Available online at www.isas.org.in/jisas
Journal of the Indian Society of Agricultural Statistics 75(2) 2021 127–140

Need and Impact of Data Analytics in Organic Farming Sector of India

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Received 03 April 2021; Revised 15 September 2021; Accepted 26 October 2021

SUMMARY

This article mainly focused in bringing out the need and importance of developing and deploying customized Information Technology based data centric Geo-Analytical tools and its related technologies that can monitor and further speed-up the growth of Organic Farming sector of any country. Initially, data pertaining to the Land related Key Indicators of Organic Farming industry of India has been analyzed and its growth status has been brought out since year 2003 to till date. The key indicators such as areal extent of Organic Land, areal extent of Wild collection, number of Organic Producers, Processors, Exporters of India as well as organic market related factors such as Production quantity, Export Volume, Export Value are analyzed in detail. Further to this the significance of deriving as well as relating the outcome of these analysis through a Geographic Information System based Decision Support System (GIS-DSS) is insisted which will further enhance the growth status of Organic Farming sector of India right from taluk, district and at state level. Overall, the need and importance of developing and deploying an advanced ML/DL based integrated GIS based Analytical Decision Support System which can accelerate the growth of Organic Farming sector of India has been brought out.

Keywords: Organic farming, Key indicators, Data mining, Geo analytics, IT & ITES.

1. INTRODUCTION

Health hazards associated with the continuous use of chemical fertilizers in agriculture farms has been well analyzed by worldwide researchers and its adverse effects over the environment as well as humans are proved beyond doubts. Worldwide, in 150 plus countries organic farming practices is gaining momentum as an alternative to synthetic fertilizer based farming system as it is able to maintain a win-win partnership with earth's natural ecosystem as well as with consumer's health (Kölling., 2010). Such awareness leads to the exponential growth of worldwide organic farming industry and its impact can be well observed in the export sector of Organic products which exhibits increasing trends in each year (Web References listed as No 63 and 64). In case of India, the growth status of key indicators of organic farming sector exhibits exponential growth since year 2003. At the same time, across the globe it has been observed there is a major gap exist in developing and deploying domain specific Information Technology (IT) based tools that can be integrated with the operational and monitoring environment of Organic Farming sector of any country. To be specific a customized Geo-Analytical tool that can map, monitor and forecast the growth status of Organic Farming commodities of specific region can be developed. When such regional organic farming Geographical Information System (GIS) is further integrated with data from district, state and national level, voluminous Geospatial information pertaining to the organic farming sector of a nation is getting evolved. Effective analyses of such voluminous data needs the support of various Machine & Deep Learning (ML/DL) based analytical algorithms which is certainly helpful in bringing out many insights and foresights of organic farming sectors right from local to district, state and national level. In this regard this article is mainly intended with the objective of identifying, analyzing the key performance indicators of organic farming sector of India by which brings out the importance of developing and deploying local to regional scale Geo-Spatial Analytical solutions which can further enhance the growth of Organic Farming sector.

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2. MATERIALS USED AND METHOD OF APPROACH

This article is primarily based on the in-depth study of listed references from where the much required critical as well as authenticated information is extracted through text mining techniques. FiBL & IFOAM Organic International reports from the year 2005 to 2020 (References No from 34 to 48) able to provide information about Land and Human groups related key factors of Organic Farming sector of India. In addition to this published Organic Farming articles focused to Indian context by Aktar *et al.*, 2009; Aniketa Horo *et al.*, 2019; Anuj Mamgain 2019; Deshmukh *et al.*, 2015; Salvador *et al.*, 2003; Seufert *et al.*, 2012; Singh *et al.*, 2017; Suryatapa Das *et al.*, 2020; Yadav 2017; Venkateswarlu *et al.*, 2008; Balachandran 2004; Yussefi Minou 2006 and Ph.D thesis of Priya Soni, 2017 were also referred. Information from Agriculture & Processed Food Products Export Development Authority (APEDA) web portal of Government of India (Web References from 58 to 62) are mainly used to cross validate the data. To fill the missing details the authenticated information submitted to the Parliament of India (Lok Sabha) against specific organic farming related queries were used (Reference No.53).Reports from few banking and private sectors who have done specific study on organic farming sector of India also used to cross validate the extracted data (Narayanan, 2005; Prahalathan *et al.* 2015 and Souvik Dutta *et al.* 2017).

3. STATUS OF USING INFORMATION TECHNOLOGY (IT), INFORMATION TECHNOLOGY ENABLED SERVICES (ITES) IN ORGANIC FARMING INDUSTRY

At international stage Ifadis *et al.* 2004 discusses about integrating Geographic Information System (GIS) with mobile and wireless communication system for the usage of organic farming agencies. Ifadis *et al.* highlights about introducing web based GIS components into Organic Farming practices which connects right from Government agencies to final consumer. With reference to analytical studies, Rathnayake *et al.* 2019 from Sri Lanka proposed a system for Organic Cultivation Management and Prediction System (OCMPS) (Rathnayake *et al.* 2019). OCMPS analyses the historical data gathered from Central Province of Sri Lanka and decisions related to Crop Selection, Harvest Prediction, Price Prediction and Verification of Organic Farmers were made available. In addition to following Machine Learning and Optimization techniques Rathnayake *et al.* 2019 proposed adopting block chain technology mainly to help the customers in tracing out genuine organic products. However, details pertaining to volume of temporal data analyzed, on field implementation details are not observed in both these studies.

At national level, Mishra *et al.* 2015 proposed a GIS based analytical methodology to identify suitable lands for Organic Farming in the Uttarakhand state of India(Mishra *et al.* 2015). Mishra *et al.* suggested Analytical Hierarchy Process (AHP) based Geospatial modelling approach mainly to boost the Uttarakhand state rural economies through self-sustainable villages. In this article multi criteria site suitability analysis is followed mainly to narrow down appropriate locations of organic farming fields based on a group of defined criteria's and constraints derived with the help of soil, drainage, slope, availability of road/network thematic layers of the study area. However, Mishra *et al.* 2015 model follows the complete foot prints of AHP techniques of Saaty 1980, 1988, 1990. AHP model is one of the promising method widely used for the agricultural land suitability analysis which is mostly based on individual criterions of farm land covering soil, drainage, slope, road networks and its related quantitative analysis(Chen *et al.* 2010; Akinci *et al.* 2013; Gomathi *et al.* 2019). Moreover, Mishra *et al.* 2015 study not brought out any information about on-field implementation hence respective article can be observed as a research publication. Overall, dedicated national level efforts on developing domain specific IT tools or ITES for Organic Farming sector is a field yet to be addressed and has wider scope in further enhancing the profitability of Organic Farming sector of India.

4. RESEARCH GAPS OF INFORMATION TECHNOLOGY IN ORGANIC FARMING SECTOR OF INDIA

This section mainly brings out the probable challenges and open research gaps of Organic Farming sector of India that could be addressed through Geo-Spatial Analytics, Big Data technologies, ML/DL Algorithms and further development of suitable IT and ITES tools or environments. It is well-known fact that any Information Technology Tools or e-commerce solutions developed for common Agricultural

Sector mostly suits for Organic Farming sector after undergoing a customization process done specific to the defined norms of Organic Farming sectoras well as with reference to specific standards followed in Organic Farming industry. However, as on date dedicated software tools or e-commerce or other IT based analytical platforms focused to the specific requirements of organic farming sector is yet to be developed. Any such attempt is certainly missing at National level as well as even at International stage too. In case of India, if any such domain specific tool or system has to be developed, it has to be in sync with the analytical related objectives of 'National Projects on Organic Farming' (NPOF) as not all the objectives of NPOF are related to IT or Analytics. Complete list of NPOF objectives can be seen in web references 65 and 66.In depth study of objectives of NPOF is out of the scope of this article. However, it can be firmly said that the analytical related objectives of NPOF certainly need to support of IT or ITES tools or environment as any such objectives need to analyze the integrated information of nationwide organic farming resources, projects and other related initiatives. This is viable only when dedicated GIS based Decision Support System (DSS) is developed specific to Organic Farming industry. When any such tool integrate nationwide data the need of Big Data Technologies, ML/DL algorithms are unavoidable mainly to bring out the insights and foresights of meaningful analytics of Organic Farming sector.

