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A review on computer applications in agricultural science

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Abstract:

Computer application in agricultural science is an advanced technology that has changed the surface of traditional agricultural systems throughout the history of human development globally. This paper aims to provide integrated information regarding the application of computers in agriculture and covers a wide range of genes that address MIS and its manifestations in science, computers and their major types and components, statistical applications, and functional services of various mobile apps in animal, extension, crop, fishery, forestry, soil and veterinary studies. Computer application affects all aspects and components of agriculture and ensures sustainable food security and economic advancement in all nations. Studies and assessments in animal science, agricultural extension, crop science, fishery, forestry and soil science have increasingly employed computer applications for different purposes. Computer application systems of various types (mainframe, minicomputer, PC, supercomputer, workstation), hardware and software, MS words, Excel and PowerPoint have played key roles in agriculture. These various types of computers deliver the most advanced interpretations of agricultural results through documentation and statistical analysis. The use of computers and computer technologies in various agricultural studies should be carefully practiced. Using agricultural computers will help ensure the accuracy of the results and technical interpretations, leading to increased food production, animal productivity, and sustainable economic development.

Keywords: *Agriculture, Computers, Computer technology, Information management, Mobile apps, Statistics*

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1. INTRODUCTION

Technological advances have led to drastic changes in various agricultural systems, resulting in a tremendous increase in production capacity [1]. These technological advances also ensure food security, meat and milk availability and the use of raw materials for industrial development [1]. Technological advances in agriculture are increasingly replacing human effort and intervention in traditional farming machinery and other equipment [2]. Technological advances have facilitated the successful automation of support functions for farming, such as the delivery of machinery and fertilizers and the production of raw products [3]. With the development of computer technology and computer systems (Table 1), the cost is further reduced, and the efficiency of farming systems is becoming increasingly powerful [4, 5]. Computer applications in agriculture are presented in three important areas: image analysis, crop models, and information technology [6]. Computers and their applications in these three areas have changed the appearance of most traditional agricultural farming activities from the most basic land use in agronomy to the highest level of industrial processing [6]. However, computer information systems (CISs) are the basic foundation for delivering the information needed for global development in agricultural and nonagricultural sectors [7, 8]. CISs can be considered sets of information needed for different sectors in human development [4]. The major types of CISs are the executive support system (ESS), decision support system (DSS), management information system (MIS), and transaction processing system (TPS) [9]. The ESSs commonly known as expert information systems (EISs) are information systems that combine many of the features of MISs and DSSs, where information is presented in the form of tailoring to the preferences of the executive using the system, such as the use of a graphic user interface (GUI) [4]. The DSS provides information to top managers, who are responsible for making judgments about particular situations, and supports decision makers in situations that are not well structured, e.g., risk analysis [4].

Table 1: *Examples of computer systems*

System	Terms	Definition
CISs	Computer information systems	Sets of information needed for different sectors in human development
ESS	Executive support system	Information systems that combine many of the features of MISs and DSSs
ESSs	Expert information systems	Computer program that uses artificial intelligence (AI) technologies to suggest the decision and actions of agricultural organization that has expertise and experience in a field of e.g. soil science, crop science, animal science etc.
DSS	Decision support system	Information to top managers
MIS	management information system	System that provides managers with information and support for effective decision making
GUI	Graphic user interface	System through which users interact with computer devices by visual indicator symbol.
EIS	Educational information system	Used for educational purpose
GIS	Global information system	Comprise technologies and software that collect, understand and present information assembled from various sources to help the researchers for better decision.
GPS	Global Positioning system	Satellite-based radio navigation system

