

Agricultural Development: Powered by GIS and Remote Sensing-A Contemporary Overview

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Abstract- Agriculture is an important and vital concern for all of us due to its real need among the human being. The field which is responsible for the agricultural systems better and scientific is Agricultural Science and additionally some of the related and allied fields viz. Agricultural Engineering, Agricultural Management, etc. There are different technologies enhancing traditional agricultural systems and among these important are Biotechnology, Information Technology, Nanotechnology, Genetic Engineering and so on. As far as Information Technology is concerned Geo Information Systems is an important name in advancing Agricultural Systems by its healthy and sophisticated features and functions. Though it is important to note that GIS in agriculture is not a new phenomenon but in recent past various new attributes been added into the. The agricultural sector is considered as mainstream for enhancing economy around the world and it is responsible also in socio-economic privileges and changes. The Technologies are important stakeholders in developing agriculture and vice versa agricultural growth. Geo Information Systems including Remote Sensing play a leading role in developing and modernizing Smart Agricultural Systems and healthy Agricultural Informatics practice. The present paper is on Agricultural Information Systems Designing and Development using GIS and Remote Sensing Based tools. The paper highlighted the basic and emerging applications in this regard.

Keywords- Agricultural Informatics, Geo Information Systems, Agricultural Systems, Smart Agriculture, Spatial Technologies, Geo Information Science,

I. INTRODUCTION

The Increasing applications of Information Technology led to the development of a new field and practicing area called Agricultural Informatics. However different subjects played important subjects in modernizing agricultural systems and among these Geo Information Systems, Remote Sensing, Global Positioning Systems, etc. play a vital role. Though these may be considered important areas within Agricultural Informatics but as per the knowledge field it is far better to consider within Geo Informatics strongly [1], [7].

GIS is important in agriculture and increasingly in the crop production and also helping in increasing the amount of production, minimizing costs, and also healthy land resource management effectively more. GIS application in agriculture is also helpful in monitoring of the quality and condition of the soil including irrigation systems. GIS enhances the agricultural mapping by timely and accurate information and technological support and control of agricultural resources. GIS agriculture technology helps in

acquiring and generating GIS agriculture data. There are different software available of GIS with respect to healthy Agricultural Informatics practice viz. ArcGIS, ERDAS Imagine/ER Mapper, MapInfo and AutoCAD Map, and ArcFM, etc [2], [14], [25].

- In Crop mapping and also yield estimation.
- In Crop assessment and enhancing Crop and plant health.
- In Soil analysis and Mapping including healthy soil development.
- In irrigation amendment analysis.
- In Erosion identification and proper management.
- Agricultural mapping and monitoring
- In the identification of damage control system and land degradation assessment studies

Sustainable agriculture is the need of the hour which deals with the agricultural practice with the environmental context and with the agenda of foods for all in increasing population context. GIS and RS also helpful in managing natural resources viz. soil, water, livestock, plant genetic, fisheries, forest, climate, rainfall, and topography, etc.

Here technology management including its infrastructure also important and valuable.

II. OBJECTIVE

The main objective of this paper entitled 'Agricultural Development: Powered by GIS and Remote Sensing-A Contemporary Overview' are as follows—

- To know about the basic about the Geo Information Systems including its fundamental attributes and features.
- To learn about the fundamental applications of the GIS and Remote Sensing in diverse areas in brief manner.
- To know about the applications and utilizations of the GIS and Remote Sensing in Agricultural Systems.
- To learn about the issues and emergence in making smart agriculture powered by the GIS and Remote Sensing tool.
- To learn about the agricultural mapping, smart farming, precision agriculture, smart technologically supported post agricultural system with GIS and RS support.