5. ANALYTICS IN ORGANIC FARMING INDUSTRY

As shown in Fig. 1, in current state of situation Analytics in Organic Farming sector mostly starts with text or web mining techniques which in general becomes the initiation point and afterwards proceed towards developing ML/DL based model. For example in Organic Farming sector data mining technique is followed to extract specific required information from voluminous unstructured data which is mostly available in the form of government annual reports, publications, expert committee reports, research articles, authenticated Government web portals etc. When such data mining techniques or models are related to the thematic spatial layers of a region or terrain the Geospatial Analytical model of Organic Farming is getting evolved. When the earlier one is integrated with the later one, a complete assessment of Organic Farming sector of a specific region is evolved. For example when the database pertaining to Organic Farming sector of a particular taluk or district or state is extracted through text or data mining techniques and further integrated with the respective Geospatial layers the performance status of respective administrative unit and its impact at national level can be very well brought out. However, as on date in India no such domain specific analytical system is developed that can integrate the data from local regions and scale up to state or at National level. Even states which declared as fully adopts Organic Farming practices don't have any such domain specific Geo-Analytical system which is helpful to manage and monitors the trend and outcome results of Organic farming practices of respective state. In this regard, the following sections will bring out more details about such data or text mining and Geospatial analytics of Organic Farming sector which certainly suitable for any part of the country as well as world.

6. KEY DATA MINING OF ORGANIC FARMING SECTOR

Data mining techniques mainly brings out the insights and foresight information of unstructured and semi-structured reports, research articles, publications, web achieves, documents, etc. In case of Organic Farming sector the availability of structured data is feasible only when authenticated database pertaining to Organic Farming sector is released by the individual Government Institutions which is hard to find in many countries. Moreover, in general information content of any such available structure data not enough to meet ML/DL based Big Data models which is more focused in bringing out the finer sub-parameter level details of insights and foresight factors of farming sector of a particular region or state or Nation. Hence, in addition to available structured data any Big Data studies need to use all sort of available information from unstructured and semi-structure database sources.

In India, as on date there is no single window interface or authenticated web archives or system exists that can make available the complete past temporal data of organic farming sector details of particular district or state. For example past data pertaining to Organic Farming sector of a particular district or state covering over a period of last 10 years and above are not available even for the state which only adopts Organic Farming practices. Temporal data of such sort is must

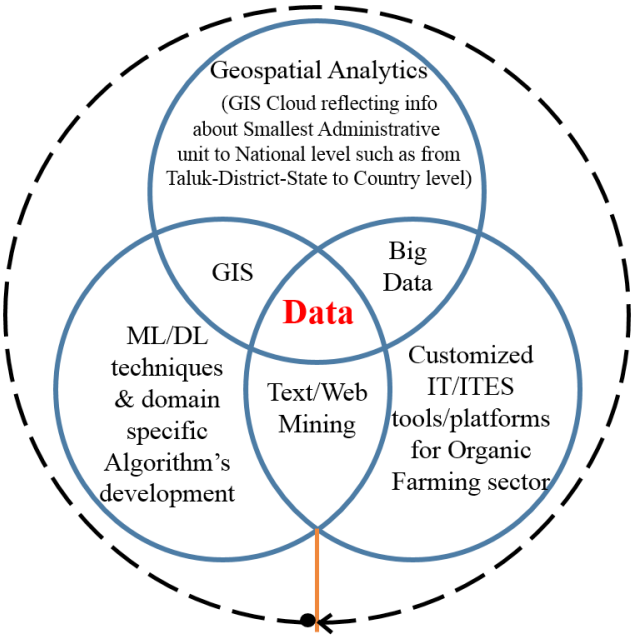

Fig. 1. Organic Farming and Data Analytics: Research and Development perspectives

to bring out the insights and foresight growth status of the respective industry as well as to decide suitable growth plan. As on date, Decision making institutions, Committees, Policy makers and domain researches has to put enormous efforts to collect such authenticated past data pertaining to Organic Farming sector of a specific region or state or nation. This certainly hampers both the decision makers and researchers in identifying and freezing out a right data driven solution which is fundamental need for any future growth plan of any industry.

To be more specific this article is interested in knowing the status of growth details of organic farming sector of India from past ten plus years. In this regard data pertaining to the key indicators such as Land used for Organic agricultural practices; Land used for Wild Collections; Total Organic land of India; Total volume of organic production; Number of Organic Producers; Number of Organic Processors; Number of Organic Exporters; Number of authenticated certification agencies; Total volume of organic products exported and Export Value or Revenue generated were extracted from the authenticated references and analytics of the extracted key indicators are discussed in the following sections.

7. ANALYSIS OF LAND RELATED KEY INDICATORS OF ORGANIC FARMING SECTOR OF INDIA

Growth status of areal extent of Organic Farming land of India from year 2002 to 2020 is shown in Fig. 2. India has initiated Organic Farming practices much before year 2000 but its progress details are available with effect from year 2003. From mere 42000 hectares of organically certified land in March 2003, the Fig. has reached to 2299222 hectares of land under organic crop management by March, 2020(Fig. 2). As on 31st March 2020, total area under organic certification process registered under National Programme for Organic Production is 3.67 million hectare (2019-20). This includes 2.299 million hectare of cultivable organic area and another 1.37 million hectare of wild harvest collection area. Among all the states, Madhya Pradesh has covered largest area under organic certification followed by Rajasthan, Maharashtra and Uttar Pradesh (listed as Web Reference 59). It is expected due to the Government of India plans such as PKVY and MOVCDNER respectively introduced during the year 2015 and 2016, the areal extent of organic farming of India is increasing in each forthcoming years. Due to these government schemes in the year 2016 Sikkim state able to bring its entire cultivable land (which is more than 76000 hectare) under organic certification process and declared as first Organic Farming state of India. Fig. 3, reflects the comparative growth status of Key Indicators of Organic Farming land of India which includes Organic Agriculture land, Wild Collection land as well as total Organic Land of India during the period 2007 to 2018 as the required common authenticated data pertaining to Organic Agricultural land and Organic wild collection land area details are available only during this period.

8. ANALYSIS OF KEY INDICATORS RELATED TO HUMAN GROUPS OF ORGANIC FARMING SECTOR OF INDIA

In organic farming industry working level groups mainly includes groups such as Producers, Processors, Exporters, and Certifying Agencies who plays vital role in the success of respective sector. Table 1 brings out the available details of number of working level group members of Indian organic farming sector from year 2007 to 2018. Data pertaining to year 2020 is yet to be published.

9. STATUS OF MAJOR MARKET RELATED KEY INDICATORS OF ORGANIC FARMING SECTOR OF INDIA

Major Key indicators of Organic Farming Market related factors includes Production quantity, Export Volume, Export Value, Retail sales, etc. Data pertaining such factors also has to be analyzed for each organic commodity which is out of scope of present article as commodity specific past market data covering 10 plus years are not available. Table 2 brings out the major market related key indicators of Indian Organic Farming sector of India covering past 10 plus years which has been text mined from various published references.Fig. 4 brings out the status of Production Quantity of Organic Farming products of India since year 2006-07. Similar to this status of Export Volume and Export Value achieved from year 2002-03 can be seen in Fig. 5 and Fig. 6.