An MIS is a system that provides managers with information and support for effective decision making [2]. MIS provide feedback on daily operation information in reports, which is considered an integrated collection of subsystems that are typically organized along functional lines within an organization (e.g., the educational information system (EIS)) [4]. It is a strategic system of collecting, storing, and distributing data in the form of information needed to carry out the functions of management in

agriculture [1, 4]. The TPS is a basic business system that serves operational levels and is characterized as a computerized system [9]. The TPS performs and records the daily routine transactions necessary for the code of the business (e.g., budgeting, general ledgers, billing, cost accounting, personnel and product records) [9]. The components of computer information technology highlighted are needed for a variety of purposes. This is because timeliness is a major factor underlying agricultural statistics and associated monitoring system information that is valuable if it becomes available too late [2]. Computer applications in agriculture can be used to support agriculture in this regard. There are several advantages of utilizing these applications for various agricultural components. These several advantages include [10] (a) providing a suitable and accurate picture of the production and productivity of agriculture, (b) providing information about a large area in an accurate manner, (c) providing information about whether the parameters of a particular area are simple, (d) helping in identifying the vegetation vigor of a particular area and monitoring drought stress, (d) helping in assessing crop phonological development, (f) assisting in gathering information about crop acreage estimation and cropland mapping, (g) mapping disturbances and land use/land cover changes, and (h) facilitating the management and control of disease and pests occurring in specific areas. Likewise, computers are widely used in various fields because, from the life of human society to work places, many activities cannot take place without the application of computers, computer intelligence, automation and other characteristics. These activities can effectively improve work efficiency and substantially improve agricultural production and sustainability [5, 7]. The aim of this paper focused on the application of computers and CISs in agriculture with specific objectives to cover subtopics such as MIS, PC basic components, and introduction to the application of statistics and mobile app applications in agriculture.

2. MANAGEMENT INFORMATION SYSTEM (MIS)

The concept of a Management Information System (MIS) can be viewed from different perspectives. For the manager who is responsible for the management of the system, MIS is considered an implementation of the organizational systems and procedures, whereas for a programmer who is programmed, MIS is regarded as filling the structures and processing the files [4]. MIS is a compound concept with three components: Management (M), Information (I) and System (S). This means that the system suggests integration and a holistic view; information refers to processed data, whereas management is the ultimate user and decision maker [4]. These three components make up what MIS is, in global advanced computer technology, and they are defined separately as follows [11]: (a) management, which covers the planning, control, and administration of the operations of an apprehension; (b) information, which refers to the processed data that help management plan, control and operate; and system, which refers to the data that are processed into information with the help of a system. The MIS is a planned system of collecting, storing, and disseminating data in the form of information needed to carry out the functions of management [9]. MIS is a system for processing data to provide proper information to management for performing its functions in various fields of sciences. The main objectives are to implement the organizational structure and dynamics of the enterprise for the purpose of managing the organization in a better way [11]. These objectives covered the detailed knowledge of the following goals [9]: (a) capturing data, (b) processing data, (c) information storage, (d) information retrieval, and (e) information propagation. MIS play a key role in agriculture. Cofas and Chiurciu observed that the following types of information management actions provide solutions to many agribusinesses [12].

a. *The management of agricultural works focuses on the planning, execution, and monitoring of agricultural works and the necessary resources (labor, use, materials).*
b. *Mapping involves mapping plots and geo-location via interconnection with GIS solutions.*
c. *Treated forecasts that focus on forecasts based on information and alerts from weather stations and field sensors.*

d. *Alerts are observant and are generated based on inspections and observations and external data (drones, other devices).*
e. *Planning agricultural works by generating work orders based on inspections and alerting with resource allocation.*
f. *Treatments that correct crop treatments, depending on adversity (diseases, pests), weather forecasts, previous treatments, and field observations.*
g. *Personnel management addresses personnel allocation for each task with a specific assignment of hours and quantities carried out individually and in teams.*

3. THE COMPUTER AND ITS COMMON TYPES

Computers are now controlling most of our everyday activities and devices in all components of life, including banks, markets, schools, hospitals, sports centers, and shopping centers. Different types of computers are classified according to their size and power, as outlined in Table 2 [13].

