

Remote sensing Indian agriculture



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RMSI has established a geospatial approach to rationalise a competent methodology for Supply Chain Management which can combat food insecurity



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Introduction

In tropical countries like India with 127 different agro-climatic zones, the impact of global climate change is evidential through varied seasonal variances such as droughts in Andhra Pradesh, Orissa, Tamil Nadu and flooding in places like Assam, Bihar, Orissa, West Bengal, Uttar Pradesh, Andhra Pradesh, etc. Coincidentally, these are also the major agricultural states. Furthermore, the dominance of middlemen increases the extent of food insecurity. The end result is that the government has to import foodgrains from other countries.

In India, we still predominantly use traditional techniques such as field based crop cutting experiments (CCE) to assess the crop yield and acreage. It is worthwhile to note that in India all crop exports and import decisions are still based on historical production data (previous year's production records), as against the growing international trend of basing these decisions on more scientific and accurate methods such as assessing the current year's yield and acreage much in advance of the actual production by using remote sensing and GIS techniques. The ramifications of taking crucial export and import decisions based on historical data is that there could be a perceived shortage or surplus. To cite an example, during FY-07, there was a bumper rubber production in India, as compared to previous few years. Still the same was imported and the price of Indian rubber went down, all due to non availability of timely data.

Agricultural data is currently generated by multiple agencies in multifarious ways; both conventional field surveys based as well as advance information technology based. Some of the prominent agriculture data publishing programmes in India are: CAPE (Crop Acreage and Production Estimation),

FASAL (Forecasting Agricultural output using Space, Agrometeorological and Land based observations). Federal Agricultural department generates the data by field sampling surveys. Industrial houses send their own field team to assess the acreage and production data. Agencies like Agriwatch, CSE are also gathering Agricultural Intelligence (AI) data from multiple sources. However, a prudent examination reveals that all the above data varies drastically.

Aiming to resolve such issues of vagaries in the AI data, RMSI has established a geospatial approach to rationalise a competent methodology for SCM (Supply Chain Management) which can benefit farmers, traders, exporters, industrial, government, and federal agencies to combat the exports. The author, in this paper highlights this through a specific case study conducted by RMSI for estimating crop acreage estimation, crop yield estimation and production estimation for various rice exporters.

Utility of Basmati Agricultural Intelligence (AI) data

RMSI understands that AI data generated is used in different ways:

1. Industries - Use this data mainly for procurement and supply chain management
2. Boards - Use this data to streamline supply chain as well as to fix the price in the market
3. Insurance companies - Create an insurance product out of the agricultural yield data

However, the conventional data does not suffice for many of the users. They need agricultural data modeled in such as changes in the cropping pattern from the last year, comparative analysis of the last

year data vs. the current year, production pertaining to respective mandis, settlement packages for farmers without affecting the profit margin of the insurance companies, etc. To create such intelligent data, RMSI followed two different aspects, namely,

1. Geospatial data validity of comparing Mandi data with remote sensing based outputs in rice production
2. Supply chain management methodology evolved from the above survey

Study area

The study area covers major rice growing districts from the Indian Ganges flood plains. This includes 13 districts each in Punjab and Haryana, 29 districts in Uttar Pradesh, 4 districts in Uttarakhand and 2 districts of Jammu & Kashmir. Geographically, this spreads across 25° 83' North to 33° 07' North latitude and 73° 87' East to 81° 86' East longitude covering an area of about 189,000 sq km.

Input data

The study entailed collection, procurement and analysis of primary and secondary sources of information. The broad classification of agricultural acreage over the entire region was carried out using IRS P6 AWiFS satellite images with spatial resolution of 56m. Information, from regional to local, were extracted using medium and high resolution satellite images of IRS series 1C, 1D, P6 LISS III and LISS IV with spatial resolution of 23.5m and 5.6m, respectively. Secondary sources of information like Survey