10. ANALYSIS OF KEY INDICATORS OF ORGANIC FARMING SECTOR OF INDIA

From Fig. 3, initially it has been observed that in the year 2017 the areal extent of Organic Agricultural land and Wild Collection land area are same which is generally not feasible (highlighted in red circle). While verifying the respective references (listed as References No 47, 48) which are FiBL & IFOM–Organic International publications of year 2019 and 2020 from where the respective information is text mined it has been found that the value of areal extent of Organic Agricultural land and Wild Collection land area are same in the year 2017 *i.e* 1780000 hectors. Any such situation where both organic Agricultural and Wild Collection areal land area are same is technically and statistically rare one and not possible. Further cross analyzing the respective factors through web content mining with reference to APEDA portal data (listed as Web Reference62) a marginal difference of 6449.29 hectors is found between Organic cultivated area (1786494.06 ha) and Wild harvest collection area (1780044.77 ha). Subsequently the actual values are updated in Fig. 3. At the same time such close value between Organic cultivated area and Wild harvest collection area is never been observed in preceding years. Hence, based on these analytical outcome it is advisable to cross verify the below highlighted concerns and its related datasets

Data References for Fig.2: Year 2002-03 and 2003-04 (Reddy Amarender *et al.* 2017); Text mining information for the year 2004-5 to 2016-17 (From References No 34-46, Year 2006-07 information is as per the corrections shared by APEDA in FiBL & IFOAM 2009 Report i.e in Reference No 37; Information for the year 2017-18 to 2019-20 are from References No 47-48 as well as financial year end details from APEDA (listed as Web References from 58 to 62)

Data References for Fig.3: For the year 2007 to 2016: (From References No 35 to 45); For the year 2017 to 2019: (From References No 46and47) as well as financial year end details from APEDA(listed under Web References from 58 to 62).

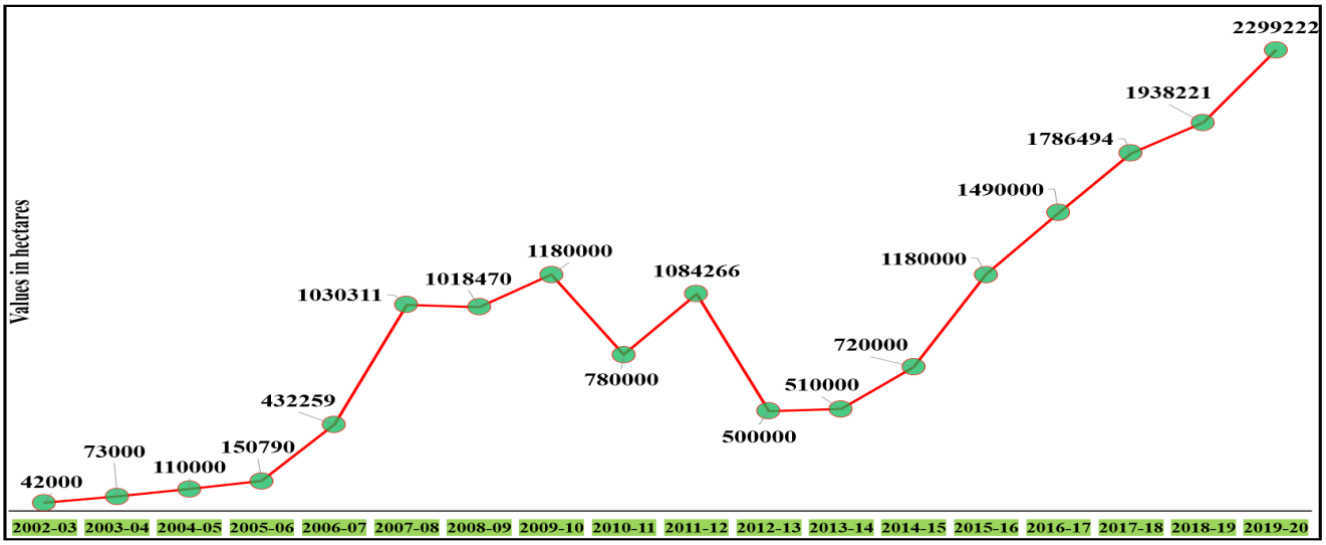

Fig. 2. Growth status of Organic Farming land of India from year 2002 to 2020
(Excluding wild collection, Apiculture, Organic Aquaculture regions)

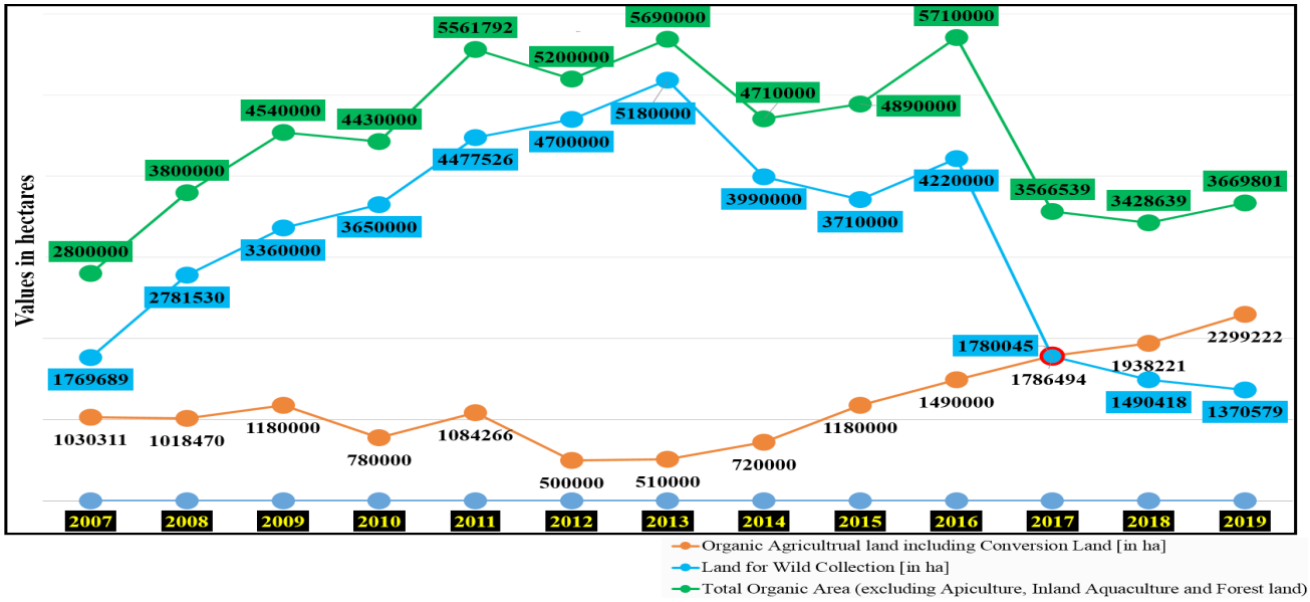

Fig. 3. Land related Key Indicators of Organic Farming status of India (from year 2007 to 2018) covering Organic Agricultural, Wild Collection and Total Organic area

About Table 1. Data Source: FiBL & IFOM–Organic International publications from year 2008 to 2018(listed as References No from36 to 47); #Data for the year 2019 is ascertained based on web content mining (not from any FiBL & IFOM reports); *Data not available.

About Table 2. Data Source: *Information from Reference No 11; @ Information from Reference No 4; # Information from Reference No 53; $Information from http://apeda.gov.in. In addition to above, text mining technique is used to extract the missing data as well as to cross validate the extracted information from References No 5-9, 16, 24, 28, 29, 32, 49, 51, 54, 56.

