactive maps, 3D scenes etc.
3) The Model View, also known as the geo processing view, includes the geographic data set and operators (called tools) on this data set.

With access to appropriate spatial data, GIS is an excellent tool for the analysis and identification of market opportunities. Spatial overlay and proximity analysis for site selection using demographic data pertaining to potential customers competitors' helps in forward planning (Nasirin and David, 2003; Gardner and Cooper, 2003). These techniques allow us to identify where the potential customers are located, study competitor locations, and analyse opportunities for new areas.

RESULTS

Milk production trend in Andhra Pradesh and India

Andhra Pradesh ranks second position in milk production after Uttar Pradesh only surpassing Punjab and Rajasthan. The state is producing more than 10 million

tonnes (mt) of milk constituting 9.12 per cent of the total milk production in the country (Figure 1and 2). The Livestock sector contributes 6.46 per cent to the total gross state domestic product (GSDP) of the state (Rs.371229 crores) at current Prices for the year 2008- 2009.

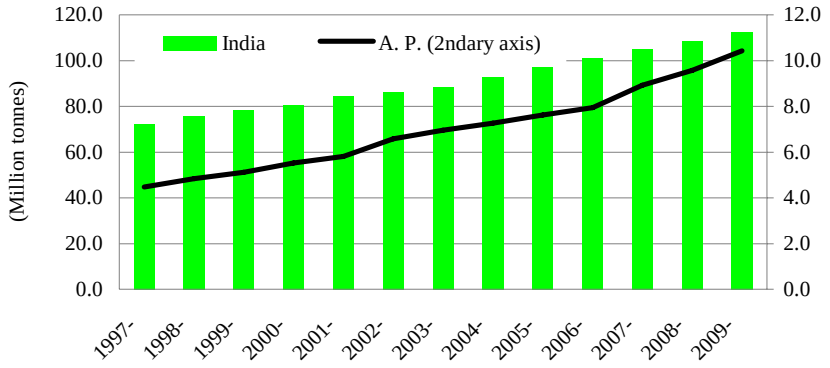

Figure 1. Milk Production in Andhra Pradesh as Compared to India

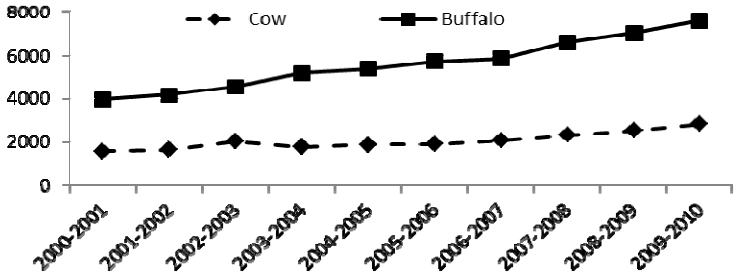

Figure 2. Milk Production (‘000 tonnes) from Cows and Buffaloes in Andhra Pradesh

Geographical Distribution in Andhra Pradesh State

Nearly half of the milk produced in the State comes from coastal Andhra region. The region wise contribution of milk production is 49.15 lakh tonnes (51.36 per cent) in coastal Andhra region, 17.25 lakh tonnes (18.03 per cent) in Rayalaseema region and 29.29 lakh tonnes (30.61 per cent) in Telangana region during 2010-11. The cow milk production in Coastal Andhra, Rayalaseema and Telangana regions is 10.24 lakh tonnes (40.47 per cent), 8.32 lakh tonnes (32.90 per cent) and 6.74 lakh tonnes (26.63 per cent), respectively. The predominant cow milk producing districts in the State are Chittoor, Srikakulam, East Godavari, Visakhapatnam, Vizianagaram, Ananthapur and Khammam districts.

Likewise, the buffalo milk production in Coastal Andhra, Rayalaseema and Telangana regions is 38.91 lakh tonnes (55.28 per cent), 8.93 lakh tonnes (12.68 per cent) and 22.55 lakh tonnes (32.04 per cent), respectively indicating that the Coastal

Andhra region of the State contributes nearly half of buffalo milk. The predominant buffalo milk producing districts in the State are Guntur, Prakasam, Krishna, East Godavari, West Godavari and Kurnool.