GIS, Geo Informatics: Basics

Geo Informatics falls under the Geo Sciences and combines with the IT and Geo Sciences. It is the applications of Information Technology in Geo and Earth related Sciences. Geo Informatics is helpful for environmental promotion and especially ecological management. There are various subjects close with the Geo Informatics viz.—

- Geo Information Sciences.
- Geo Spatial Science and Technology.
- Environmental Informatics.
- Geo Information Systems.
- Remote Sensing (RS).
- Geo Computing & Earth Observations, etc.

The field GIS becomes important in Geo Informatics and other allied fields (refer fig: 1). There are different applications of GIS and Geo Informatics in the environment and societal development, Education, Healthcare, Transportation, and Governance so on viz.—

- It is needed in healthy Information Systems and Spatial Science promotion.
- In Collection, analysis and development of spatial data, Geo Information System is important and required.
- In Public Administration and disaster Management also Geo Information System consider as valuable.
- Regarding the transformation of the data from hard copy to digital copy or vice versa here GIS and Remote Sensing considered as important.
- In mapping, analyzing, longitude, latitude including in atmosphere measurements also Geo Information System considers as valuable.
- In Environmental Mapping and Designing including Monitoring of the agriculture also Geo Information System easily effective.

- In designing of traffic control regarding healthy Urbanization, Rural Development, etc Geo Information System is important.
- In Measurement of the water and climate systems, Geo Information System practice may be considered as valuable.
- In Topographical modeling also GIS and Remote sensing considered as important tools and valuable.

Remote Sensing

Remote Sensing is considered as valuable in Geo Information Science/ Informatics dedicated in geo information of different types and needed in various fields like geography, survey land, Hydrology, Meteorology, Oceanography, etc. It is dedicated to delivering of information with the following—

- Spatial Resolution,
- Spectacle Resolution,
- Radio metric Resolution,
- Temporal Resolution, etc [3], [12], [26].

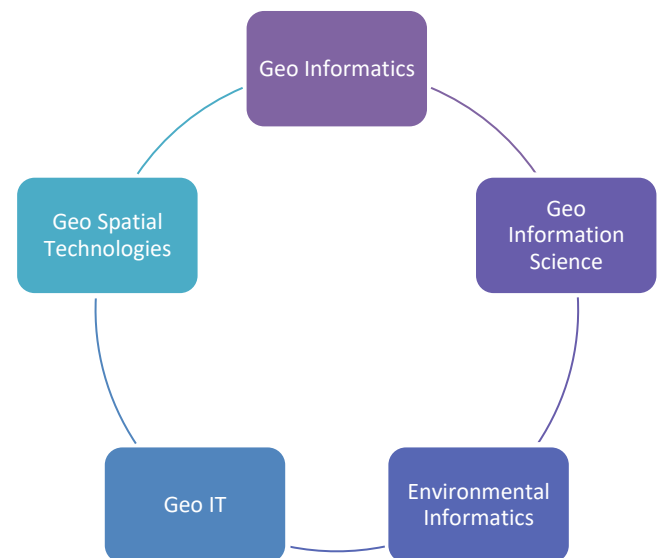


Fig: 1-Fields in which GIS and Remote Sensing are well connected

Basic Remote Sensing Applications

Remote Sensing is needed in spatial data management and takes the help of Geo Information System. And it is applicable in different areas such as—

- In Conventional Rader which is normally used for the aerial traffic control including in early warning and to get large scale meteorological data, Remote Sensing is effective.
- Here Remote Sensing helps in digital data and image collection and analysis for healthy spatial data management.
- Remote Sensing is applicable in crop type classification and identification including in crop monitoring, also in crop damage assessment.
- In soil management like Mapping of soil, with soil type, soil evaluation, etc. Remote Sensing Practice is important.

- In forest management also viz. different characteristics identification of the forest including the type of tree, height, density may be analyzed using Remote Sensing.
- Remote sensing is needed in weather management including in predicting weather situations.
- Remote Sensing is also helpful in Bio-Diversity Management effectively.