Table 1. Number of Organic Producers, Processors and Exporters of India

Year	No of Producers	No of Processors	No of Exporters	No of Certification Bodies
2007	195741	*	*	12
2008	340000	*	*	13
2009	677257	299	233	16
2010	400551	299	*	17
2011	547591	71	*	22
2012	600000	699	669	24
2013	650000	*	*	*
2014	650000	699	669	*
2015	585200	699	669	*
2016	835000	699	669	*
2017	*	*	*	*
2018	1149371	1452	*	*
2019#	650000	699	669	28

Table 2. Major market related Key Indicators of Organic Farming Sector of India

Year	Production Quantity (in MT)	Export Volume (in MT)	Export Value (in Crores)
2002-03*	14000	4161	619.6
2003-04*	Data Not Available	6288	726.6
2004-05*	Data Not Available	8344	953.3
2005-06*	Data Not Available	7953	1281.6
2006-07@	585970	7528	987
2007-08*	976646	37533	498.22
2008-09*	1811111	44476	537
2009-10*	1700000	58408	526
2010-11*	3900000	69837	699
2011-12*	700000	147800	1866.33
2012-13*	1300000	165262.06	2106.81
2013-14*	1240000	194088	2563.08
2014-15#	1100000	285607.81	2099
2015-16#	1350000	263687.011	1975
2016-17#	1100000	309766.94	2478
2017-18#	1700000	458339.084	3453
2018-19#	2600000	614089.614	5150.99
2019-20$	2750000	638900	4686

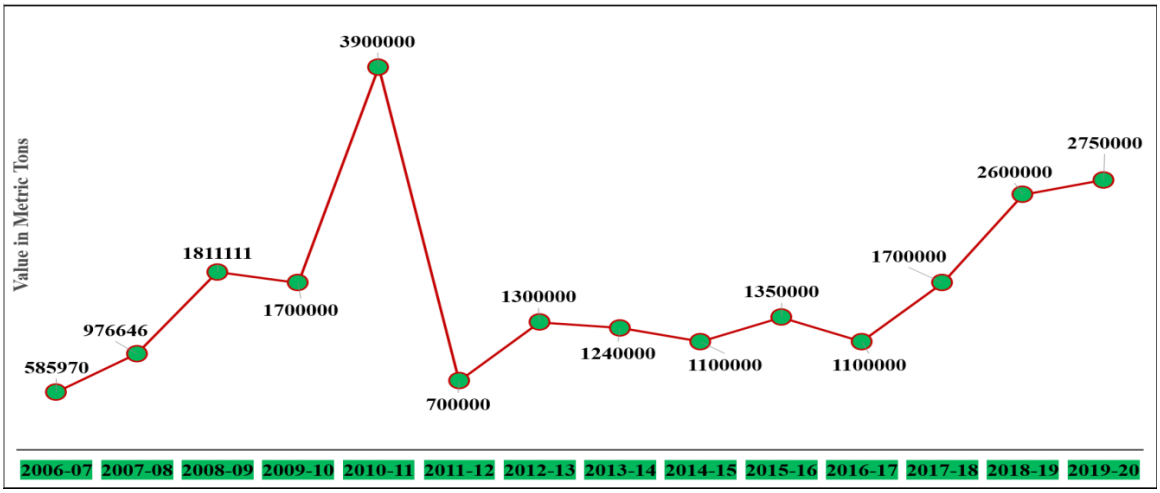

Fig. 4. Production Quantity of Organic Products of India from year 2006 to 2020 (Values in MT)

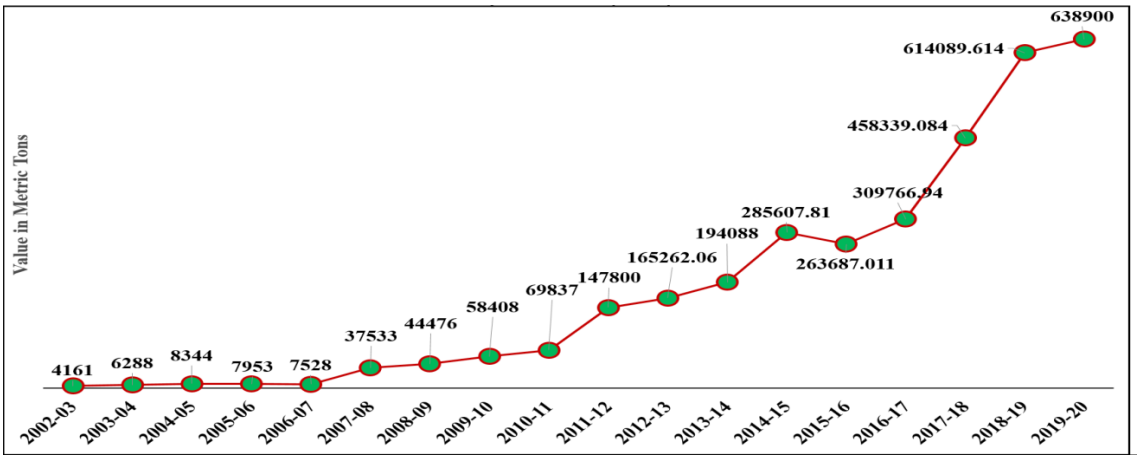

Fig. 5. Export volume of Organic Products of India from year 2002 to 2020 (Values in MT)

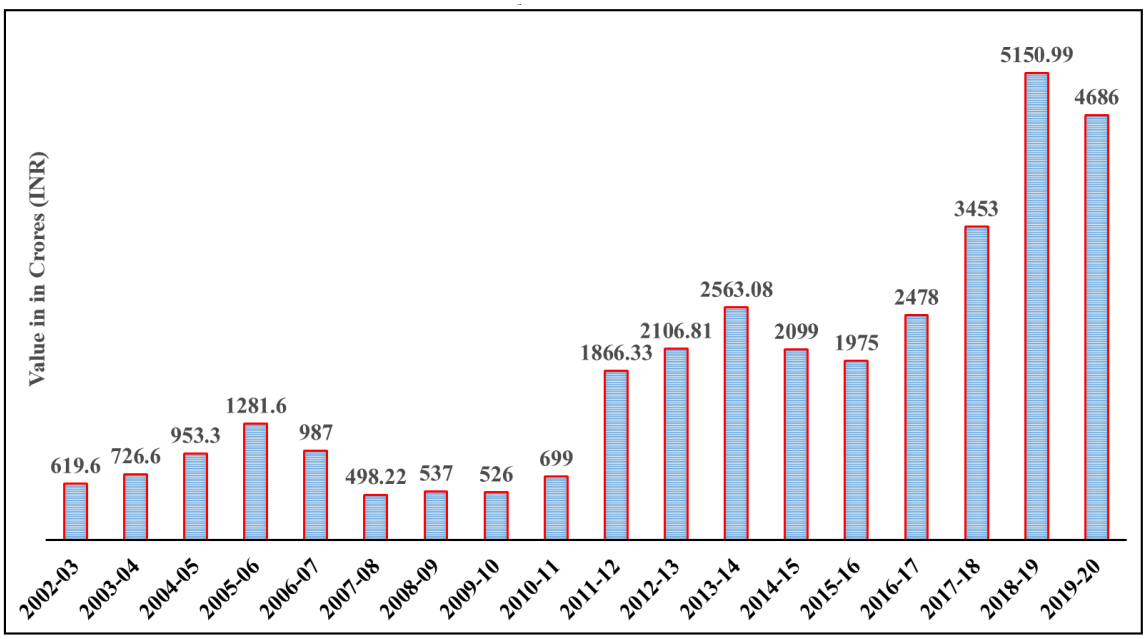

Fig. 6. Export value of Organic Products of India from year 2002 to 2020 (Values in Crores INR)

