Full Length Research Article

© 2025, Centre for Advanced Research in Agricultural Sciences
Research Journal of Agricultural Sciences
Volume 16; Issue 01 (Jan–Feb 2025); pp 10–15

ISSN: 0976-1675 (P)
ISSN: 2249-4538 (E)

Rooted in Data: Transforming Urban Agriculture through Decision Support Systems

J. R. Shalini*[1], G. S. Sreedaya[2] and K. S. Amritha[3]

[1, 3] Department of Agricultural Extension and Education, College of Agriculture, Vellayani - 695 522, Thiruvananthapuram, Kerala, India

[2] Training Service Scheme, Vellayani & ADE(SZ), Kerala Agricultural University, College of Agriculture, Vellayani - 695 522, Thiruvananthapuram, Kerala, India

Received: 30 Nov 2024; Revised accepted: 02 Jan 2025

Abstract

Urban agriculture is emerging as an inevitable solution to address food security, sustainability, and community resilience in rapidly growing cities. However, the potential of community-based urban farming is often limited by challenges such as resource management, decision-making inefficiencies, and a lack of coordinated support systems. This article explores the transformative impact of data-driven decision support systems (DSS) on urban agriculture networks. These technologies enable local farmers to make well-informed decisions about crop selection, resource allocation, pest management, and yield optimization by combining sophisticated data analytics, real-time monitoring, and predictive modelling. We look at how data-driven strategies improve sustainability practices, increase operational efficiency, and promote cooperation in urban farming communities. We also show examples of how DSS has effectively facilitated resource sharing, community involvement, and scalability in urban agriculture projects. The paper concludes by showing how technology may fully realize the potential of urban agriculture, opening the door to more resilient, sustainable, and food-secure urban areas.

***Key words*:** Food security, DSS, Sustainability, Community involvement, Resilient

Urban agriculture has become a significant approach for improving food security, promoting sustainable practices, and strengthening community resilience in urban areas. This strategy not only meets the growing demand for fresh produce in cities but also transforms neglected spaces into vibrant green areas, helping to improve the urban landscape. A key factor in the success of urban agriculture is the creation of strong, interconnected networks that bring together stakeholders such as local farmers, community groups, and policymakers. These networks enable the exchange of resources, knowledge, and best practices, fostering collaboration that drives urban agricultural projects forward.

To effectively address the challenges of urban farming, incorporating decision support systems (DSS) into urban farming practices are essential. These systems combine data, models, and analytical tools to help stakeholders make informed decisions that improve productivity and sustainability. Enhanced by data-driven methods, DSS become even more powerful, allowing communities to leverage a wide range of information—from climate patterns to market trends—tailored to their specific needs and circumstances.

The role of data-driven decision support systems in empowering urban agriculture is highly notable. By providing valuable insights and aiding in strategic planning, DSS help urban farmers optimize their practices, reduce waste, and adapt to changing conditions. Moreover, DSS facilitate greater collaboration across agricultural networks, enabling a collective response to challenges such as food insecurity and environmental degradation. Ultimately, the integration of data-driven decision-making allows urban agriculture networks to flourish, fostering more resilient, sustainable, and healthy urban environments.

Urban agriculture

Urban and peri-urban agriculture (UPA) refers to agricultural practices that generate food and other products in urban neighborhoods and the surrounding areas through farming and associated processes including processing, distribution, marketing, and recycling [1]. It involves a variety of stakeholders, including local communities, institutions, policies, and systems, and operates within the urban ecology and economy. UPA relies heavily on local resources to address the evolving needs of city populations while fulfilling multiple objectives and functions. As such, UPA is a key strategy for enhancing the resilience of a city's food supply system. UPA can contribute to the development of more sustainable food systems by integrating food processing, distribution, and marketing into urban environments. This holistic approach can help reduce food waste, support local economies, and increase access to fresh, nutritious food for urban residents.

Importance of urban agriculture

***Correspondence to:** J. R. Shalini, E-mail: jarashasha@gmail.com; Tel: +91 9751594203

Citation: Shalini JR, Sreedaya GS, Amritha KS. 2025. Rooted in data: Transforming urban agriculture through decision support systems. *Res. Jr. Agril. Sci.* 16(1): 10-15.

