ISSN: 2641-6379 DOI: 10.33552/WJASS.2019.03.000555

World Journal of
Agriculture and Soil Science

Iris Publishers

Review Article

Horticulture Development in India: Issues and Scenario of Space Technology

Gouri Sankar Bhunia*

Independent Researcher, Bihar Remote Sensing Application Centre (BCST), India

***Corresponding author:** Gouri Sankar Bhunia, Independent Researcher, Bihar Remote Sensing Application Centre (BCST), Patna, India.

Received Date: August 13, 2019

Published Date: August 21, 2019

Abstract

Present paper provides a comprehensive review on the development and application of space technology for horticultural development in India. The review includes various application of geospatial technology including satellite data, image processing operation for orchard delineation and proposed planning for smart horticultural development in India. A conceptual framework was design for big data applications in smart farming of horticultural development and strategy for future development. This study will be helpful to encourage researchers to advance the horticultural development with post-harvest management of the crops in India and other developing countries.

Keywords: Horticulture; Geospatial technology; Data infrastructure; Crop management

Introduction

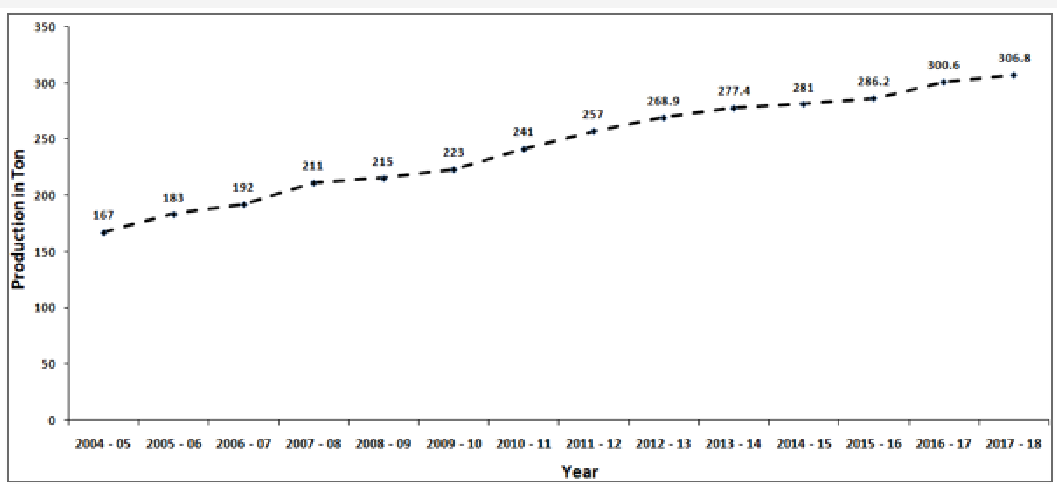

Figure 1: Horticultural production of India during period between 2004 and 2018.

Horticulture refers to the art and science of growing fruits, vegetables, flowers and other plants for human food, non-food uses and social needs. India is the domicile for numerous horticultural crops of commercial significance. 30% of the India's GDP accounts from horticulture and provides about 37.1% of the total exports of agricultural commodities. In 2017-2018, approximately 306.8 million tones production have been estimated and shared about 33% of total agricultural production (Ministry of Agriculture, India). Historical report suggested that the growth rate of horticultural crop production accounted for 2.7% per year (Figure 1). This may be attributed to irrigational facilities, technological improvement, involvement of small and marginal farmers and better agronomic practice and improved varieties of seeds etc. However, horticulture in India is facing several challenges like, inadequate availability of planting materials, rein fed horticulture, dearth of market facility, post-harvest management, lack of processing facilities and insufficient trained manpower etc. Forecasting Agricultural output using Space, Agrometeorology and Land based observations (FASAL) programme, Govt of India aims at providing multiple pre-harvest production forecast and crops at National/State/district level [1]. Present paper is to provide a review of studies of use of geospatial technology and its future prospects in horticulture development in India.