- In the year 2017, chances for data entry related error may be possible while updating the details about the areal extent of land and wild collection area. If anything so this particular factor also lead to another error such as in estimating the total organic land of India during the year 2017 (Fig. 3 and Fig. 8).
- From year 2017 onwards the Wild collection land area exhibits downward trend. That is while comparing the data from year 2007, first time steep decrease in the wild collection land area is observed in the year 2017 and same is continued in subsequent years. There may be very little scope to judge that the Government of India in the year 2017 might have modified policy decision about accounting the Wild Collection area of Organic Farming sector and if anything so respective details are not found in referred publications or in any other formal departmental announcement or in social medias (Fig. 3 and Fig. 8).
- With reference to cultivable Organic area 'average' gradual decline observed in the areal extent of cultivated organic farming land from the year 2009 to 2013 (highlighted in red line in Fig. 8). This can be attributed to the issues associated with India's genetically modified Bacillus thuringiensis (Bt) cotton cultivation. Finer level discussion of Bt cotton issues is out of scope of this article and respective details can be seen in (References No 14, 15 and Web Reference No. 67). Comparatively from year 2018 onwards organic agriculture land area exhibits upward growth than wild area land.
- Fig. 7 brings out the details about number of Organic Producers of India from year 2007. With reference to number of producers, it is observed that other than an outlier (no data available for the year 2017) the average growth rate of number of organic producers exhibits a positive trend from year 2007 to 2018.
- When comparing the number of organic producers of year 2011 and 2012, in the year 2012 the number of organic producer is increased (Fig. 7). However in the year 2012 the areal extent of organic land decreased to the bottom line (of 500000 ha) and at the same time the areal extent of wild area continue to increase (of 4700000). Respective details are highlighted in Fig. 8 using red circles. Statistical significance and growth details of such relationship can be understood only when a in depth analysis of commodity wise study is carried out comprising both organic agriculture and wild products.
- While comparing Table 1, Fig. 3 and Fig. 7, it has been found for the year-2017 no data entry details are available for the number of producers, processors and exporters from any one of the references listed under this article. When relating this particular observation with the earlier observations (observation made related to the areal extent of organic land and wild area in the year 2017), it can be said that all data pertaining to year 2017 need to be rechecked to know the facts for the sudden fall of wild organic land during the year 2017 as well as downward trend of same since year 2017. Hence, till the year 2017 data entry details

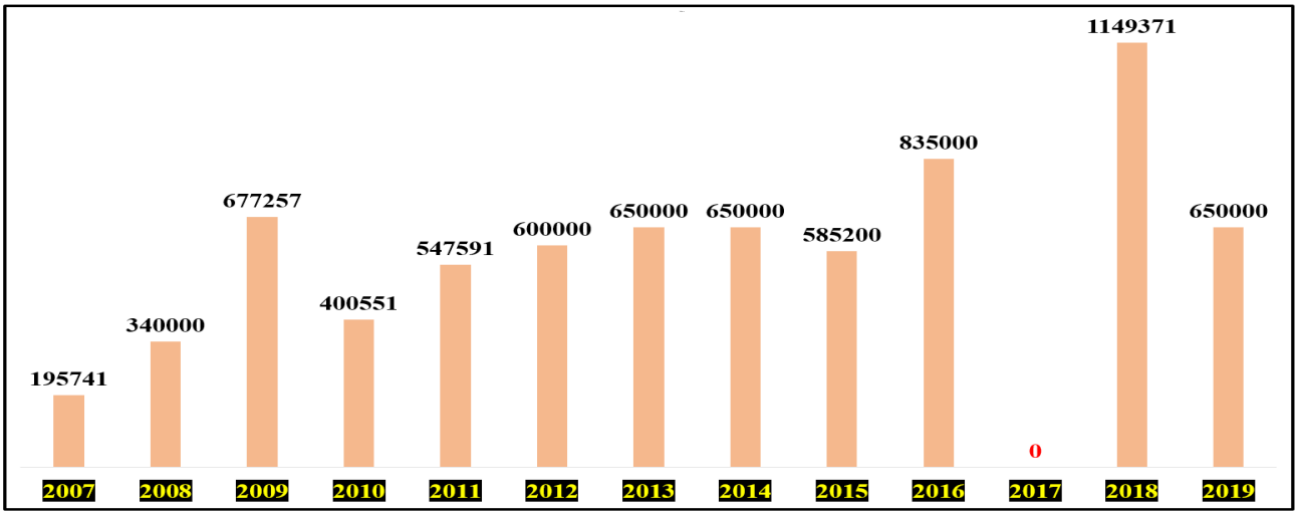

Fig. 7. Number of Organic Producers of India from year 2007

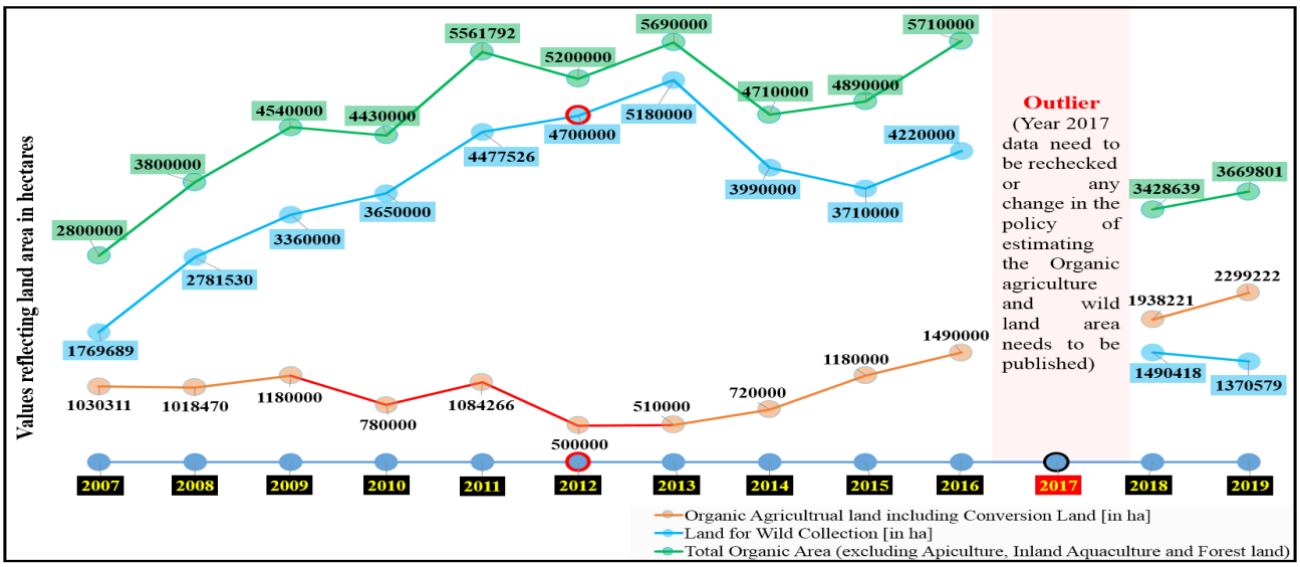

Fig. 8. Data Analytics outcome of major Key Indicators of Organic area of India (from year 2007 to 2019)

are going to be validated the following Fig. 8 is more suitable than Fig. 3.

About Data Source: FiBL & IFOM–Organic International publications from year 2008 to 2019 (From References No 37-48); #Data for the year 2019 is ascertained based on web content mining (not from any FiBL & IFOM reports); *Data not available

The above listed observations are the outcome of extensive data mining and subsequent analytics of major key indicators of organic farming sector of India starting from year 2003 to 2020. However, for most part of the analytical study the common data available during the period from 2007 to 2020 is considered. Overall this study is much useful in tracing out the above highlighted concerns of Organic Farming sector of India which may be possible to overcome with the help of respective functional organizations of Organic Farming sector of India as well as by deeply analyzing the commodity wise products of both organic agriculture and wild products which is currently out of the scope of this article due to the non-availability of commodity wise data from the year 2003 or 2007 onwards.

11. NEED AND SIGNIFICANCE OF GEO-SPATIAL ANALYTICS IN ORGANIC FARMING

The GeoSpatial Analytics of Organic Farming sector mainly brings out the area specific information pertaining to a taluk or district or state level which can be integrated together mainly to project the status at National and International levels. Any such Geo-Analytical systems certainly make uses the spatial thematic layers of the corresponding region which has to be digitally analyzed in a GIS environment mainly to derive and displays the results of analytical outcomes or queries along with its spatial context related details. In case of Organic Farming studies, with reference to region or scale of the study area (aerial extent of the study area), Analytics in Organic Farming can be classified as Local or Regional. Statistical analysis of individual organic farming fields performed through data analytics techniques can be called Local Analytics. Any such analytics which works on the defined dataset of local farm mostly make uses structured data. Past data pertaining to minimum three years of the plot area is needed for any meaningful statistical analysis. Any analytical model of such sort is useful to know the growth as well as yield status of the respective plot in subsequent years and mostly can forecast the status of the respective organic farm from forth year onwards. The vegetation indices which are used to check the growth of the plants, calculates the yields, monitors the health and progress details of the normal agriculture fields also need to be fine-tuned to such Organic Farming plots.