In India's cities, urban farming is essential to maintain food security. Reducing the need for long-distance transportation and bringing agriculture closer to customers lowers carbon emissions and promotes environmental sustainability. A better lifestyle and a sense of community are also promoted by urban gardening, which gives people a chance to get back in touch with nature. Additionally, by boosting local economies and generating job opportunities, urban agriculture has a positive economic impact.

Urban agriculture network

A network of people, groups, and projects working together to grow, produce, and distribute food in urban settings is known as an urban agricultural network. Community gardens, rooftop farms, vertical gardens, and other urban agriculture initiatives are commonly included in this network. It seeks to improve community involvement, encourage sustainable practices, increase food security, and offer educational opportunities about environmental stewardship and food production. These networks facilitate the growth of resilient food systems in urban areas by bringing together different stakeholders, including citizens, nearby companies, nonprofit organizations, and governmental bodies.

Community based urban agriculture

While community members are responsible for their individual plots, they also share responsibility for security, fencing, paths, and other items, as well as the supply of water and power [2]. Community-based urban agriculture has also been described as having shared access to water resources and common land tenure [3]. Last but not least, Smit and Bailkey [4] contend that social connection is the primary benefit of community-based urban agriculture, which in turn empowers local resources. They also believe that the most important component is community cooperation. Community gardens are typically started by outside organizations rather than by local residents. Schools, churches, prisons, and community centers are frequently located next to community gardens. Informally organized groups of people can engage in community-based urban agriculture.

Need for community based urban agriculture

Community-based urban agriculture addresses several critical needs in urban environments [5-6] including:

Food security: It helps increase access to fresh, nutritious food, particularly in food deserts where availability is limited.

Health and nutrition: By promoting local food production, it encourages healthier eating habits and reduces reliance on processed foods.

Community engagement: It fosters social connections, strengthens community bonds, and encourages collaboration among residents.

Sustainability: Community-based urban agriculture promotes environmentally friendly practices, such as composting and biodiversity, which contribute to healthier urban ecosystems.

Economic opportunities: It can create jobs, support local economies, and provide opportunities for entrepreneurship in urban areas.

Education and skills development: These initiatives offer educational programs that teach gardening, nutrition, and sustainability, empowering residents with valuable skills.

Resilience: By diversifying food sources and fostering local food systems, urban agriculture enhances community resilience to economic or environmental shocks.

Green space creation: It transforms underutilized land into green spaces, improving urban aesthetics and providing recreational areas for residents.

Present status of urban agriculture

The study conducted by [7] shows that there are several reasons that contribute to the decline in urban agriculture over the years which insist that there is a need for intervention in the existing urban system that would lead to improvement meeting the demands of growing population in the near future. The intervention that supports the growth of urban agriculture would be the integration of DSS into the urban agriculture system.

Decision support system

By offering pertinent data, analysis, and suggestions, a decision support system is an interactive, computer-based tool that helps users make better decisions [8]. By delivering timely, accurate, and actionable information, a DSS aims to increase the efficacy and quality of decisions. A DSS combines data from several sources, such as sensors, weather stations, and market data, with human input and sophisticated algorithms to generate insights that aid in decision-making [9].

Applications for DSSs are numerous and include business, agriculture, water resources, the environment, organizational management, and health [10]. In these domains, they are used to improve organizational control, encourage education and training, foster interpersonal communication, expedite the resolution of issues, and boost individual productivity. Agronomists, soil scientists, agricultural engineers, entomologists, weather specialists, farmers, students, and extension agents, for example, can all use DSS in the agricultural area. Their main focus can be on a variety of habitats or agricultural goods, including upland or lowland areas, rainfed or irrigated environments, rice or wheat, fruits or grains, watersheds or field levels, temperate or tropical climates, and more [11]. A typical decision support application might gather and present the following kinds of information: weekly weather forecasts; the yield of a particular crop prior to harvest; the impact of different decision options; the optimal fertilizer dosage for a particular crop to maximize yield; the prediction of pathogen infestation based on fictitious climatic conditions; the application of fertilizer, water, and temperature; and so forth.