Remote Sensing & Horticultural Development

Over the past few decades, horticulture has grown from planned monitoring using satellite derived information for large scale decision building to strategic planning and control. Consequently, integration of Global Positioning System, Geographic Information System and remote Sensing technology has modernized horticultural revolution [2]. Remote sensing technology like crop identification, crop intensification, orchard rejuvenation, aqua horticulture soil health mapping, crop yield estimation, land resource mapping would help the farmers to grow their horticulture crops in a profitable manner. Satellite data provide the precise information of irrigated crop areas by monitoring the phonological development of crops through multi-temporal image [3]. Weather condition is important aspects that hasten/delay the phonological phases of horticultural crops [4]. Hence, timely monitoring horticultural crop and advanced image processing techniques can be applied to infer the spectral reflectance values of phonological changes in development. Sensors are designed to identify the crops based on the spectral signature of the various wavelengths of electromagnetic spectrum. Multi-spectral satellite data with visible and Near-infrared (NIR) bands provides ample evidences for differentiating fruit plants based on the spectral characteristics, available in the visible and NIR bands. However, some fruit crops have a very long range for the highest spectral reflectance (800–1,100 nm band). Sutherland et al. [5] have used Thermal-infrared (TIR) imagery to detect frost on horticultural crops for subsequent decision making. Moreover, the use of Light Detection and Ranging (LIDAR) data has an enormous capacity because it can resolve plant heights along with spectral characteristics [6]. Consequently, different remote sensors were developed to identify the factors that may affect the crop growth and yield variability. For instance, large area orchard mapping can easily be done using medium resolution satellite data (pixel size 10 – 100m); but small orchards (<2.5 ha) surrounded by forest or tall grasses cannot be differentiated easily [7]. Sharma & Panigrahy [8] used Indian Remote Sensing Satellite (IRS) LISS III (spatial resolution 23.5m) and IRS AWiFS (spatial resolution- 55 m) satellite data to develop an apple orchard database for Himachal Pradesh (India) and were victorious in the demarcation using a comparatively coarse satellite data. Torres et al. [9] used 0.25 – 1.5m resolution data to distinguish olive tree by clustering assessment technique. Lee et al. [10] discussed the different characteristics of the satellite sensors to monitor and measure the biotic and abiotic stress associated to crop. Veena et al., (2016) used World-view-2 and IRS-P6-LISS-III multispectral data to investigate the young and mature horticulture fruit crops in Hisar district of Haryana (India). Recent advancement of image processing techniques and use of microwave and hyperspectral data, most fruits and nut plants can be distinguished from the mixed vegetation or other small shrubs [11-13] investigated the role wireless sensor in future perspective of agriculture and food industry. Advanced Land Observing Satellite/ Phased Array L-band Synthetic Aperture Radar (ALOS/PALSAR) provides the possibility of estimating soil moisture distribution in small farmlands [11]. The hyper-spectral sensors have been evaluated for estimating crop yield [14], green biomass [15], and crop disease [16]. The Global Navigation Satellite System (GNSS) play an important role to retrieve different geophysical parameters, like soil moisture monitoring of the Earth's surface [17].

Modernise Horticulture and Space Technology

Site-specific crop management (SSCM) is one of the most important activity for horticulture which involves spatial referencing, crop and climate monitoring, attribute mapping, decision support system and so on [18]. Tall crop canopy (sugarcane), pigeon pea, and other horticultural crops has confirmed challenging task for competent praying process. In wet land situation, ground stirring instrument persuade undesirable impact for instance hardpan improvement. Low altitude remote sensing (LARS) is very effective for horticultural development with manned airplanes at 300 – 1000 m and Unmanned Aerial Vehicles (UAVs) at 10 – 300 m. LARS data is helpful for crop monitoring and managing crops duration during the growing season through variable rate applications of seeds, fertilizer, pesticides and water etc. Moreover, UAV-based sensors have provided very high spatial resolution data (e.g., the pixel resolution from 5.57 m to 1 mm) for crop acreage change monitoring, crop yield estimation, crop growth monitoring, soil moisture monitoring, disaster monitoring and information service etc. [19]. Ahirwar et al. [20] studied application of Drone technology in agriculture. Currently Maharashtra state government signed a partnership with the World Economic Forum (WEF) Centre for the Fourth Industrial Revolution exploring the use of drones to improve irrigation systems in agricultural field by estimating soil conditions, crop yield prediction, crop disease, pest management, unpredictable seasonal variations etc. The innovative UAV platform for farming may lure to rural youth which diminishing, as it is having the comfortable working environment. Agriculture Insurance Company (AIC), India along with Skynet has carried out few pilot investigations in Gujrat and Rajasthan to evaluate UAV viability for agricultural surveying, crop disease mapping for crop insurance claim settlement [21]. The Director of India Flying Lads (i.e., part of We Robotics) providing training of the tribal people of the Dahanu-Palghar belt of Maharashtra on crop rotation, aquaponics, hydroponics, fish farming, bio-waste management, organic farming, bio-based crop protection using Drone. This congregated information can be considered to presume pinpoint causes of problems and surface up efficient explanation for improving agricultural production, efficiency, and net profit of farming society.