The Regional scale Analytics of organic farming supports for the integrated analysis of data collected from the smallest administrative unit level (taluk) to districts, states and finally tend to relate and consolidates the impact of respective region at state as well as at

National level. In such scenarios Geo-Analytical models play vital role right from data collection, ETL process (Extract, Transform, Load), pre and post processing of data and finally in defining a suitable model which can find out the future insights with the help of various ML/DL algorithms. All these certainly requires in developing as well as in integrating respective analytical model over the GIS environment as this can only act as a meaningful Decision Support System (DSS). As on date both COTS and few Open source GIS tools supports Python based ML/DL interpreter or plugins as part of their tool extension mainly to develop, test and deliver many such domain specific ML/DL models. Hence, with reference to National Organic Farming sector a GIS supported Analytical DSS is need of the hour as this helps in effectively monitoring and improving the Organic Farming sector's performance as well as during real time decision making process. Both the Local and Regional Analytical models requires minimum three plus year's temporal information of respective organic forming plot or region and such temporal data analytics is mandatory to project and derive a meaningful predictive forecasting model that suits for the respective farm or region that has to be analyzed. Also both the above detailed local and regional Geo Analytical models has to explore the complete advantages of various fields of data science as shown in Fig. 1. Integration of taluk, district and state level information will brings out the actual status of Organic Farming sector of a country right from small administrative unit to national level. At Global level, the outcome of nationwide organic indices are consolidated to derive the status at continents level. Such integrated mechanism can only be achieved through a GIS-DSS based ML/DL model which can only deliver answers for the following major challenges of Organic Farming sector of India or any other country.

12. GRAND ANALYTICAL CHALLENGES OF ORGANIC FARMING SECTOR OF INDIA AND NEED OF DEVELOPING ADVANCED RESEARCH MODELS

Ramesh *et al.* 2005, 2010 is first from India identified the actual major analytical challenges of Organic Farming sector of India and part of his views is captured in the first Column of following Table 3. Though Ramesh *et al.* articles did not talk about any data Analytics, these challenges can be very well answered by developing advanced analytical research models for which the above detailed GIS-DSS based ML/DL approach forms the basic foundation. In line to this, the following table is an attempt to address Ramesh *et al.* 2005 observations using ML/DL based Analytical approach. As on date getting the much required input data from authenticated agencies for taluk, district, state level is first major challenge which is not available for any meaningful analytical research.

13. CONCLUSION

Government of India has recognized Organic Farming industry as a potential export sector due to its exponential growth over the years. In line to this through an extensive in-depth analysis of major key indicators of Organic Farming sector of India the following technological gaps can be can be achieved to further spread and enhance the profitability of the organic farming sector of India

- First as per the defined scientific criterions of Organic farming practices a nationwide GIS based mapping has to be undertaken mainly to digitally map the terrain which are suitable for Organic farming. In addition to collecting, integrating and analyzing voluminous data right form taluk, district and state level, such domain specific customized GIS also need to have provisions to incorporate details related to temporal organic farming practices followed at respective local regions
- Such data centric GIS tool further need to be fine-tuned as a real time Decision Support System (DSS) with the support of various ML/DL based Geo-Analytical models which needs to be developed through Research and Development and field validation process
- In addition to above a web based information dissemination portal of such study can be made available under the banner of 'National Digital Atlas of Organic Farming Sector of India' which can displays the information in 24/7 mode between and across the decision makers locations.
- A GIS based mobile interface has to be developed which can deliver the selective services and advices of respective atlas directly to the mobiles of farmers
- Overall, an integrated GIS+Analytics+DSS, ITES based Organic Farming Real Time System has to be developed that can deliver answers for any

Table 3. Table listing out the grand analytical challenges of Organic Farming sector of India that need to be focused by developing suitable advanced analytical models

Challenges of Organic Farming	Primary data required	Type of Analytics	Probable approach of data analytics model	Outcome of model
Can organic farming produce enough food for everybody?	The following data from taluk to district to state level are required: i) Data pertaining to commodity wise crop details from each taluk, districts, state level are mandatory ii) Details related to total cultivable land used for Organic Farming, yield per acre produced at taluk, district level are mandatory. iii) To predict the yield of organic farms through ML/DL based models the parameters such as Soil native-natural carbon level, leaf biomass index, chemicals avoided during the phase change periods, weather conditions such as humidity, temperature, etc. are needed. iv) Socio-economic details including population, Consumption of food grains, etc. Any such analysis requires temporal data covering over a period of three to four years of the region or farm	Predictive Analytics	Data Capture -> Storage -> Preprocessing -> ETL-> Analytics with suitable ML/ DL techniques -> Post Processing -> Data integration on GIS-DSS environment-> Query-> Visualization	Foresight Information
Is it possible to meet the nutrient requirements of crops entirely from organic sources?	Terrain specific factors such as Soil type, water, pH details, No of manure production units its quantity, manure supply-demand details, etc.	Diagnostic Analytics & Predictive Analytics	Data Capture -> Storage -> Preprocessing -> ETL-> Analytics with suitable ML/ DL techniques -> Post Processing	Insight & Foresight information
Are there any significant environmental benefits of organic farming?	Need land specific information during the pre-organic farming period, during land conversion period and after the land conversion period, other terrain specific details, etc.	Descriptive Analytics & Predictive Analytics	Data Capture -> Storage -> Preprocessing -> ETL-> Analytics with suitable ML/ DL techniques -> Post Processing -> Data integration on GIS-DSS environment-> Query-> Visualization	Hindsight and Insight Information
Is the food produced by organic farming superior in quality?	Product inspection reports of farm and certification agencies	Descriptive Analytics & Predictive Analytics	Data Capture -> Storage -> Preprocessing -> ETL-> Analytics with suitable ML/ DL techniques -> Post Processing	Hindsight and Insight information. (The superiority details will become part of the label of the Organic Product)
Is organic agriculture economically feasible?	Population, Total cultivable area, total area used for organic farming, commodity wise production details, consumption details, etc	Prescriptive Analytics	Data Capture -> Storage -> Preprocessing -> ETL-> Analytics with suitable ML/ DL techniques -> Post Processing Data integration on GIS-DSS environment-> Query-> Visualization	Foresight information
Is it possible to manage pests and diseases in organic farming?	Specific details related to disease happened during before and after land conversion stage	Descriptive Analytics & Predictive Analytics	Data Capture -> Storage -> Preprocessing -> ETL-> Analytics with suitable ML/ DL techniques -> Post Processing -> Data integration on GIS-DSS environment-> Query-> Visualization	Hindsight and Insight information

queries raised both by decision makers as well as farmers of India

Any such integrated system will be able to brings out many hidden data centric facts of Organic Farming sectors of India and real time practical use of such data centric system will certainly enhance the productivity of the Organic Farming sector of our country right from taluk, district and at state level. Such practices helps the small farmers to take the advantage of the lucrative Organic Farming market which could directly contribute towards the improvement of their economic well-being.

ACKNOWLEDGEMENTS

Author sincerely acknowledges the support extended by Dr. Sudarsan, Executive Director of C-DAC, Bengaluru in successfully completing this study. Author is thankful to the anonymous reviewer for the useful comments which helped in improving the paper.

REFERENCES

Akinci, H, O¨ zalp, A.Y, Turgut, B, (2013) Agricultural land use suitability analysis using GIS and AHP technique. Computers and Electronics in Agriculture, 97:71–82. http://dx.doi.org/10.1016/j.compag. 2013.07.006.

Aktar, W, Sengupta, D and Chowdhury (2009), Impact of pesticides use in agriculture: their benefits and hazards. Interdisc Toxicol. 2(1): 1–12. DOI: 10.2478/v10102-009-0001-7.