Agricultural Mapping

Technological systems and geospatial technology is required in development dynamic and healthy agricultural systems supported by the environment. The GIS can be important and helpful in controlled and managed agriculture for developing effective development of the crop, soil analyses and erosion identification; and towards a perfect, accurate and reliable crop estimates and development.

Agricultural development is concern with the productivity, and supply or marketing and here GIS can be an effective means. GIS in agriculture, further helps to the farmers in crop forecasting, enhanced agriculture production. The GIS and Remote Sensing is required in analyzing and visualizing agricultural workflows which could be helpful developing healthy farming industry. GIS analyze the soil data and helps farmers to achieve increased production with healthy management, including land resources. Further GIS and RS helps in marginalization of small and marginal farmers and Geomatics Technology can help in find out of the current and future agro related aspects viz. precipitation, temperature, crop output, etc [1], [13], [17]. Agricultural mapping is needed in healthy monitoring and management regarding the agricultural soil, irrigation, crops, etc. In agricultural and rural development geographic systems helps to the farmers to create more effective and efficient farming techniques and helps in more corrective actions, healthy and better utilization of fertilizers, pest control, protecting natural resources, enhancing the quality food production.

Smart Farming

Sensors and its applications are rising worldwide in different areas and agriculture is not the exemption of this. Uses of sensors in agriculture are applicable in wider areas viz. cultivating fields, on vehicles viz. tractors and so on. Further, using satellites and advanced technologies farmers and land managers can use and boosts productivity, responsible in reducing environmental impacts [4], [18], [24]. Moreover for smart farming various equipments and tools are being used such as—

- Internet of Things (IoT)
- Sensors and Actuators.
- Geo-Positioning Systems
- Big Data Analytics.
- Robotics and AI, etc.

The concept of agriculture is being changed using IT and Computing and led in precision agriculture. With this the farmers can take the help of geospatial technologies for

bringing and increasing agricultural production. Precision agriculture is integrated with the high technology for cost effective and user-friendly and productive crops. According a study by 2024 internationally the precision farming market size will reach \$10 billion. The agricultural sector is integrating new technologies not only productive but also more nutritious food.

Precision Farming

The GIS and Remote Sensing Technologies play an important role in Precision Farming and consider as important and essential tool in the agriculture industry; it is thus helps in cost saving, productivity enhancement, farmers and community development, healthy environment. Here use of the machine sensors also consider important to gather information about the crop sand application of fertilizer and its need. The Agricultural Machines may be connected with the satellite and will help in precision farming (refer Fig: 2) [12], [15]

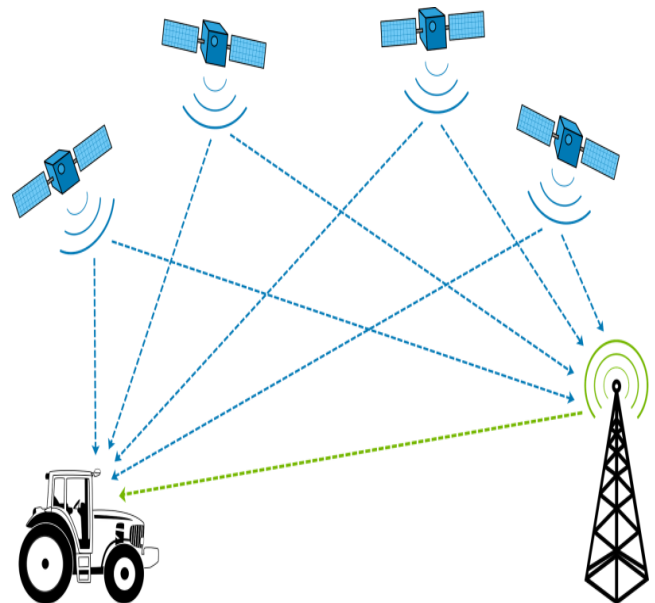


Fig: 2-Structure and style of Satellite and Sensors in Precision Farming

Variable rate technology; which is also called as VRT treated as an important component of precision agriculture and helps in collecting required data of farm machinery, control systems, and application at exact times or locations. VRT offers both economic and environmental advantages and agro benefits in seed, fertilizer, pesticides, etc.