Smart Horticulture and Development

A significant trend for agricultural development has been considered using technology stack, for investment and realization of additional value within the agri-food sector [22,23]. Smart agriculture technologies provide three basic requirements for horticultural development by identifying the precise location of the field, spatiotemporal variability of soil and crop conditions and farming practices at field level. More, smart farming in horticulture includes, bench marking, tele-communication deployment, advance processing and geo-computation, predictive modelling, manager of crop failure risk, agri-business, live-stock production, nutritional balance, sustainable development. A schematic diagram of smart farming for horticultural development is represented in Figure 2. By using smart phone and camera in the form of snapped pictures, pinpoint locations, soil colors, chlorophyll measurements and ripeness level provides more accurate and reliable information for precision farming. Moreover, Global Positioning System (GPS), Microphone, Accelerometer and gyroscopes offered the location of crop production, fertilizing, solar radiation protection, predictive maintenance of machinery, leaf area index and equipment rollover. Recently, many smartphones have instigated to add Internet of Things (IOT) to bring up-to-date actionable information to small farmers regarding weeding, seeding, watering and fertilizing. Recently, data science and big data technology are progressively combined into precision agricultural design that will be helpful for timely decision making [23]. Recently, the agribusiness data such as purchasing inputs, feeding, seeding, use of fertilizer boosted by the IOT to record and monitor business events of interest. Hence, the space technology is changing the scope and organization of farming through geo-computation, telecommunication, advance image processing operation, agribusiness, IOT, planning and decision making.