Average Milk Yield in the State

The average milk yield in Andhra Pradesh state was 3.548 kgs during 2007-08 and 3.773 kgs per day per milch animal during 2008-09. The average yield among exotic/crossbred cows, non-descriptive cows, graded murrah buffaloes and non-descriptive buffaloes during 2008-09 was 7.189, 1.776, 6.940 and 2.649 kgs per day per animal, respectively. An increase of 36 grams, 8 grams and 206 grams was noticed among exotic/crossbred cows, non-descriptive cows and grade murrah buffaloes, respectively. A minute decline of 7 grams was observed in the daily milk yield of non-descriptive buffaloes. The milk production from the goats was almost static at 100 grams per goat per day.

Number of Dairy Organisations in Andhra Pradesh

There are 34 registered dairy plants in the state under co-operative/private/other sectors. The installed capacity of those plants shows large number of private dairies with lot of growth potential (Table 1).

TABLE 1. NO. OF DAIRY ORGANISATIONS IN ANDHRA PRADESH

(1)	No. of co-operative dairies (2)	Capacity ('000 LPD) (3)	No. of private dairies (4)	Capacity ('000 LPD) (5)
By central authority	7	1925	7	3855
By State authorities	1	25	19	1067

Source: National Livestock Sample Survey Report 2008-09.

Case of Creamline Dairy

It is a leading private dairy in Andhra Pradesh, initiated in 1992 after MMPO permitted private dairies. The company collects about 7 lakh litres milk per day from 1.50 lakh households/3500 villages. It is situated in 3 metros, Hyderabad, Bangalore, Chennai, and now also entered into Mumbai. The turnover of the company in 2009-2010 was Rs. 445 crores. The company has 30 own and 9 associate milk chilling centers (MCC), 40 bulk milk chilling units (BMCUs), 7 packing stations, 6 sales offices and, 1 state of the art powder plant/SBU at Ongole. It has a combined milk processing capacity of 7 lakh liters per day. It is having well laid distribution network with company owned parlours, exclusive franchise outlets, and product push carts also sells its products through 5000 agents across Southern India and Maharashtra.

Critical Issues in the Dairy Supply Chain

Co-ordinating the external and internal activities of a firm is the basic philosophy of supply chain management. The simplest network consists of facilities which perform procurement, manufacturing and distribution. These networks are called value added chains or supply chains. A supply chain consists of all stages involved directly or indirectly in fulfilling a customer's request.

TABLE 2. CRITICAL ISSUES IN THE DAIRY VALUE CHAIN

Stage (1)	Priority (2)	Issues (3)
Policy environment	▪ Developing livestock policy ▪ Breed development	• Lack of a coherent livestock development policy • Ineffective implementation of policy and projects due to lack of clarity in roles of different agencies • Lack of regulation for quality of feed and medicines
Services	▪ Disease control/ health/ breeding/extension services ▪ Support to dairy farmer organisations	• Inadequate coverage of veterinarian and breeding services • Non-existent extension services • Lack of private sector involvement in dairy development services and activities
Inputs	▪ Feed & fodder supply ▪ Medicines/vaccine supply	• Quality/cost of feed • Ineffective approach for management of common property resources • Quality of medicines
	▪ Formal credit for animal purchase	• Very poor access to formal credit at the farm level
	▪ Informal loans for animal purchase or other dairy needs	• Very high rate of interest; farmer has to sell milk at low price to the trader from whom he/she has borrowed money
Production	▪ Dairy farming ▪ Selling to milk cooperatives/ traders/private dairy agents	• Low productivity because of poor genetic potential, poor feeding and management practices, poor access to health and breeding services, lack of good-quality animals • Low profitability from dairy enterprise
Marketing/ processing	▪ Collection of milk from farmers through village society, processing and marketing of milk in cities and urban areas	• Lack of coverage of villages • Lack of transparency in milk testing and pricing • Marketing only in peri-urban/urban areas • Milk prices declared by cooperatives kept low and used as a benchmark price by other players
	▪ Purchase milk from farmers and selling milk and processed products to consumers	• No transparency in milk pricing • Adulteration and quality of milk and milk products • Unhygienic conditions for milk processing
	▪ Purchase of milk from farmers through village agents, processing and selling milk	• No transparency in pricing of milk • Quality of milk
Retailing	▪ Selling of milk and milk products processed by cooperatives and private dairies	

Source: FAO, 2008.

In today's highly competitive market, the manufacturers face the challenge of decreasing manufacturing cycle time, delivery lead-time and inventory reduction. It is the core interest of the decision-makers to reduce the cost, expanding the business, improving the customer service, improving the quality of finished goods and reducing the time taken in producing finished goods. Supply chain management can be defined as a process of integrating suppliers, manufacturers, warehouses, and retailers, so that the goods are produced and delivered at the right time in right quantities while minimising cost as well as satisfying customer requirements. Supply Chain Management (SCM) is the process of planning and management of materials, information and financial flow in a network consisting of manufacturers, distributors, suppliers and customers with the objective of reducing the costs, increasing the business and improving the customer service.