Components of decision support system

Decision support systems vary greatly in application and complexity, but they all share specific features [12]. A typical Decision support systems has four components:

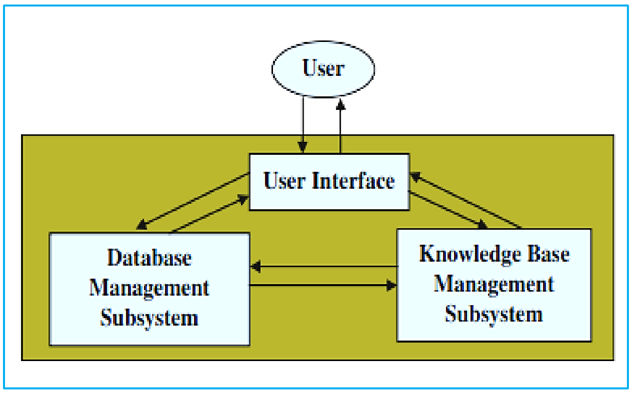
- Data management,
- Model management,
- Knowledge management and
- User interface management.

Data management component

Data management component consists of wide range of data from various sources that are embedded within software.

Model management component

Model management includes the development and maintenance of mathematical and statistical models that simulate various scenarios. These models help in analyzing data and forecasting outcomes based on different decision paths.



Components of DSS

Knowledge management

This component focuses on capturing, organizing, and disseminating knowledge within an organization. It includes expertise from stakeholders, best practices, and lessons learned from past decisions.

User interface management

The user interface (UI) management component ensures that users can interact effectively with the DSS. This includes the design of user-friendly interfaces that allow users to input data, manipulate models, and visualize results easily.

Types of decision support systems

The decision support system have been classified based on the data they utilize and mode where they are applied [13] as:

Communication-driven: Makes it possible for businesses to support jobs that call for multiple workers. It comes with integrated technologies like Google Docs and Microsoft SharePoint Workspace.

Model-driven: Makes financial, organizational, and statistical models accessible and manageable. Information supplied by users is used to gather data and establish parameters. To analyze circumstances, the data is incorporated into a decision-making model.

Knowledge-driven: Provides precise and specialized solutions to situations using stored facts, procedures, rules, or interactive decision-making structures like flowcharts.

Document-driven: Manages unstructured information in different electronic formats.

Data-driven: Helps companies to store and analyze internal and external data.

Data- driven DSS

A computer program that bases decisions on information from internal or external databases is known as a data-driven DSS [14]. In order to identify trends and patterns and make predictions about the future, a data-driven DSS usually use data mining techniques. In the public sector, DSSes are also utilized to assist in decision-making, including forecasting the probability of future criminal activity. Internal and external databases have different but complementary functions in the context of data-driven decision support systems (DSS) in agriculture.

Internal databases

Internal databases consist of data generated and maintained within the organization or agricultural operation.

- Historical yield data
- Soil quality metrics
- Pest and disease records
- Crop rotation histories
- Weather patterns specific to the farm

Usage

- Supports operational decisions (e.g., planting schedules, resource allocation).
- Enables tracking of past performance to inform future practices.
- Facilitates real-time monitoring and analysis of farm activities.

External database

External databases contain data sourced from outside the organization and can provide broader context or comparative benchmarks.

- Market trends and prices for crops
- Regional and national agricultural statistics
- Research data from agricultural studies
- Environmental data (e.g., climate change impacts)
- Government regulations and subsidy information

Usage

- Assists in strategic planning (e.g., crop selection based on market demand).
- Helps to benchmark performance against industry standards.
- Provides insights into external factors affecting agriculture (e.g., climate trends).

Data mining

The process of analyzing big data sets and identifying valuable patterns and classifications within them is called data mining [15]. Data mining facilitates the extraction of knowledge from unprocessed, raw data. Knowledge can be extracted from data marts, data warehouses, and, in certain situations, even operational databases by using data mining techniques. These methods' primary goal is to identify trends and obscure but significant relationships that could result in more revenue. The primary distinction between traditional database operation techniques and data mining techniques is that the latter make the database passive and only use a vast population of data, which aids in the future discovery of that particular data. On the other hand, the database is not now providing valuable information on the business strategies under debate, making it no longer passive. Regression, decision, neural, and clustering analysis are only a few of the many statistical algorithms, shape recognition, classification, fuzzy logic, machine learning, genetic algorithms, neural networks, and data visualization that are used in data mining.

Data mining is a technology that may be used for the following purposes:

Pattern and relationship identification: Data mining can assist in identifying patterns and relationships in agricultural data to support decision-making.

Trend prediction: Data mining can assist in forecasting upcoming agricultural trends.

Issue detection: Fraud, security flaws, and agricultural bottlenecks can all be found with the aid of data mining.

User knowledge: Data mining can be used to gain a better understanding of agricultural users.