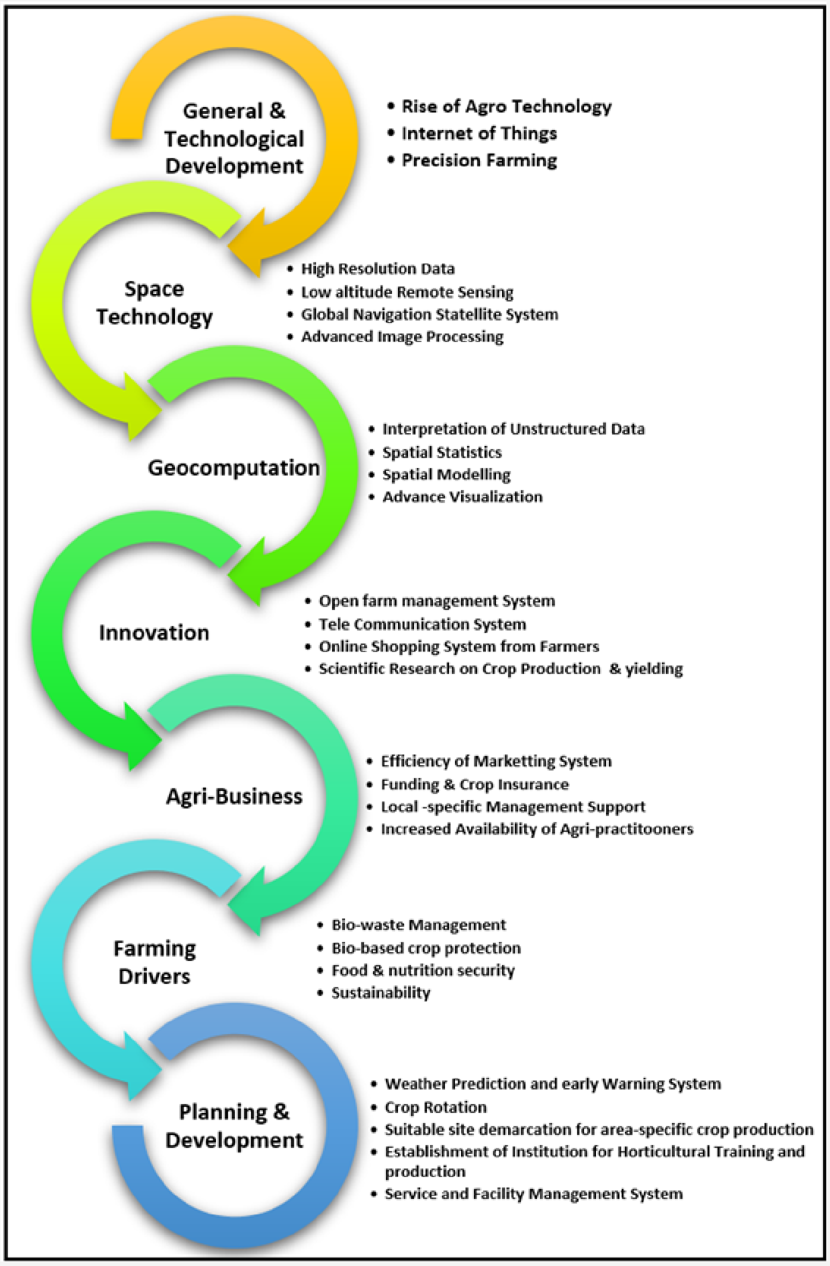

Figure 2: Schematic Diagram for the development of smart farming.

Spatial Modelling & Horticulture Development

Spectral reflectance curves have been created for individual fruit and crops from the satellite data through Crop modelling and management system [24]. In regard to this, hyperspectral images are preferred for accurate classification of different crops. Moreover, spatial pixel swapping, spatial simulated annealing and Hopfield neural networks, feed-forward back-propagation neural networks methods have been considered for mapping and interpretation of super-resolution data. SAMIR model derived through the SPOT sensor data have used to estimate the regional evapotranspiration and crop water consumption [25]. Liou and Kar [26] developed surface-energy-balance-algorithms for estimation of the evapotranspiration to improve the irrigation crop management. Several vegetation indices (e.g., enhanced vegetation index [EVI], soil adjusted vegetation index [SAVI], simple ratio [SR], normalized difference vegetation index [NDVI], soil and plant analyzer development [SPAD]. leaf area index [LAI] etc) have been set-up to measure the different crop parameters such as, crop density, biomass, chlorophyll, nitrogen, water content related to physiological processes (e.g., transpiration and photosynthesis) [27,28]. Currently, deep learning has been developed from remote sensing image classification [29]. Plants showing symptoms of wilting emit more longwave infrared radiation, revealing canopy temperature. U.S Water Conservation Laboratory in the 1970s and 1980s, was developed Crop Water Stress Index (CWSI) model for the irrigation purpose [30]. Advanced satellite image classification methods such as ISODATA, WARD-minimum variance technique, k-means clustering, Bayesian classification algorithm, fuzzy, multivariate cluster analysis, and artificial neural and self-organizing map are being worn to define horticultural crops [7]. The object-based image classification (OBIC) provides a novel plan to execute image segmentation for orchard mapping to combine the neighborhood pixel with similar spectral signature [31]. Rathore et al. [32] proposed a real time big-data analytical architecture that will be helpful for the horticultural development to solve large scale technical problems. This machine learning techniques handles deep feature extraction with huge volume of satellite data for horticultural mapping and analysis.

Post-Harvest Management and Space Technology

Losses of horticultural production are the key delinquent in poor-harvest, began by a wide diversity of aspects, vacillating from rising situations to handling at marketing level (Adeoye et al., 2009). Post-harvest management and post-harvest behavior (e.g., cooling, transportation, storage, lack of awareness, poor management, market dysfunction etc) of horticulture productions have not been assumed proper attention over the years. Approximately 15-50% of the developing nations are suffering from post-harvest management of horticultural crops [14]. Hegazy [33] investigated that post-harvest losses in India range from 5.8 to 18% in case of fruits and 6.8% to 12% for vegetables. The integration of remote sensing and GIS techniques offers great potentiality for better extraction of environmental variables for spatial data management. Vijjapu et al. [34] studied deficiency of post-harvest infrastructure assessment of potato for Bihar state in India using IRS LISS III and AWiFs satellite data and proposed new location for cold storages to reduce the loss of agricultural production. Geospatial technology has been used in wide range of post-harvest management in horticultural activities including cold storage facility, market availability, site specific crop management and proposed site demarcation for suitable crop production etc.

