

# A Systematic Study of Application of Spatial Decision Support System in Agriculture

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**ABSTRACT** - Agriculture is a foundation in Indian Economy. Sustainable Agriculture production and processing systems have become more complex with involvement of biological, chemical, physical processes such as soil, water, climatic scenarios and crop management practices respectively. It is a great challenge to extract knowledge from these data. Information technology based expert systems are playing important role for sustainable agriculture development. The effectiveness of decision making in agriculture domain can be improved by integrating Geographical Information System (GIS) and advanced in information technology techniques. This paper reviews and summarizes the application of spatial decision system and spatial data mining techniques and algorithms in agriculture.

**Keywords:** Agriculture, Decision Support System, GIS, Spatial Decision Support System, Spatial Data Mining

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## 1.0 Introduction:

Agriculture has undergone several fundamental changes during the past century. Soil, water, labour resources, climatic scenarios and crop management practices are important components of sustainable agriculture [1]. With the involvement of such biological, chemical and physical processes the agriculture production and processing systems have become more complex [2]. Thus for sustainable agriculture management modern frontier technologies such as space technology, geographical information system and the information technology based decision support is very much essential. Decision Support System (DSS) offers a framework within which complex systems can be represented in a structured way, allowing them to be more easily understood and helping to draw out additional information and new insights [3]. It is an interactive computer based system that helps decision makers to utilize data and models to solve unstructured problems [1]. The applicable use of successful decision support can assist in the sustainability of agricultural resources.

## 2.0 Need for Geographical Information System (GIS) in DSS:

A spatial technology called as "Geoinformatics", comprising of remote sensing, Geographical Information System (GIS) and Global Positioning System (GPS) is rapidly becoming important in management of natural resources and monitoring environmental degradation. GIS and GPS facilitate interpretation, analysis, presentation and planning related to sustainable agriculture [4]. GIS forms the basis of DSS that is

powered by latest image and map information and transforms reaming tables into graphic maps, which is known as Spatial Decision Support System (SDSS) [5]. SDSS deals with spatial dimension through digitized Geo-referenced spatial databases. It is a framework that is integration of analytical and spatial modelling capabilities, spatial and non spatial data management, domain knowledge, spatial display capabilities and reporting capabilities [6] [7]. It can organize the spatial and non spatial data such as permanent agricultural resources of agriculture by applying various models, algorithms which in turn is very useful for agricultural planning, forecasts, early warnings, decision making and policy making [1]. (Fig. 1) shows various activities involved in sustainable agriculture. For effective and sustainable agriculture management application of SDSS at each of these activities is very much essential [8]. This paper has studied application SDSS in various activities of agriculture management.

## 3.0 Application SDSS in Agriculture:

### 3.1 SDSS in Precision Agriculture

One of the important activities in agriculture is precision farming. It is considered to be a suite of technologies consisting of crop, weather, pest complexes and marketing arrangements rather than a single technology [1]. The first simulation based DSS comprising of soil module, weather module and crop module called as Decision Support System for Agro-technological Transfer (DSSAT) was developed for different regions and crops to decide the type of seed to grow, when and how much to irrigate, rate of application of fertilizer and crop yield prediction [9]. The spatial simulation based SDSS called as "Apollo DSS" was designed as a part of DSSAT for precision agriculture management in Central Iowa, United States to improve corn grain yield [10]. The web based SDSS called as "RiceCheck" was developed for Paddy Precision farming in Tanjung Karang, Malaysia. It allowed information sharing among farmers especially on rice production, such as

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recommendations of fertilizer, and to provide equal access to web-based information from end-users to policy makers for improving the productivity and efficiency of rice production through precision farming [11]. The SDSS was also developed for cotton crop precision farming on the eastern side of Livingston Field on the Kenneth Hood Farm in Bolivar County, MS, USA using soil type, soil fertility index, weather, nitrogen and site specific water application data. The results of successive simulation models tested showed that there is potential increase in the yield with optimum nitrogen and water rates [12].

### 3.2 Crop Productivity Improvement

The world's largest project on SDSS named as "SDSS to manage and analyse citrus production information management" was conducted at "Three Gorges area", of south-western part of China, which is one of the optimum citrus productions in world. The project used spatial and non-spatial data to increase agriculture production and improve crop management decisions [13]. Soil fertility is an important parameter in crop productivity improvement. The SDSS named as "SIGAA" (Advanced Agricultural Geographical Information System) was developed in Romania, which helped to consider the interactions between different environmental factors to decide the crop suitability and increase in crop yield [14]. The biophysical parameters are one of the important parameters for the crop yield in agriculture. The SDSS named as "AGROLAND" was developed in Germany to evaluate the biophysical agricultural land resources. It helped decision makers to evaluate the current and future agricultural land resources based on marginality index (MI) [15]. Crop simulation and web-GIS based framework is proposed by Chinese Academy of Agricultural Science and National , 863-306 project of China, which simulates daily growth of crop under water and nitrogen stress under different environmental conditions to improve crop production management [16]. The SDSS named as "Sugarcane Information and Management System", was developed in Thailand for decision making and planning to improve sugarcane production based on the parameters such as planting date, crop type, water resource, fertilizer application rate [17].