Table 2: *Different types of computers classified according to their size and power*

S/N	Types of computers	Description
a.	PC	This is a small, single-user computer based on a microprocessor. These computers, which were designed for an individual user, first appeared in the 1970s.
b.	Workstation	This is a powerful, single-user computer and is similar to a PC but has a more powerful microprocessor and a higher quality monitor compared to a PC. These are computers used for engineering applications (CAD/CAM), desktop publishing, software development, and many other types of applications that require a moderate amount of computing power and relatively high-quality graphics. They come with a large and high-resolution graphic screen, a large amount of RAM, built-in network support, and a graphical user interface. Their disk drive has mass storage capacity.
c.	Minicomputer	This is a multiuser computer capable of supporting up to hundreds of users simultaneously. These computers are midsize with a multiprocessing system capable of supporting up to 200 users at a time.
d.	Supercomputer:	This is an extremely fast computer that can perform hundreds of millions of instructions per second. These computers are specific for specialized applications and require an immense amount of mathematical calculations. They are used for programs such as weather forecasting, scientific simulations, graphics, fluid dynamic calculations, nuclear energy research, electronic design, and analysis of geological data such as photochemical and energetic pesticide ingredients.
e.	Mainframe	This is a powerful multiuser computer capable of supporting hundreds of thousands of users at the same time. The term mainframe refers to the cabinet containing the central processor unit of a room-filling Stone Age batch machine. The name was used to refer to computers that are fast and quick at solving problems. The main difference between the supercomputers and mainframe is very clear. Supercomputer channels all its power in executing a few programs as fast as possible, whereas mainframe computers use its power to execute many programs at the same time.

Different types of computers have been developed and manufactured for different purposes [13]. A computer is a machine that can be programmed to manipulate symbols [13]. A computer has basic principles that include responding to a specific set of instructions in a well-defined manner, executing a prerecorded list of instructions, and quickly storing and retrieving a large amount of data [13, 14, 15]. However, the most commonly used types of computers are portable computers, palmtop computers, notebook computers, laptop computers, docking stationary computers, desktop computers, workstations and terminals, hand-held computers and subnotebook computers [9].

3.1. Hardware and Software

The classes of computers outlined above are built with hardware and software. Hardware refers to physical devices and other bits of equipment that are used in computer systems, such as a hard drive or a hard disk drive, whereas software consists of devices that are nonphysical parts of a computer, e.g., programs [16]. Similarly, some of these computers have navigating windows of various types and forms. The windows 3, 7, 8 and even 95/98 and the WindowsXP millennium and the most recent version, Windows 11, are available. Windows are common in most PC computers. Some of these windows protect important system files and help end users develop more stable operating systems [17]. Working with these windows requires regular practical exercise that can help the user become more conversant to them.

3.3. MS Word, Excel and PowerPoint

PC computers are provided with important programs that operate as MS office packages. These MS office packages include MS Word, MS Excel and MS PowerPoint [13]. MS Word is widely used as a processing program that allows for the creation of both simple and compound documents. From a typical overview of your PC, when you open the Word document, the dialog box field name will appear. This provided a set of items that guided you to use Word easily and functionally. These items included File, Home, Insert, Design, Layout, References, Mailings, Review and View. On the top left, there are Save box (Ctrl+S), Undo typing (Ctrl+Z) and Repeat typing (Ctrl+Y) icons, and on the right end, there are Minimize, Restore Down and Close icons. However, below these cross-referenced items, there are other sets of functions that are made available by clicking each of the main items highlighted at the top of the Word document. For example, by clicking the Insert, you will be display with sets of items such as Cover Page, Table, Pictures, Online Pictures, Shapes, SmartArt, Chart, Screenshot, Store, My Add-ins, Wikipedia, Online Video Media, Hyperlink, Bookmark, Cross-reference, and many others. These sets of items are made available for different purposes, such as the formation of tables, charts, and cover pages. A large volume of information can be developed in Word by typing or copied and pasted. This information can be saved, stored and retrieved for a variety of uses.