Future Prospects

Future policy for implementation of horticulture in India should contemplate the problem of land fragmentation, deficiency of highly urbane technical centers for horticulture, data management, agri-business, and dead reckoning system. Spatial data provides valuable information for horticultural variables, such as yield, biotic, abiotic indicators of crops, analyses different sites and farms [35,36]. UAV and big data technology offer a novel toolset to farmers and growers to lessen the costs and rise yields by curtailing the practice of fertilizer, insecticides, fungicides and other chemicals, while improving overall plant health and crop yield. Substantially, space technology has provided growers with a vigorous and trustworthy technique for decision making about spatial management of their fields. The establishment of four-layer-twelve-level (FLTL) and five-layer-fifteen-level (FLFL) remote sensing data management structure provides management and application framework for huge volume data management and local farm studies. Overall, several aspects need to be considered for the horticultural development through geospatial technology, such as reliable data with high temporal resolution, efficient organization and management of satellite derived information, horticultural information infrastructure building with automated processing and simulation models to enhance the quality and competent of horticultural spatial analysis. Expansion of postharvest protocol for various fruits, vegetables, preservation of fruits, and market-based farming practice, assortment of cultivar, rising season needs to be appraised and modernized. Small entrepreneurs at farm level may be encouraged for agribusiness. Large scale multiplication of important varieties for distribution among farmers to be standardized through specific management practice. Screening and development of appropriate protected environment and structures for disease control.

Acknowledgement

None.

Conflict of Interest

No conflict of interest.

References

1. Parihar JS, MP Oza (2006) FASAL: an integrated approach for crop assessment and production forecasting. Proc. of SPIE Vol. 6411641101 Agriculture and Hydrology Applications of Remote Sensing, edited by Kuligowski RJ, Parihar JS, Saito G.
2. Zhang N, Wang M, Wang N (2002) Precision agriculture - a worldwide overview. Computers and Electronics in Agriculture 36: 13–132.