Aniketa Horo and Jagruti Das (2019) Organic farming in India: Status and challenges with special reference to vegetables', Journal of Pharmacognosy and Phytochemistry. SP4:09-13. E-ISSN:2278-4136; P-ISSN:2349-8234; JPP 2019; SP4: 09-13

Anuj Mamgain (2019) Status, importance, prospects, and vision of organic farming in India. International Journal of Advance Research, Ideas and Innovations in Technology. 5(1):436-441. ISSN: 2454-132X

Arpita Mukherjee, Avantika Kapoor & Souvik Dutta, (2018) Organic Food Business in India: A Survey of Companies. Research in Economics and Management, 3(2):72-90. ISSN2470-4407 (Print) ISSN 2470-4393

Aulakh and Ravisankar (2017) Organic Farming in Indian Context: A Perspective, Agricultural Research Journal. 54(2):149-164. DOI: 10.5958/2395-146X.2017.00031.X

Baisakhi Mukherjee (2017) Indian Consumers and Organic Product-With special reference to North India. IRACST – International Journal of Commerce, Business and Management. 6(1):91-101. e-ISSN: 2319-2828

Baisakhi Mukherjee (2017) From Local to Global-Indian Organic Produce an Overview. IOSR Journal of Business and Management. 19(2):34-39. e-ISSN: 2278-487X, p-ISSN: 2319-7668.

Bhubaneswari Bisoyi and Biswajit Das (2017) Organic Farming: A Sustainable Environmental Ingenuity for Biotechnological Intervention towards a Green World. International Journal of Innovative Research in Science, Engineering and Technology, 6(9):17900- 17905. ISSN(Online): 2319-8753; ISSN (Print): 2347-6710

Chen Y, Yu J, Khan S (2010) Spatial sensitivity analysis of multi-criteria weights in GIS-based land suitability evaluation. Environmental Modelling & Software. 25(12):1582-1591. http://dx.doi.org/10.1016/j.envsoft.2010.06.001.

Deshmukh and Nitin Babar (2015) Present Status and Prospects of Organic Farming in India. Journal of European Academic Research. 3(4): 4271-4287. ISSN 2286-4822

Gomathi M, Pavithra, V, Balasubramani K, and Kumaraswamy K. (2019) A Spatial Analysis of Crop-land Suitability for Sustainable Agricultural Development in Aiyar Basin, Tamil Nadu. Journal of Geography, Environment and Earth Science International. 18(4):1-12. https://doi.org/10.9734/JGEESI/2018/46109

Ifadis I. M, Mavridis A. P and Savvaidis P. D, (2004) Internetic GIS: An Open System for Organic Agriculture Administration, Verification and Planning. FIG Working Week 2004 Athens, Greece. pp.1-16

Karihaloo J.L and Kumar, P.A (2009) Bt Cotton in India – A status report (Second Edition). Asia-Pacific Consortium on Agricultural Biotechnology, New Delhi, India. pp.1-59

Kranthi K.R and Stone G.D (2020) Long-term impacts of Bt Cotton in India. Journal of NATURE PLANTS. 6: 1192–1193. https://doi.org/10.1038/s41477-020-0750-z

Makadia. J.J and Patel. K.S (2015) Prospects, status and marketing of organic products in India-A Review. Agriculture Review. 36(1):73-76. DOI: 10.5958/0976-0741.2015.00009.4

Mishra A.K, Deep S, Choudhary A (2015) Identification of suitable sites for organic farming using AHP & GIS. The Egyptian Journal of Remote Sensing Space Science. 18(2):181-193 http://dx.doi.org/10.1016/j.ejrs.2015.06.005

Ramesh P, Singh M and Rao S. A, (2005) Organic farming: Its relevance to the Indian context. Current Science, **88(4)**, 561–568.

Ramesh P, Panwar N R, Singh A. B, Ramana S, Yadav S. K, Shirvastava R, and Rao A.S, (2010) Status of organic farming in India. Current Science, **98(6)**, 1190-1194.

Rathnayake R.M.S.M, Ekanayake E.W.L.M.B, Kahandawala K.A.I.P., de Silva W.G.S.C., Nawinna D.P, and Kasthurirathna, D., (2019) Predictive Analytics Platform for Organic Cultivation Management. International Conference on Advancements in Computing. pp. 204-209, doi: 10.1109/ICAC49085.2019.9103344.

Salvador V.G., and Katke J (2003) Market opportunities and challenges for Indian Organic Products. Research Institute of Organic Agriculture (FIBL) and ACNielsen ORGMARG; Swiss State Secretariat of Economic Affairs. pp.1-38. http: // orgprints.org / 000026841.

Saaty T.L. (1980) The Analytic Hierarchy Process. McGraw-Hill, New York.

Saaty T.L. (1990) How to make a decision: the analytic hierarchy process. European Journal of Operational Research. 48(1):9-26. http://dx.doi.org/10.1016/ 0377-2217(90)90057-I.

Sathiya and Banumathy (2017) An economic analysis of area, production of organic products and its export in India, International Research Journal of Agricultural Economics and Statistics, 8 (1):75-82 e.ISSN-2231-6434

Seufert V, Ramankutty N, Foley J.A (2012) Comparing the yields of organic and conventional agriculture. NATURE, 485:229-232

Singh R, Ravisankar N and Prasad K, (2017) Improvement in productivity and economics of major food production systems of India through balanced dose of nutrients. Current Science. 112(12):2470–2474. doi: 10.18520/cs/v112/i12/2470-2474.

Suryatapa Das, Annalakshmi Chatterjee and Tapan Kumar Pal (2020) Organic farming in India: a vision towards a healthy nation. Journal of Food Quality and Safety. 4:69–76. doi:10.1093/fqsafe/fyaa018

Ummyiah, Sumati Narayan, Pradeep Kumar, Ambreen Nabi, Malik Ajaz and Mudasir Magray (2017) Export of organic products: Opportunities and challenges. Journal of Pharmacognosy and Phytochemistry.6(6):1084-1088. E-ISSN: 2278-4136; P-ISSN: 2349-8234

Varghese Manaloor, Divyanshu Srivastava, Shahidul Islam (2016) Growth of Organic Food Industry in India. AGROFOR International Journal. 1(2):69-76. DOI: 10.7251/AGRENG1602069M UDC 631.147(540)

Yadav M. (2017) Towards a healthier nation: organic farming and government policies in India. International Journal of Advance Research and Development, **2**, 153-159

Kölling, A. (ed.) (2010) International Federation of Organic Agriculture Movements (IFOAM-2010) Organic food and farming: A system approach to meet the sustainability challenge. Publisher: IFOAM EU GROUP, Belgium.

Kumara Charyulu Deevi and Subho Biswas (ed) (2010). Organic Input Production and Marketing in India – Efficiency, Issues and Policies. CMA Publication No. 239, Second Publication from Allied Publishers Pvt Ltd dated April 2016. ISBN-10 : 8184246900, ISBN-13 : 978-8184246902

Venkateswarlu B, Balloli S. S, and Ramakrishna Y.S, (Eds.,) (2008) Organic farming in Rainfed Agriculture: Opportunities and constraints. Central Research Institute for Dryland Agriculture, Hyderabad. pp. 185.