### 3.3 Suitable Area Identification to Crop Cultivation

Identification of suitable areas is very important in agriculture to increase the crop productivity. The multi-Criteria Evaluation (MCE) based SDSS was developed in china to identify the suitable areas for the cultivation of common oat and naked oat based on climatic and topographic attributes. The web based support for soil and area suitability improved oat crop production for that area [18]. The MCE based SDSS is also applied in semiarid and arid regions of mainland of China, Hong Kong to identify the suitable level and area for maize production in whole plastic-film mulching on double ridges [19]. The web based SDSS is developed for farm level decision making for regular and irregular fields in Guangzhou, China, which helped farmers to select appropriate fertilizer type as well as the amount of the fertilizer that should be applied as per the crop requirement

[20].

3.4 Water Resource Planning SDSS has also played very important role in water resource management. WebGIS based SDSS is developed in northwest of China provides support for water resource dispatch by monitoring plants, crops in Shule River Basin. The Service DSS part of it analyzes, the zone acquired amount of water staged and condition of water facilities to decide the direction of infrastructure construction and to decide the crop cultivation even if the soil fertility index is favorable [21]. GIS based generalized framework is developed in assessment of groundwater resources in Godavari Delta Central Canal Irrigation Project in Andhra Pradesh (AP), India. The integrated model of rainfall, soil, water use, canal flow model, soil water balance model and groundwater flow model is used as a effective decision support system for deciding the cropping pattern as per the groundwater availability to increase the crop production [22].

### 3.5 Weed Control and Pest Management

To optimize the crop production "Agriculture Pest Management" is an important area of concern. The first pest management SDSS named as "Hemlock Looper DSS" was implemented in Newfoundland, Canada for the management of eastern hemlock looper pest [23]. SDSS named as "MedCla" was also developed for eastern part of Israel to control Medfly in citrus. The decision tree based SDSS helped to decide management of spraying action particular farm maintaining environmental balance [24].

## 4.0 Conclusion:

It is observed that, GIS based techniques are widely applied in different areas of agriculture such as to increase crop yield, crop water requirements, precision farming, site suitability and to study the impact of climatic parameters. SDSS are widely applied in the countries like China and United States of America. In India majority of the rural population lives in rain-fed regions, therefore challenge before Indian agriculture is to transform rain-fed farming into more sustainable and productive systems to better support the population dependent on it. The literature also shows that there is a need to develop a GIS based decision support systems in India. The expert systems based on spatial database on agriculture will improve the performance on agriculture management which in turn will be helpful for sustainable agriculture management in India.

## References

- [1] M. Narayana Reddy and N.H.Rao "GIS Based Decision Support Systems in Agriculture," National Academy of Agricultural Research Management Rajendranagar, 1995, pp. 1-11.
- [2] P. Heinemann, "Decision Support Systems for Food and Agriculture", Systems Analysis and Modeling in Food and Agriculture, Encyclopedia of Life Support Systems (EOLSS)