The use of various harmful methods in agriculture deals with the negative environmental impacts i.e. certain uses of chemicals, pesticides etc. and VTR can also be addressed to solve the problem and to make farmer right amount of support. A precision agriculture operation always helps to collect/analyze data and further helps in plans [5], [14], [22].

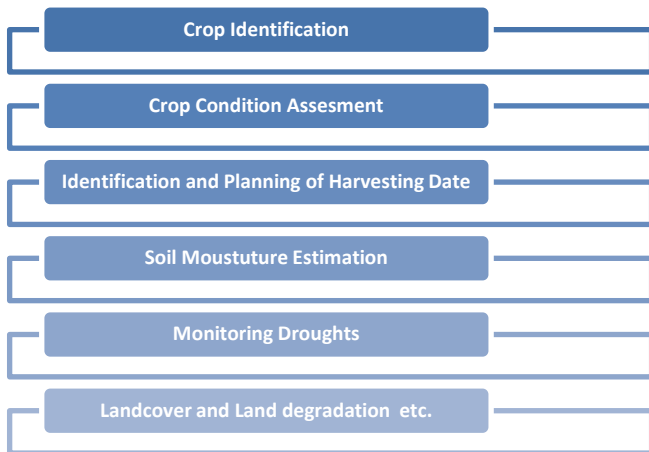


Fig: 3-Few areas of agriculture where GIS and RS are being used

Effective and Real-Time Farming

The satellites and drones have been grown rapidly in the past decade. As we are aware that farming deals with various kinds of challenges in the crops, fields, weather and water and so on and here GIS and satellite technology is helpful in real-time data collection of the Earth's surface. Satellite and Drones are useful in the following viz. –

- In monitoring of the condition of the land and its uses.
- Regarding the Soil Moisture Ocean Salinity.
- In identification of the Vegetation growth using Lands at imagery.
- In preparing of the Normalized Difference Vegetation Index (NDVI),
- To estimate crop productivity and further.
- To monitoring drought and also on flooding etc [8], [13].

Drone technology is dedicated to collecting local agro field data including plant height, weed presence, and to calculate the volume calculations Therefore with this the farmers are able in field analysis, inspecting the health of the crops, etc and this can be recorded. It leads to making real-time actionable decisions. Also, in Monitoring yields, use of the precision water sensors, regarding the health and productivity of their land this is important and useful. The National Agricultural Statistics Services (NASS), in US has developed an online mapping on agro systems and known as Crop Scape. It helps in knowing estimates of crops, type of crops, food security, pesticide control and changes to land use, and so on [11], [16],[19].

Food Security and Management

Worldwide the population is growing and to secure the necessary food supply modern methods of the agriculture are highly needed in the context of continuous rise in population; it is expected that the current production of crops will be double by 2050 and in this context GIS and allied technologies may be used in real-time analyses, in Lands at satellite imagery and these can ultimately helpful in predicting the amount of arable land required and also the real supply chain of the food.

Impact of GIS in Agricultural Informatics

As far as agriculture is concerned it deals with several issues and challenges viz. Droughts, floods, swarms of insects, and so on and these are the core concern in the agricultural community. However, there are significant improvements noticeable internationally to gain crop production worldwide and in this regard GIS and Remote Sensing Technologies are doing well [10], [21], [26].