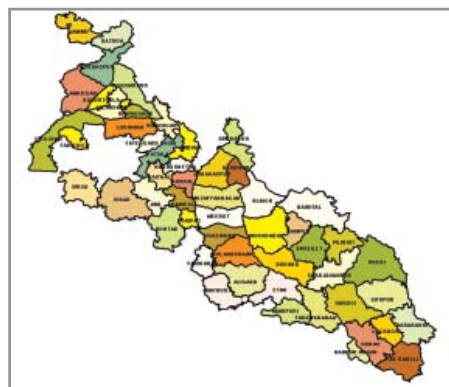


Figure 1: The study area

of India Toposheet on 1:50,000 scale, district maps for the study area were used as reference maps. RMSI also collected primary information for ground truth, field validation, sample based farmer survey and Mandi data through field based-surveys in all the districts.

Secondary information was also collected from district agriculture and state agriculture boards/offices for reference.

Methodology

Major components of compiling a methodology for SCM included Market survey and assessment and Agriculture and Land Resource Mapping. While market survey is done through direct field authenticated data, agriculture and land use map was envisaged through interpretation of remote sensing satellite images.

With a cursory look at mandi information, it is apparent that both quantity and expected time of arrival information are vital. RMSI selected a sample district mandi in each of the Basmati growing states. Mandi arrival data (quantity) and time of arrival was collected from important mandis and market board at block/tehsil level and mandi board at district and state level. It was observed that

Rice and Bajra (Pearl Millets) crops come early in the market i.e., September–October and Basmati and Sugarcane varieties come later in November–December months. To envelop this variation in time, a thorough, periodic and regular survey was carried out. Table 1 gives details of the mandi data collected from a sample mandi survey in Amritsar and Taran mandi in Punjab.

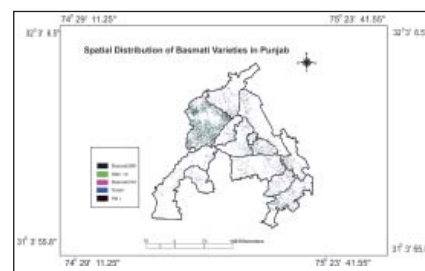


Figure 2: Spatial Distribution of Basmati varieties in Punjab

Details of crop varieties availability, quantity availability and the market share in total purchase of produced crop was collected from different mandi head offices. Agriculture crop mapping was carried out using strict scientifically programmed algorithms of supervised and unsupervised classification in image processing software. Training sets collected from the ground survey were used in this process to identify and delineate different crops. Figure 2 shows the Basmati crop variety map for selected districts of Punjab. Analysis was carried out using the information collected from remote sensing interpretations and mandi survey from various sources. Final production estimation was carried out using combined analysis of remote sensing outputs and mandi data.

Geo-spatial data validity

In conventional ways, after the estimation, second level sample surveys are carried out (crop cutting experiments) or remote sensing-based ground verification is done. However, the data produced, often does not sync with the final output data produced from mandis or markets or final government figure. This, in turn, leads to the question of authenticity of data produced from remote sensing.

RMSI undertook a hybrid approach to compare and assess the accuracy of remote sensing-based production estimation of Basmati rice for kharif 2005 against the mandis arrivals and other related sources at the end of the Kharif season-2005. Mandi arrival data of rice and Basmati was collected for Haryana and Punjab, whereas in Uttar Pradesh and Uttaranchal only total rice data was available and the same was collected. The survey experts also collected data from rice mills, state marketing boards of respective states and the Agents (Arthias). Analysis was carried out based on information gathered from various sources like discussions with respective mandi officials, mandi agents (Arthias), and rice millers to arrive at the conclusion. Based on comparative analysis between Kharif 2005 estimates derived using remote sensing approach and Mandi arrivals (as well as allied sources) as on 31st March 2006 and considering certain calculated and logical assumptions and limitations, it is concluded that the remote sensing based estimated results for Kharif 2005 is matching up to an accuracy of 90% to 94% in the states of the study area. As a by-product, an interesting result on RS data being always higher than total supply chain sources confirms the reliability of this data. Table 2 gives the results so produced and the comparison analysis.