Process of DSS

1. *Data collection*

Data collection, the initial stage of any decision support system, is locating and compiling pertinent data from multiple sources. This can comprise both unstructured data, like text documents and multimedia, and organized data, like databases and spreadsheets. The caliber and diversity of the data gathered are essential since they have a direct bearing on the conclusions drawn subsequently. Meaningful analysis is made possible by efficient data collection, which guarantees a thorough dataset that captures the complexity of the problem under study [16].

2. *Pre-processing*

Once the data is collected, the next step is pre-processing, which aims to enhance data quality and usability. This stage involves data cleaning, where inconsistencies, duplicates, and inaccuracies are addressed to eliminate noise from the dataset. Normalization ensures that data is on a consistent scale, making comparisons easier. Additionally, transformation techniques may be applied to convert data into suitable formats, such as encoding categorical variables. Feature selection is also critical, as it helps identify the most relevant attributes for analysis, reducing dimensionality and improving model performance.

3. *Development and validation of algorithms*

With pre-processed data in hand, the focus shifts to the development and validation of algorithms. This step involves selecting appropriate algorithms based on the specific type of analysis required—whether it's regression, classification, or clustering. The chosen models are then trained on the historical data, where parameters are optimized for accuracy. Validation techniques, such as cross-validation and the use of test datasets, are employed to assess the model's performance and robustness. This iterative process allows for refining algorithms and ensuring they provide reliable predictions, ultimately enhancing decision-making capabilities.

4. *Visualization*

Effective data visualization is crucial for communicating insights derived from analysis. This step involves creating visual representations of the data, such as charts, graphs, and dashboards, which help users easily interpret complex information. Interactive visualization tools enable users to explore data dynamically, facilitating a deeper understanding of trends and patterns. By combining visuals with storytelling techniques, insights can be presented in a compelling narrative, making the findings more accessible and actionable for stakeholders.

5. *Insights*

The final step in the DSS process is the extraction of insights from the analyzed data. This involves interpreting the results to derive meaningful conclusions that can inform strategic decisions. Clear and concise reporting is essential, focusing on actionable recommendations that align with organizational goals. Moreover, creating a feedback loop is important, as the insights gained can inform future data collection and processing strategies. This continuous improvement cycle ensures that the DSS remains relevant and effective in addressing evolving decision-making needs.

Why DSS is gaining importance in agriculture?

- Increasing importance of knowledge as a factor of production in agriculture,
- Significant value addition, from both economic and environmental points of view, results from timely knowledge-based decisions from large variety of data,
- Information and knowledge need to be shared and assessed,
- Available data and knowledge are incomplete and uncertain,
- Often decisions are under pressure

Thus, inclusion of DSS allow a more knowledge-based approach to decision-making in agriculture [17].

Applications of DSS in agriculture

The DSS have various application [18]:

1. Nutrient management
2. Irrigation management
3. Pest and disease management
4. Weather forecasting
5. Crop Simulation
6. Marketing

Applications	DSS
Nutrient management	FarmN, DSSNMC
Irrigation management	IRRINET
Pest and disease management	CROPPEST DSS, PEST DOCTOR
Weather forecasting	AGROMET DSS
Crop Simulation	DSSAT

Cloud based DSS

By distilling a thorough analysis of the most recent developments in the field, ID3SAS aims to give researchers and developers who wish to create an SAS a set of fundamental needs, standards, and guidelines. In the context of this study, an SAS is a system that integrates various technologies (such as cloud computing, IoT, sensors, actuators, and artificial intelligence) to enable farmers and managers to have control over agricultural processes and make better decisions more quickly [19].

Contribution of DSS in urban agriculture

More than half of the world's population lives in cities, and urban agriculture is a method of growing food there. It has been demonstrated to have a number of potential advantages, such as lowering waste and logistics expenses. By lowering the amount of production that farmland must provide and providing space for it to recuperate from the harm that has been done to it over time due to the usage of unsustainable farming methods, increased urban farming adoption can even lessen the strain on the environment. DSS can be integrated into the farming system to increase the advantages of urban farming by boosting efficiency and productivity, which will ultimately lead to sustainability in the long run.