Geographic Information Systems is useful in mapping and planning of agricultural systems in pre production and post production including future fluctuations management and more. The geographic scientists and allied technologies are helpful for agricultural scientists and farmers to make more effective and efficient food production. GIS is changing the agriculture and food systems and traditional/historical farming practices towards healthy crops to plant, soil nutrition, and enhanced plants. Apart from individual farmers, various organizations and institutions are doing well in GIS and Remote Sensing Technologies applications viz. USDA; they are using GIS to transform and combine large amounts of data into a data set for protecting crops, solve crop issues, crop damage, and so on. Due to the significance of the GIS it is called as Agricultural Geographic Information Systems (AGIS) which is fruitful in topographical mapping, crop health, etc. In solving of wider economic issues and changing rural farming practices GIS and Remote Sensing Technologies can be considered as important and valuable. With Crop Scape program the farmers can get the data which helps and allows farmers to interact with the data without having a GIS. Therefore, GIS and RS consider as important in Agricultural Informatics apart from the traditional information technology components viz.

- Software Technology
- Database Technology
- Network Technology
- Web Technology
- Multimedia Technology, etc.

Suggestion and Trends

One of the important aspects of GIS, the proper awareness need to create on its benefits due to its various benefits viz. food scarcity, food security and so on. Here Web mapping tools can also be used for.

The agricultural industries are rapidly using GIS and Remote Sensing and other allied geospatial technologies. The accessibility of GIS including digital mapping both has changed their land management and agricultural systems.

The visualization, analysis of geographic data is collecting on a regular basis and communicated easily using GIS and Remote Sensing Technologies. The field GIS and Remote Sensing Technologies is useful in other allied areas and fields viz.—

- Geography,
- Survey land,

- Hydrology,
- Meteorology,
- Oceanography and so on.

Furthermore, other allied technologies can be used for a better result in Geo Informatics such as Big Data Technologies, Cloud Computing, Virtualization Systems, Human Computer Systems, and so on [7], [15], [20].

III. CONCLUSION

The growth in agriculture today purely depends on new technologies which help in bringing out of cost-effective, smarter, healthy, effective agricultural systems. Today various technologies are involved with the agriculture viz. genetic improvement by the Genetic Engineering for better seeds and yields. However, for data improvements, GIS could be useful and partially helpful in better research and results including in sustainable planning. The increasing amount of Information and Computing Technologies already empowering agriculture and allied sectors and GIS and RS is not an exception to this. Further latest GIS systems are making agriculture smarter and more intelligent. However, it is very much important that allied departments viz. agriculture, horticulture, ecology and environment, social development, etc. should take proper steps in modernizing and proper advancement of the GIS and allied technologies in agricultural systems.