- [3] J.D Cain, K Jinapala, I.W Makin, P.G Somaratna, B.R Ariyaratna, L.R Perera, "Participatory decision support for agricultural management. A case study from Sri Lanka", *Agricultural Systems*, Volume 76, Issue 2, May 2003, Pages 457-482
- [4] N. Patel "Geo-Information for Sustainable Development of Agriculture-Some Examples of North India", Chapter 12, *Geo-informatics for Natural Resource Management*, Nova Science 2009.
- [5] Anonymous (2011) "Establishment of National GIS" Under Indian National GIS Organization (Ingo), Government of India Planning Commission National GIS Interim Core Group
- [6] P.J. Densham 1991. "Spatial decision support systems", Ch 26 in Maguire al. (eds) *Geographical Information Systems: Principles and applications*. Harlow, UK: Longman
- [7] S. Yan, C. Xiao, and Y. Qiao, "Spatial Decision Support System and its General Platform 1," *Science And Technology*, 1999, pp. 1-6.
- [8] V.Kumbhar,T.Singh , " A comprehensive study of application of decision support system in agriculture in Indian context",*International Journal of Computer Applications* ,Volume 64,No.14,February 2013,Pages 6-11
- [9] J.W. Jones, G.Hoogenboom, C.H Porter, K.J.Boote, W.D.Batchelor, L.A.Hunt, P.W Wilkens, U Singh, A.J.Gijsman,J.T Ritchie(2003)."The DSSAT cropping system model". *European Journal of Agronomy*, Volume 18, Issues 3-4, January 2003, Pages 235-265.
- [10] K.R.Thorp, K.C. DeJonge, A.L. Kaleita, W. D. Batchelor, J. O. Paz. "Methodology for the use of DSSAT models for precision agriculture decision support". *Computers and Electronics in Agriculture*, Volume 64, Issue 2, December 2008, Pages 276-285.
- [11] S. Nik Norasma Che'Ya, Abdul Rashid Mohamed Shariff, Mohd Amin Mohd Soom and F.A.A.A. and E. Khairunniza Bejo, Ahmad Rodzi Mahmud, Jahansiri, "Generating Online GIS Decision Support System For Paddy Precision Farming," In proceedings of GSD11 World Conference Spatial Data Infrastructure Convergence-Building SDI Bridges to address Global Challenges,2011
- [12] J.M. McKinion, J.N. Jenkins, D. Akins, S.B. Turner, J.L. Willers, E. Jallas, F.D. Whisler (2001)." Analysis of a precision agriculture approach to cotton production". *Computers and Electronics in Agriculture*, Volume 32, Issue 3, October 2001, Pages 213-228
- [13] W. Wu, H.bin Liu(2009), "A spatial decision support system for citrus management - A case study of the Three Gorges area of China," *Structure*, 2009, pp. 601-603.
- [14] C.Pirna, S. Lache (2011), "Integration of Soil Specific Parameters in Designing Decision Support System in Precision Agriculture" , In proceedings of 10th International Scientific Conference "Engineering for Rural Development", Latvia
- [15] R. Laudien, M. Pofagi, J. Roehrig (2010). "Development and implementation of an interactive Spatial Decision Support System for decision makers in Benin to evaluate agricultural land resources— Case study: AGROLAND". *International Journal of Applied Earth Observation and Geoinformation*, Volume 12, Supplement 1, February 2010, Pages S38-S44
- [16] J. Zhang, J.Li, Y.Zhu , "Integrating crop simulation models with WebGIS for remote crop production management," *Geoscience and Remote Sensing Symposium*, 2004. IGARSS '04. Proceedings. 2004 IEEE International , Vol. 4, no., pp. 2598- 2600 Vol. 4, 20-24 Sept. 2004
- [17] P. Weerathaworn, R. Saravanan ,M. Prabpan, "Sugarcane Information and Management System for Mitr Phol Sugar Group, Thailand" *"Sugar Tech (8)(1) 2006*
- [18] F.Wan, Wang, Z., Li, F., Cao, H. and Sun, "GIS-based crop support system for common oat and naked oat in china" G., (2009).*IFIP International Federation for Information Processing*, Volume 293, *Computer and Computing Technologies in Agriculture II*, Volume 1, eds. D. Li, Z. Chunjiang, (Boston: Springer), pp. 209-221.
- [19] C. Jia, W. Zhao, Y. Chen, and G. Sun, "Delineation of Suitable Areas for Maize in China and Evaluation of Application for the Technique of Whole Plastic-Film Mulching on Double Ridges," *IFIP International Federation For Information Processing*, 2011, pp. 390-400.
- [20] Z. Sha and F. Bian(1993). "An Integrated GIS and Knowledge-Based Decision Support System in Assisting Farm-Level Agronomic Decision-Making," *Knowledge Acquisition*, 1993.
- [21] H. Zhang, S. Yi, Y.Wu(2012)."Decision Support System and Monitoring of Eco-Agriculture Based on WebGIS in Shule Basin". *Energy Procedia*, Volume 14, 2012, Pages 382-386.
- [22] V.M Chowdary, N.H Rao, P.B.S Sarma (2003). "GIS-based decision support system for groundwater assessment in large irrigation project areas". *Agricultural Water Management*, Volume 62, Issue 3, 30 October 2003, Pages 229-252
- [23] J.M. Power, H. Saaremaa."Object-oriented modeling and GIS integration in a decision support system for the management of eastern hemlock looper in Newfoundland"(1995).*Computers and Electronics in Agriculture*, Volume 12, Issue 1, January 1995, Pages 1-18
- [24] Y. Cohen, A. Cohen, A. Hetzroni, V. Alchanatis, D. Broday, Y.Gazit, D. Timar (2008). "Spatial decision support system for Medfly control in citrus".



Fig. 1 Activities involved in Agriculture Management

Table 1 Summary of Application SDSS in Agriculture

Sr.No	Activity of Agriculture Management	Implemented Country Name
1.	Precision Agriculture	United States, Malaysia
2.	Crop Productivity Improvement	China, Romania, Germany, Thailand
3.	Suitable area identification for crop cultivation	China
4.	Water Resource Management	India, China
5.	Weed Control and Pest Management	Canada, Israel



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