Empowerment of urban agriculture

An essential component of UA empowerment is knowledge. Growing crops, rearing animals, and applying sustainable agricultural methods in urban areas are all part of urban agriculture. Community members who have access to information on urban farming techniques, such as hydroponics, composting, vertical gardening, and pest control, are better prepared to produce food in constrained areas [17]. This information covers a wide range of topics, such as plant nutrition, soil health, water management, and urban farming laws. UA communities are more equipped to make decisions, adjust to local conditions, and maximize their agricultural methods for greater sustainability and productivity when they have access to pertinent information. Urban agriculture communities can effectively acquire specialized knowledge and insights in a variety of urban farming topics by interacting and networking with specialists [20]. This gives them access to important networks and resources that support their urban farming endeavors, helps them obtain specific insights, keeps them informed about the most recent research and developments, and gives them individualized counsel and direction. Their urban agricultural efforts may eventually yield more as a result, enabling them to grow more crops and raise overall productivity. It is essential for UA communities to acquire practical skills in order to prosper and become self-sufficient. A variety of abilities are needed for urban agriculture, such as marketing, farming, composting, and gardening. Community members can increase crop yields, grow their own food, and possibly make money by selling extra produce if they learn these skills. Workshops, training sessions, and skills development programs can be arranged to improve community members' technical competence in urban farming methods. In conclusion, the basis for empowering Malaysian urban agriculture communities is knowledge, skills, and participation [21]. Active involvement promotes teamwork, community involvement, and group decision-making. Having access to information on urban farming techniques facilitates community creativity and well-informed decision-making. Development of practical skills gives community members the know-how to grow food in a sustainable manner, increase output, and possibly make money. Urban agriculture communities may flourish, provide food security, encourage sustainable practices, and help create a more resilient and empowered urban environment by fostering these factors.

How DSS leads to empowerment of urban agriculture

From the study conducted by [22], the requirement of urban agriculture empowerment is the knowledge, participation and essential skills that can be fulfilled with the inclusion of DSS as it provides access to knowledge and access to relevant information. The presence of participation, knowledge, and skills within UA communities further strengthens the movement and promotes sustainable and resilient urban environments.

By integrating decision support systems (DSS) into urban agriculture (UA) initiatives, communities can better plan, manage, and optimize agricultural practices. This includes selecting suitable crops, improving resource allocation, and addressing environmental challenges like water scarcity and soil degradation. Access to timely and relevant information fosters innovation and adaptability, ensuring UA practices remain sustainable and resilient. Moreover, the active participation of UA communities, supported by DSS, creates a collaborative environment where shared knowledge and collective problem-solving thrive. This synergy strengthens the movement, enhancing its capacity to address urban food security, reduce waste, and promote ecological balance [25]. The combination of knowledge, participation, and skills—empowered by DSS—contributes to building sustainable urban environments. It also supports long-term resilience by fostering self-reliance, inclusivity, and adaptability within UA communities, making them key contributors to urban sustainability and food system resilience [26].

CONCLUSION

In conclusion, empowering community-based urban agriculture networks through a data-driven decision support system significantly enhances the capacity of local stakeholders to optimize agricultural practices, improve resource management, and foster sustainable food production. By leveraging real-time data and analytics, communities can make informed decisions that address specific challenges, such as food security, environmental sustainability, and economic viability. This approach not only strengthens community resilience but also encourages collaboration among urban farmers, policymakers, and researchers, ultimately leading to healthier urban environments and more vibrant local economies. Embracing such innovative solutions positions urban agriculture as a pivotal element in the quest for sustainable urban living.