REFERENCES

- [1] Abbasi, A. Z., Islam, N., & Shaikh, Z. A. (2014). A review of wireless sensors and networks' applications in agriculture. *Computer Standards & Interfaces*, 36(2), 263-270.
- [2] Adão, T., Hruška, J., Pádua, L., Bessa, J., Peres, E., Morais, R., & Sousa, J. J. (2017). Hyperspectral imaging: A review on UAV-based sensors, data processing and applications for agriculture and forestry. *Remote Sensing*, 9(11), 1110.
- [3] Al-Adamat (et.al) (2012). The combination of indigenous knowledge and geo-informatics for water harvesting siting in the Jordanian Badia. *Journal of Geographic Information System*, 4(4), 366-376.
- [4] Altbach, P. G. (1993). The dilemma of change in Indian higher education. *Higher Education*, 26(1), 3-20.
- [5] Dayal, I. (2002). Developing management education in India. *Journal of management Research*, 2(2), 98-106.
- [6] Dong, B., Andrews, B., Lam, K. P., Höyneck, M., Zhang, R., Chiou, Y. S., & Benitez, D. (2010). An information technology enabled sustainability test-bed (ITEST) for occupancy detection through an environmental sensing network. *Energy and Buildings*, 42(7), 1038-1046.
- [7] DU, P. J., LI, J., ZHANG, H. R., & CHEN, Y. H. (2007). Discussion on Specialty Education of GIS based on UCGIS Geographic Information Science and Technology Body of Knowledge. *Geomatics World*, 4.
- [8] Ehlers, M. (2008). Geoinformatics and digital earth initiatives: a German perspective. *International journal of digital earth*, 1(1), 17-30.
- [9] Kingra, P. K., Majumder, D., & Singh, S. P. (2016). Application of remote sensing and GIS in agriculture and natural resource management under changing climatic conditions. *Agric Res J*, 53(3), 295-302.
- [10] La Rosa, D., Barbarossa, L., Privitera, R., & Martinico, F. (2014). Agriculture and the city: A method for sustainable planning of new forms of agriculture in urban contexts. *Land use policy*, 41, 290-303.
- [11] Li, M., & Ye, L. R. (1999). Information technology and firm performance: Linking with environmental, strategic and managerial contexts. *Information & Management*, 35(1), 43-51.
- [12] Li, T. S., & Li, B. (2007). Research on Data Model and Query Optimization of Electronic Map in Embedded GIS. *Aeronautical Computing Technique*, (2), 26-35.
- [13] Moqi, J. H. L. (2010). Application of Geographic Information System in Digital Mining Information System [J]. *Standardization of Surveying and Mapping*, 3.
- [14] Paul, P. K. (2013). MSc-Information Science [Geo Informatics]: Overview emphasizing twoproposed curriculum for sophisticated Geo Spatial development. *International Journal of Pharmaceutical and Biological Research (IJPBR)*, 4(5), 218-227.
- [15] Paul, P. K. and Aithal, P. S. (2020). Environment and Studies related to Environmental Sciences: The Overview of Allied Areas. *Educational Quest: An Int. J. of Education and Applied Social Science*, 11(1), 01-05.
- [16] Paul, P.K., A. Bhuimali, Aithal, P. S.,Tiwary, K. S., Ripu Ranjan Sinha (2020). Environmental Informatics: Educational Opportunities at Bachelors level—International Context and Indian Potentialities. *International Journal of Applied Engineering and Management Letters (IJAEML)*, 4(1), 243-256.
- [17] Paul, P.K., Aithal, P.S., Bhuimali, A. (2020). Environmental Informatics and Educational Opportunities in Post Graduate level—Indian Potentialities based on International Scenario. *IRA-International Journal of Management & Social Sciences*, 16(2), 45-58.
- [18] Sandler, S. I. (1996). Infinite dilution activity coefficients in chemical, environmental and biochemical engineering. *Fluid Phase Equilibria*, 116(1-2), 343-353.
- [19] Singh, A. (2016). Managing the water resources problems of irrigated agriculture through geospatial techniques: An overview. *Agricultural Water Management*, 174, 2-10.
- [20] Suprem, A., Mahalik, N., & Kim, K. (2013). A review on application of technology systems, standards and interfaces for agriculture and food sector. *Computer Standards & Interfaces*, 35(4), 355-364.
- [21] Tochtermann, K., & Maurer, H. A. (2000). Knowledge management and environmental informatics. *Journal of Universal Computer Science*, 6(5), 517-536.
- [22] Thompson, S., Treweek, J. R., &Thurling, D. (1997). The ecological component of environmental impact assessment: a critical review of British environmental statements. *Journal of environmental Planning and Management*, 40(2), 157-172.
- [23] Yakhou, M., &Dorweiler, V. P. (2004). Environmental accounting: an essential component of business strategy. *Business Strategy and the Environment*, 13(2), 65-77.
- [24] You-yi, J. I. A. N. G. (2012). Teaching of GIS Course for Surveying and Mapping Engineering Specialty in Universities. *Technology and Innovation Management*, (5), 28-37.
- [25] WANG, J. X., & GUO, H. L. (2010). The Characteristics and Teaching Methods of High-tech Disciplines of GPS, GIS and RS—Taking the GIS majors of Zhengzhou University as an example [J]. *Geomatics World*, 6.
- [26] WU, Q., & LI, X. Y. (2015). Remote sensing dynamic monitoring of mining geo-environment based on computational geometry and information TUPU. *Journal of China Coal Society*, (1), 26-34.