3. Thorp KR, Gore MA, Andrade Sanchez P, Carmo Silva AE, Welch SM, et al. (2015) Proximal hyperspectral sensing and data analysis approaches for field-based plant phenomics. Comput Electron Agric 118: 225–236.
4. Rao P (2007) Remote Sensing for Assessing Vegetation Dynamics and Productivity of a Peatland in Southern Sweden. M.S. Thesis, International Institute for Geo-Information Science and Earth Observation, Enschede, The Netherlands.
5. Sutherland RA, Hannah HE, Cook AF, Martsolf JD (1981) Remote sensing of thermal radiation from an aircraft—An analysis and evaluation of crop freeze protection methods. J Appl Meteorol 20: 813-820.
6. Polo JRR, Sanz R, Llorens J, Arnó J, Escolà A, et al. (2008) A tractor mounted scanning LIDAR for the non-destructive measurement of vegetative volume and surface area of tree-row plantations: A comparison with conventional destructive measurements. Precis Agric 102(2): 128-134.
7. Panda SS, Hoogenboom G, Paz J (2009) Distinguishing blueberry bushes from mixed vegetation land-use using high resolution satellite imagery and geospatial techniques. Comput. Electron Agr 67: 51-59.
8. Sharma A, Panigrahy S (2007) Apple orchard characterization using remote sensing and GIS in Shimla district of Himachal Pradesh. In Proceedings of Remote Sensing and Photogrammetry Annual Conference, Newcastle, UK, pp. 1-4.
9. Torres LG, Pena Barragan JM, Lopez Granados F, Jurado Exposito M, Fernandez Escobar R (2008) Automatic assessment of agro-environmental indicators from remotely sensed images of treeorchards and its evaluation using olive plantations. Comput. Electron Agr 61: 179-191.
10. Lee WS, Alchanatis V, Yang C, Hirafuji M, Moshou D, Li C (2010) Sensing technologies for precision specialty crop production. Comput Electron Agric 74: 2–33.
11. Cross JV, Walklate PJ (2008) The UK PACE scheme for adjusting the dose to suit apple crops. Agr Eng Int CIGR EJournal 6.
12. Wang N, Zhang N, Wang M (2006) Wireless sensors in agriculture and food industry-Recent development and future perspective. Comput. Electron. Agric 50(1): 1-14.
13. Walklate PJ, Richardson GM, Baker DE, Richards PA, Cross JV (1997) Short-range LIDAR measurement of top fruit tree canopies for pesticide application research in United Kingdom. Proc SPIE 3059: 143-151
14. Zarco Tejada PJ, Ustin SL, Whiting ML (2005) Temporal and spatial relationships between within-field yield variability in cotton and high-spatial hyperspectral remote sensing imagery. Agric J 97: 641–653.
15. Cho MA, Skidmore A, Corsi F, Van Wieren SE, Sobhan I (2007) Estimation of green grass/herb biomass from airborne hyperspectral imagery using spectral indices and partial least squares regression. Int J Appl Earth Obs Geoinf 9(4): 375–391.
16. Huang W, Lamb DW, Niu Z, Zhang Y, Liu L, et al. (2007) Identification of yellow rust in wheat using in-situ spectral reflectance measurements and air borne hyper spectral imaging. Precis Agric 8: 187–197.
17. Roussel N, Darrozes J, Ha C, Boniface K, Frappart F, et al. (2016) Multi-scale volumetric soil moisture detection from GNSS SNR data: Ground-based and airborne applications. In Proceedings of the 2016 IEEE Metrology for Aerospace (MetroAeroSpace), Florence, Italy.
18. Magri A (2005) Soil test, aerial image and yield data as inputs for site-specific fertility and hybrid management under maize. Precis Agric 6: 87-110.
19. Huang Y, Zhong Xin C, Tao Y, Xiang Zhi H, Xing Fa G (2018) Agricultural remote sensing big data: Management and applications. Journal of Integrative Agriculture 17(9): 1915–1931.
20. Ahirwar S, R Swarnkar, S Bhukya, Namwade G (2019) Application of Drone inAgriculture. Int J Curr Microbiol App Sci 8(1): 2500-2505.
21. Sinha JP, Kushwaha HL, Kushwaha D, Singh N, Purushottam M (2016) Prospect of Unmanned Aerial Vehicle (UAV) Technology for Agricultural Production Management. International Conference on Emerging Technologies in Agricultural and Food Engineering Agricultural and Food Engineering Department, IIT Kharagpur, pp. 53-66.
22. Yang C (2014) Big data and its potential applications on agricultural production. Crop Environment & Bioinformatics 11: 51-56.
23. Wolfert S, Lan G, Verdouw C, Bogaardt M (2017) Big data in small farming - a review. Agricultural Systems 153: 69–80.
24. Panda SS, Hoogenboom G, Paz JO (2010) Remote Sensing and Geospatial Technological Applications for Site-specific Management of Fruit and Nut Crops: A Review.Remote Sensing 2(8): 1973-1997.
25. Saadi S, Simonneaux V, Boulet G, Raimbault B, Mougenot B, et al. (2015) Monitoring Irrigation Consumption Using High Resolution NDVI Image Time Series: Calibration and Validation in the Kairouan Plain (Tunisia). Remote Sens 7: 13005–13028.
26. Liou YA, Kar SK (2014) Evapotranspiration Estimation with Remote Sensing and Various Surface Energy Balance Algorithms-A Review. Energies 7(5): 2821–2849.
27. Alvino A, Marino S (2017) Remote Sensing for Irrigation of Horticultural Crops. Horticulturae 3(2): 40.
28. Diker K, Bausch WC, Heermann DF (2001) Monitoring Temporal Changes of Irrigated Corn by Aerial Images; ASAE Paper No. 01-1144; American Society of Agricultural and BiologicalEngineers: St. Joseph, MI, USA.
29. Mohanty SP, Hughes D, Salathe M (2016) Using deep learning for image-based plant disease detection. Frontiers in Plant Science 7: 1–10.
30. Zarco Tejada PJ, González Dugo V, Williams LE, Suárez L, Berni JAJ, et al. (2013) A PRI-based water stress index combining structural and chlorophyll effects: Assessment using diurnal narrow-band airborne imagery and the CWSI thermal index. Remote Sens Environ 138: 38-50.
31. Blaschke T (2010) Object based image analysis for remote sensing. ISPRS Journal of Photogrammetry and Remote Sensing 65(1): 2–16.
32. Rathore MMU, Paul A, Ahmad A, Chen B, Huang B, Ji W (2015) Real-time big data analytical architecture for remote sensing application. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing 8(10): 4610–4621.
33. Hegazy R (2013) Post-harvest Situation and Losses in India, Technical Report.
34. Vijjapu P, Kimothi MM, Roy S, Mamatha S, Ray SS (2019) Geospatial perspective for post-harvest infrastructure management: positioning of new cold storage. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XLII-3/W6, 2019 ISPRS-GEOGLAM-ISRS Joint Int. Workshop on “Earth Observations for Agricultural Monitoring”, India.
35. Kojima Y, Oki K, Noborio K, Mizoguchi M (2016) Estimating soil moisture distributions across small farm fields with ALOS/PALSAR. International Scholarly Research Notices 8: 4203783.
36. Panda SS, Hoogenboom G, Paz J (2009) Distinguishing blueberry bushes from mixed vegetation land-use using high resolution satellite imagery and geospatial techniques. Comput Electron Agr 67: 51-59.