LITERATURE CITED

1. FAO. Food and Agricultural Organization. 2024. Urban and peri-urban agriculture [on-line]. Available: https://www.fao.org/urban-peri-urban-agriculture/en [23 Sept. 2024].
2. Smit J, Nasr J, Ratta A. 2001. Cities that feed themselves. *In*: *Urban agriculture: Food, jobs and sustainable cities*. The Urban Agriculture Network, Inc. United Nations Development Programme. pp 2-30.
3. Neergaard A, Drescher AW, Koname C. 2009. Urban and peri-urban agriculture in African cities. *In*: (Eds) Shackleton, C. M., Pasquini, M. W., and Drescher, A. W. *African indigenous vegetables in urban agriculture*. Earthscan, London, Sterling. pp 68-98.
4. Smit J, Bailkey M, Veenhuizen R. 2006. Urban Agriculture and the building of communities. *Agric. Food Sci. Socio. Environ. Science* [on-line].
5. Volenikova L, Oprsal Z. 2016. The role of urban agriculture in household wellbeing: Case study of community-based urban agriculture in Ndola, Zambia. *Agric. Food Sci. Socio. Eco.* [on-line].
6. Ben-Othmen MA, Cardoze V, Hani J, Sauvee L. 2023. Chapter 2: Community-based urban agriculture for food justice: A review. *In*: (Eds) Droege, P. Urban and regional agriculture, Academic Press, [on-line]. Available: https://doi.org/10.1016/B978-0-12-820286-9.00008-X [26 Sept .2024].
7. Sikdar S. 2023. Urban and peri-urban farming: Some insights from a developed nation. *Journal of Agric. Extn. Management* 24(2): 105-115.
8. Anonymous. 2010. Components of decision support systems [on-line]. Available: https://dsssystem1.blogspot.com/2010/01/components-of-decision-support-systems.html [20 Sept.2024].
9. Mir S, Quadri SMK. 2009. Decision support systems: Concepts, progress and issues – A review. *In*: (Eds) Lichtfouse E. *Climate Change, Intercropping, Pest Control and Beneficial Microorganisms* [on-line]. Available: DOI:10.1007/978-90-481-2716-0_13.
10. Anonymous. 2024. What are agriculture decision support systems? [on-line]. Available: https://www.bankbarn.io/blog/what-are-agriculture-decision-support-systems.

11. Bakker-Dhaliwal R, Bell MA, Marcotte P, Morin S. 2001. Decision support systems (DSS): Information technology in a changing world. *Int. Rice Research* 26(2): 5-12.
12. Sridevy S, Djanaguiraman M. 2023. A glance at agricultural decision support systems. *Pharma Innovation Journal* 12(5): 755-757.
13. Segal T. 2024. Decision support system (DSS): What it is and how businesses use them [on-line]. Available: https://www.investopedia.com/terms/d/decision-support-system.asp.
14. Power DJ. 2008. Understanding data-driven decision support systems. *Info. Sys. Management* 25(2): 149-154.
15. Shirsath R, Khadke N, More D, Patil P, Patil H. 2017. Agricultural decision support system using data mining. *In*: International Conference on Intelligent Computing and Control (I2C2); 23-24 June, 2017 [on-line]. Available: DOI: 10.1109/I2C241136.2017 [29 Sept.2024].
16. Fernando JG, Baldelovar M. 2022. Decision Support System: Overview, Different Types and Elements. *Technoarete Trans. Intell. Data Min. Knowl. Discovery* 2(2): 2-5.
17. Mandel L. 2013. *Eat Up: The Inside Scoop on Rooftop Agriculture*. New Society Publishers. pp 264.
18. Kumbhar V, Singh TP. 2013. A comprehensive study of application of decision support system in agriculture in Indian context. *Int. Jr. Computer Application* 63(14): 30-36.
19. Araujo SO, Peres RS, Filipe L, Manta-Costa A, Lidon F, Ramalho JC, Barata J. 2023. Intelligent data-driven decision support for agricultural systems-ID3SAS. *IEEE Access* 11: 5-10.
20. Weber EP, Khademian AM. 2008. Wicked problems, knowledge challenges and collaborative capacity builders in network settings. *Wiley* 68(2): 335-349.
21. Hassanein N. 2008. Locating food democracy: Theoretical and practical ingredients [on-line]. Available: https://doi.org/10.1080/19320240802244215 [24 Sept.2024].
22. Awang N, Saad S, Sum SM. 2024. Fostering empowerment of urban community gardening through urban agriculture initiatives in Malaysia. *Int. Jr. Acad. Res, Bus. Soc. Science* 14(1): 5-12.
23. Managave SS, Kumbhar DR. 2019. Decision support systems for agricultural crop planning to enhance farmers income. https://doi.org. CP2019/APR-SEPT/ARTCL4.
24. Marinko J, Ivanovska A, Marzidovšek M, Ramsden M, Debeljak M. 2023. Incentives and barriers to adoption of decision support systems in integrated pest management among farmers and farm advisors in Europe. *Int. Jr. Pest Management*. 1-18. Available: DOI:10.1080/09670874.2023.2244912.
25. Gent DH, De Wolf E, Pethybridge SJ. 2011. Perceptions of risk, risk aversion, and barriers to adoption of decision support systems and integrated pest management: An introduction. *Phytopathology* 101(6): 640-649.
26. Zhai Z, Martinez JF, Beltran V, Martinez NL. 2020. Decision support systems for agriculture 4.0: Survey and challenges. *Comput. Electron. Agriculture* 170: 24-38.