Discussion

In recent years, remote sensing has been accepted as an indispensable tool in the field of agriculture. It helps in crop acreage and yield estimation; health monitoring, agriculture information system, supply chain management, etc. by trimming the cost and human effort. It is increasingly being used to take vital decisions for crop marketing and export, crop inventory and commodity trading. The major activities in SCM that are answered through this RS & GIS approach are:

1. Satellite based crop mapping and acreage estimation at district/tehsil level
2. Crop health monitoring using temporal satellite images and derived vegetation indices
3. Satellite derived indices and weather parameter based yield estimation
4. Comparative analysis on remote sensing based production and actual arrival in the market
5. Spatial database creation of agri-market location and proximity analysis from the produce
6. Vehicle routing from farm to retail outlet using network analyses
7. Decision support system for supply-chain design and management

It is evident from here that AI data produced using geospatial technology is authentic. However, the data in raw format may not yield results. Hence a methodology is discussed to use the above data for supply chain management. This approach uses a statistical model developed to use the AI data for making price forecast of different Basmati varieties, a robust statistical model was used as given in the following equation:

Equation 1

$$\text{Price} = \{f(\text{ma}, \text{ta}, \text{cd}, \text{pv})\} / f_{\text{price}}$$

Where,

ma – Mandi Arrival

Comparison of Kharif 2005-06 Satellite-based estimated production and Mandi arrival for Punjab, Haryana, UP and Uttaranchal

Description	Punjab	Haryana	Uttar Pradesh	Uttaranchal	
Satellite Based-Estimated Production of Basmati 2005 [a]	100.00	100.00	100.00	100.00	
Total Basmati Arrival in Mandis [b]	49.16	63.36	68.97	65.45	
Personal Use and Seed Purpose [c]	15.00	10.00	10.00	10.00	
Sold through other channels [d]	Contract Farming	6.67	1.00	2.00	2.00
	Millers	6.67	2.00	2.00	2.00
	Agents	6.67	7.00	1.00	1.00
	Unorganised Sector	10.00	10.00	10.00	10.00
Sub-Total [e] = [c + d]	45.01	30.00	25.00	25.00	
Total Basmati Accounted by Satellite Based Study [f] = [b + e]	94.17	93.36	93.97	90.45	

Table-2: Gives the results so produced and comparison analysis

Name of the Mandi	Basmati Varieties	Sources of Material (District)	Rice Arrived in Mandi (in %)
Amritsar & Taran Mandi, Punjab	Basmati 386	Amritsar	60-70%
	Basmati 370		60-70%
	HBC 19		20-30%
	Sharbati		50-60%
	Pusa 1121		60-65%
	Super Basmati		50-60%
	Basmati 386	Patiala	30-35%*
	PB 1		15-20%*
	Super Basmati		15-20%*
	Sharbati		20-25%*
	Basmati 386	Hoshiarpur	30-35%*
	Pusa 1121		10-15%*
	Basmati 386	Ludhiana	25-30%*
	Sharbati	Gurdaspur	20-25%*
	PB 1		15-20%*
	PB 1		15-20%*
PB 1	Kaithal	15-20%*	
PB 1	Sirsa	10-15%*	
Basmati 386	Saharanpur	20-25%*	
PB1		8-10%*	

* Depend on Mandi rate

Table-1: Gives details of mandi data collected from a sample mandi survey in Amritsar and Taran mandi in Punjab.

ta – Time of Arrival

cd – Competitor details

pv – Production of variety

$f_{\text{price}} = f(\text{last year low, last year high, Month, Mandi arrival})$

Conclusion

Conventional methods of generating data such as undertaking extensive surveys are time consuming and expensive. At times the government takes important decisions on importing wheat, rubber, sugar, etc with insufficient and pseudo-geospatial data. Similarly, traders rely on the information provided by the middle lemen who in turn get this information from the farmers.

This methodology clearly depicts the advantage of Geospatial based supply chain management techniques. However, the study has a few limitations such as paucity of secondary data and cloud free satellite data especially during Kharif season. However, if the industrialists and federal government jointly produce such data, future generations will have easy utility of this supply chain management model. ■