Willer, Helga and Minou Yussefi (Eds.) (2005), The World of Organic Agriculture, Statistics and Emerging Trends 2005, IFOAM & FiBL Organic International, © 2005, International Federation of Organic Agriculture Movements (IFOAM) & Research Institute of Organic Agriculture FiBL

Willer, Helga & Minou Yussefi (Eds.) (2007), The World of Organic Agriculture, Statistics and Emerging Trends 2007, FiBL & IFOAM Organic International © 2007 FiBL & IFOAM

Willer, Helga, Minou Yussefi-Menzler and Neil Sorensen (Eds.) (2008), The World of Organic Agriculture, Statistics and Emerging Trends, FiBL & IFOAM Organic International © 2008 FiBL & IFOAM

Willer, Helga and Kilcher, L. (Eds.) (2009), The World of Organic Agriculture, Statistics and Emerging Trends 2009, FiBL & IFOAM Organic International © 2009 FiBL & IFOAM

Willer, Helga and Lukas Kilcher (Eds.) (2010), The World of Organic Agriculture, Statistics and Emerging Trends 2010. IFOAM, Bonn and FiBL, Frick © 2010 FiBL & IFOAM

Willer, Helga and Lukas Kilcher (Eds.) (2011), The World of Organic Agriculture, Statistics and Emerging Trends 2011. FiBL-IFOAM Report. IFOAM, Bonn and FiBL, Frick © 2011 FiBL & IFOAM

Willer, Helga and Lukas Kilcher (Eds.) (2012), The World of Organic Agriculture, Statistics and Emerging Trends 2012. FiBL-IFOAM Report. IFOAM, Bonn and FiBL, Frick © 2012 FiBL & IFOAM

Willer, Helga, Julia Lernoud and Lukas Kilcher (Eds.) (2013), The World of Organic Agriculture, Statistics and Emerging Trends 2013. FiBL-IFOAM Report. IFOAM, Bonn and FiBL, Frick © 2013 FiBL & IFOAM

Willer, Helga and Julia Lernoud (Eds.) (2014), The World of Organic Agriculture, Statistics and Emerging Trends 2014. FiBL-IFOAM Report. IFOAM, Bonn and FiBL, Frick © 2014 FiBL & IFOAM

Willer, Helga and Julia Lernoud (Eds.) (2015), The World of Organic Agriculture, Statistics and Emerging Trends 2015. FiBL-IFOAM Report. IFOAM, Bonn and FiBL, Frick © 2015 FiBL & IFOAM

Willer, Helga and Julia Lernoud (Eds.) (2016), The World of Organic Agriculture, Statistics and Emerging Trends 2016. FiBL-IFOAM Report. IFOAM, Bonn and FiBL, Frick © 2016 FiBL & IFOAM

Willer, Helga and Julia Lernoud (Eds.) (2017) The World of Organic Agriculture, Statistics and Emerging Trends 2017. FiBL-IFOAM Report. IFOAM, Bonn and FiBL, Frick © 2017 FiBL & IFOAM

Willer, Helga and Julia Lernoud (Eds.) (2018), The World of Organic Agriculture, Statistics and Emerging Trends 2018. FiBL-IFOAM Report. IFOAM, Bonn and FiBL, Frick © 2018 FiBL & IFOAM

Willer, Helga and Julia Lernoud (Eds.) (2019), The World of Organic Agriculture, Statistics and Emerging Trends 2019. FiBL-IFOAM Report. IFOAM, Bonn and FiBL, Frick © 2019 FiBL & IFOAM

Willer, Helga, Bernahard Schlatter, Jan Travnicek, Laura Kemper and Julia Lernoud (Eds.) (2020), The World of Organic Agriculture, Statistics and Emerging Trends 2020. FiBL-IFOAM Report. IFOAM, Bonn and FiBL, Frick © 2020 FiBL & IFOAM

Raghuveer Singh, Jat, Ravisankar, Sudhir Kumar, Ram, Yadav (2019) Present Status and Future Prospects of Organic Farming in India. In book: Sustainable Agriculture, Chapter 12, pp.275-297; Scientific Publishers (India)

Saaty T.L (1988) What is the Analytic Hierarchy Process?. In: Mitra G., Greenberg H.J., Lootsma F.A., Rijkaert M.J., Zimmermann H.J. (eds) Mathematical Models for Decision Support. NATO ASI Series (Series F: Computer and Systems Sciences), vol 48. Springer, Berlin, Heidelberg.

Arpita Mukherjee, Souvik Dutta, Disha Mendiratta, Avantika Kapoor, Tanu M Goyal (2017) Promoting Organic Food Products and Exports - Status, Issues and Way Forward. Indian Council for Research on International Economic Relations. Working Paper, **342**, 1-44.

Balachandran V (2004) Future in the Past: A study on the status of organic farming in Kerala. Discussion Paper No. 82:1-111. www.researchgate.net/publication/237592753_Future_in_the_Past_A_study_on_the_status_of_organic_farming_in_Kerala.

Government of India, Lok Sabha (2020) Unstarred question no.306, Answered on the 4th February, 2020 under the title of Assistance for Agricultural Practices by Ministry of Agriculture and Farmers Welfare, Department of Agriculture, Cooperation and Farmers welfare. http://164.100.24.220/loksabhaquestions/annex/173/AU306.pdf

Narayanan S (2005) Organic Farming in India: Relevance, Problems and Constraints. National Bank for Agriculture and Rural Development. Occasional Paper – 38, Department of Economic Analysis and Research, NABRD, Mumbai.

Reddy A Amarender (2017) Report on Impact Study of Paramparagat Krishi Vikas Yojana, Submitted to Department of Agriculture Cooperation and Farmer's Welfare, Ministry of Agriculture and Farmer's Welfare, National Institute of Agricultural Extension Management (MANAGE), Hyderabad, pp.210

Prahalathan. S, Sumana Sarkar, Simaran Kaur (2015) Potential For Trade of Organic Products from India. Export-Import Bank of India (EXIM Bank). Occasional Paper No.174. www.eximbankindia.in/Assets/Dynamic/PDF/Publication-Resources/ResearchPapers/57file.pdf

Yussefi Minou (2006) The World of Organic Agriculture: Statistics and Emerging Trends 2006. mündlich Vortrag bei: BioFach Congress 2006, NürnbergMesse, Nuremburg, Germany, 16.-19.2.2006. Archived at 2997. https://orgprints.org/2997/2/yussefi_2006_world-of-organic.pdf

https://apeda.gov.in/apedawebsite/index.html; Last Accessed: 14 September, 2021

http://apeda.gov.in/apedawebsite/organic/Organic_Products.htm]; Last Accessed: 14/09/2021

http://apeda.gov.in/apedahindi/organic/Organic_Products.htm#:~:text=India%20exported%20135%20products%20last,growth%20over%20the%20previous%20year.); Last Accessed: 14 September, 2021

Agriculture & Processed Food Products Export Development Authority, Ministry of Commerce & Industry, Government of India.

http://apeda.gov.in/apedawebsite/organic/Organic_Products.htm#:~:text=As%20per%20the%20available%20statistics,for%20Organic%20Production%20(NPOP) Last Accessed: 14 September, 2021

http://apeda.gov.in/apedawebsite/organic/Organic_Products.htm#:~:text=India%20produced%20around%202.75%20million,%2C%20Vegetables%2C%20Processed%20foods%20etc

https://apeda.gov.in/apedawebsite/organic/data_2017-18.htm#Summary_Statistics Last Accessed: 14 September, 2021

https://www.alliedmarketresearch.com/press-release/organic-food-beverage-market.html

Last Accessed: 14 September, 2021

https://www.alliedmarketresearch.com/organic-food-beverage-market

Last Accessed: 14 September, 2021

https://ncof.dacnet.nic.in/; Last Accessed: 14 September, 2021

https://ncof.dacnet.nic.in/objectiveandimplementation/ObjectivesandImplementationcomponents.pdf] Last Accessed: 14 September, 2021

15 Years of Bt Cotton in India, Admission of failure official now, Article from Coalition for a Genetically Modified-Free India; Last Accessed: 14 September, 2021

http://indiagminfo.org/wp-content/uploads/2017/06/15-yrs-of-Bt-Cotton-in-India.pdf;

Priya Soni (2017) Ph.D. Thesis titled Organic Food Industry: Problems and Prospects. Department of Banking & Business Economics, Faculty of commerce, Mohanlal Sukhadia University, Udaipur, Rajasthan, India

Souvik Dutta, Arpita Mukherjee, Avantika Kapoor, (2017) Understanding the Opportunities and Risks in Organic Food Businesses Case Studies of Companies in India and the UK, Working Paper, No: 561. IIMB-WP N0. 561, Study sponsored by Amway India Enterprises Private Limited.