GIS IN SUPPLY CHAIN MANAGEMENT

Geographical Information Systems (GIS) offer a valuable supply chain management tool. It provides the opportunity to represent the information visually, allowing the decision maker to visualise a complete company profile to include manufacturer, office and warehouse locations, employee, client, customers, distributors and supplier locations. Relationships can be drawn between these locations, allowing for the company's supply chain to be identified and monitored (Johnston *et al.*, 1999; Vlachopoulou *et al.*, 2001).

Data Preparation

The concept of transportation and routing analysis has been quite appealing for all industries which deal with perishable food products including the dairy industry, because it helps in getting the information quick on hand and in managing the complex supply chain in an effective manner.

Data Collection

In this project both primary and secondary data have been collected. For mapping the bulk milk cooling units (BMCU) and milk chilling centres (MCC) of the Cream Line dairy, the latitude and longitude data of every BMCU, MCC and processing centres has been mapped. Andhra Pradesh district wise map has been digitised, over which the road network layer was overlapped, for looking at the road connectivity to the respective BMCUs and MCCs.

Types of Data Available:

(a) *Spatial Data:* This includes Andhra Pradesh district wise boundary Shape file, Andhra Pradesh road network shape file, Hyderabad main road shape files, Latitude longitude data of BMCUs, MCCs, processing plant of the Cream line dairy etc.

(b) *Attribute Data:* District wise milk production data, District wise Cow and buffalo population data of Andhra Pradesh etc.

District wise milk production data, cow and buffalo population data of Andhra Pradesh has been collected from secondary sources *(AP Livestock Sample Survey)* and symbolised on the GIS platform and map accordingly.

(c) *Procedure:* Step 1. Location address of the Creamline Dairy procurement centers were taken from Cream Line dairy office and the longitude and latitude position of each center have been recorded. Step 2. Mapping of these locations was made on Andhra Pradesh map shape file. Step 3. Linking location address with various attribute data was done to get the required results (Geoprocessing). Step 4. Analysis has been done for seeing the locational advantage or disadvantage of the collection centers/chilling centers.

Software Used for Study

(A) ArcGIS is a geographic information system (GIS) for working with maps and geographic information. It is used for: creating and using maps; compiling geographic data; analysing mapped information; sharing and discovering geographic information; using maps and geographic information in a range of applications; and managing geographic information in a database.

(B) Google Earth: It is online georeference address providing software which helps in getting the location of any address virtually.

Catchment Area Analysis

This has been done by using different kind of Geoprocessing tools like proximity analysis, buffering, thematic mapping etc. The *Arc INFO* Geoprocessing environment has many tools for processing all types of data. Some of these tools that have been used for this study are: *Proximity analysis* (Buffer tool). Buffer analysis tool creates a new feature class of buffer polygons around the geocoded centers. Buffers work in Euclidean space and use a two-dimensional algorithm (ArcGIS 9.3 Desktop Help). These buffer polygons gave information about the related road network in the study

area. Thematic mapping also helps in close analysis of the centers in locational preferences.

The supply chain of Creamline dairy is similar to any milk supply chain prevailing in India (Fig 3). They collect milk from farmers through milk collection agents who provide/supply milk to Bulk milk cooling unit (BMCU), which is the first point of refrigeration/cooling. Then milk goes to Milk chilling center (MCC) for further cooling and then finally goes to the processing plant, situated at Uppal (Hyderabad). After processing, different kinds of products are being made and stored in warehouses located in different localities in the city. From there it goes to milk vendors/dealers in the city and finally to the end customers. Like Creamline Dairy, most of the private dairies in Andhra Pradesh are targeting metro cities for final selling of their processed products like ice cream, pasteurised milk, butter, ghee etc.

After doing the catchment area analysis on data provided by Creamline Dairy Pvt. Ltd., all the centres of the company were plotted on map (Fig 4). Latitude, Longitude data of different centres of Creamline dairy in Hyderabad have been collected with the help of Google map/Google earth and addresses provided. In Andhra Pradesh, a total 33 centres were located out of which 7 are MCC, 25 are BMCU and one is Processing plant. Most of the centres are located around MCC and processing plant, while the milk producing districts are situated in coastal area of the state. One MCC is located around a cluster of the BMCUs as the milk from BMCU goes to MCC. The capacity of one BMCU is about 10000 liters. Finally all the milk from MCCs goes to processing plant.

A buffer of 25 km for each milk chilling centre (MCC) was created alongwith the road network connectivity and nearness to the BMCUs (Fig 5). Thus, all the BMCUs were covered by the existing 7 MCCs. Six BMCUs located near Mahboobnagar are not in the buffer zone of MCC, it might be possible that milk from these BMCUs are coming directly to the processing plant due to its vicinity to the processing plant. The road networks among different MCCs and towards the processing plant are connected by the main road.

Further, a buffer of 15 km around all the BMCUs was made to explore the connectivity with processing plants and road penetration in the respective BMCUs. It was observed that most of the BMCUs were connected by 3 roads at least (Fig 6). All the BMCUs are intersected by different road networks. Some of the BMCUs are covering (overlapped) the area of Mahboobnagar and Rangareddy districts. These areas are in high milk producing zone, and hence more than one BMCU have been established in the 15 km radius.

For the processing plant, 150 km buffer was made to identify the MCCs and BMCUs covering the processing plant area of Andhra Pradesh (Fig 7). The assumption behind taking the buffer radius of 150 km was the driving time and shelf life of raw milk after procurement. The raw milk is suitable for processing up to 4 hours after fresh procurement. Taking the average speed in the state as 40 kmph, it comes to 160 km. With little margin for safety, 150 km radius buffer was assumed. It

was observed that all the MCCs and BMCUs except in Guntur and Parigi, comes under the buffer zone of processing plant. Fig 8 depicts the road network in the area of buffer zone of processing plant. It clearly indicates that milk processing plant located in Uppal, Hyderabad, is exactly in the middle of the procurement zone of the Creamline dairy.

In the state, the population of buffalo is more than that of the cow population. While most of the districts like- Prakasam, Guntur, Krishna, East Godawari are highly populated with buffaloes, Chittoor district has high cow population. The BMCUs and MCCs of Creamline dairy are mostly situated in the high or medium (151-300 thousand) population zone of buffaloes.

The total milk production in the Andhra Pradesh state across the districts is depicted in Fig 9. It was observed that none of the BMCU is situated in the low milk production zone, and most of these are situated in the medium milk production zone. Only 4 BMCUs and 2 MCC are situated in the high (601-850 thousand MT) milk producing districts. There is scope for opening new BMCUs in the high milk producing districts like- Chittoor, Prakasam, East Godawari and Guntur. The map below shows the close view of the spread of the BMCUs and MCCs, across the milk production areas in the state.

Among all the BMCU's of Chotuppal, Hayathnagar BMCU is the major procurement center. In this BMCU, months of September, January and February are the major procurement season. Though for Jammikunta BMCU, there is no specific trend as procurement quantity of milk was almost constant round the year. Here, Chelluela and Amudalapally link BMCU are major procurement centers. But still for Amudapally BMCU, the same trend follows like Adda road. The procurement gradually decreased and it was lowest in September. It can be inferred that, September month is the lean season for most of the BMCUs. Therefore, Creamline dairy should expand its procurement area so that milk procurement in these months would also meet the regular supply to the processing plant. In Janagaon MCC, major procuring BMCU is Ganpur. In this BMCU, procurement is constant over the year.

CONCLUSIONS

The conceptualisation and implementation of IT tool like GIS for a dairy industry is a challenging task. It is distributed data architecture on different stages of the supply chain. There are many critical success factors such as: understanding the baseline operation, implementation of the tool in an effective manner, etc. Milk production in Andhra Pradesh has grown remarkably in this decade. The role of private dairy industry like Creamline dairy will be very crucial in procurement and supply of processed milk and its milk products to the customer. In this study, attempts have been made to assess the milk procurement potential of BMCUs from different villages of mandals. Tools like GIS and its analytical applications like proximity analysis, buffering help in taking business decisions like tapping new

villages as procurement centers. For growing private dairy firm like Creamline dairy, the implementation of IT tools like GIS will be a strategic decision for quick and effective decision making in optimising procurement expenditure, identifying new procurement areas and also for diversifying the business in terms of providing input services, rural marketing of milk and milk products etc. Information system with real time data can prove to be a boon to the dairy enterprises. Milk procurement in different BMCUs of Creamline dairy follows a specific seasonality pattern. Maintaining the balanced supply of raw milk to processing plant will be a challenge to private dairy. GIS as IT tool discussed in the present study could prove to be beneficial for practical and effective decision making.

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