MS Excel is a spreadsheet program for educational research and business applications that gives users the opportunity to format, organize and calculate data within a short period of time [14]. With Excel, millions of items can be calculated in the second step. In this program, an absolute cell reference identifies the location of a cell or group of cells, which are used in formulas. It consists of column and row numbers surrounded by dollar signs ($) and is used when you want a cell reference to stay fixed on a specific cell. This means that as a formula or function is copied and pasted to other cells, the cell references in the formula or function do not change. In this regard, conditional formatting allows the presentation of numeric data in different colors and presents list data against a background pattern of altering shades. AutoFill is a convenient feature that allows automatic filling of cells with preset data and the customization of the lists of data with AutoFill so that data can be easily added for frequent use. The data validation allows you to define what type of data you want to enter in a cell; these include the numbers, dates and times, length, and list of values. Likewise, for each cell you validate, you can display two different massages – the one that appears before the user enters data and the one that appears after the user tries to enter data that does not meet your requirements. They are classified as input messages and error messages, respectively. This means that the input message appears as soon as a user clicks the validated cell, whereas the error message appears only when the user types of data are not valid and presses Enter. Therefore, to validate the data in Excel, the following processes must be considered: (a) set up a worksheet (enter data and formula), (b) define the setting for a cell (use the data validation dialog box), (c) set up validation for other cells, (d) test the validation rules, (e) set up lists of valid choices, (f) apply protection, if desired, (g) share the workbook, if desired, and (h) check the results for invalid data. This setting would help you carry out various statistical analyses with Excel.

PowerPoint is a program that helps you to create a style presentation of data to the public, students or research colleagues [13]. The Slide Master (SM) contains the format on which the titles and text of all slides will be based [9]. In addition, the background and any graphics or text to be displayed on all slides can be set. The SM can change at any time. Individual slides can be set to differ from the SM if desired. The SM can be accessed from the View menu. Generally, from SM, you can also add footers and slide numbers to any presentation. You can do many things with PowerPoint in your presentation, including Bullet Styles, Overriding Master Styles, Handout Master View, and Note Master View, among others.

3.4. PC Basics

A personal computer (PC) is normally used privately for education, business, communication, or research purposes. This PC can be used for writing, calculations, analyses, graphics, data processing, data storage, data manipulation, and a variety of educational activities, such as online meetings, online lectures, and conferences [13]. PCs are also employed for publishing, printing, chatting, and leisure purposes. Indeed, PCs are already more important to everyday life than most people realize because, to many people, the question is not 'do I need it' or 'how to use it' but which type, class or model do I need to buy or possess. This indicates the need to understand PC itself in the global educational environment. Specifically, the PC has three separate parts: the display screen or the monitor, the keyboard, and the console that contains the computer itself [9]. Portable computers of all sizes are expected to have all three components so that they can work easily and portably [13].

There are several key elements inside the PC, including the processor, the RAM and the hard disk. The processor is the true computer and is considered to be the 'brain' playing a vital function in the PC [17]. It is the part that sits at the core of machine and works out how to do whatever you tell it to do. The type and speed of a PC processor are two elements that indicate how good a processor is and depend greatly on megahertz (MHz) frequencies; the greater the frequency is, the better the processor is [9]. Therefore, this needs to be checked whenever a particular PC is chosen. RAM, on the other hand, is alphabetically defined as random access memory (RAM), which is the area in which the user stores instructions for the machine to obey them [14]. Thus, all the programmes installed or software are placed in the RAM before the PC can process it. This means that when you install or download software, it goes directly into the RAM, and any information held in the RAM can be stored for later recall (i.e., saving). Conversely, the hard disk is a memory that stores programs and information so that PCs can find them before they can be loaded into the RAM. Hard discs play a key role in storing and saving all the information and programs, especially when PCs are shut down. Sometimes, a backup floppy memory disk is used on a PC to store and save information that can later be retrieved for future use. Other discs include optical disc drives such as CDs, CD-ROMs or zip drives such as 100,250 or 500 megabytes, 1 million bytes, 1000 kilobytes (KBs), 50 megabytes (MBs), and 1 gigabyte (GBs or gigabytes), among others. Memory chips, e.g., RAM and ROM (read-only memory) chips, are also available for this purpose and are used for holding the programs and data either temporarily or permanently. RAM holds the data and instructions that the central processing units (CPUs) are presently processing, whereas ROM stores instructions and data permanently [9].

3.5. Statistical Analyses

Agricultural studies enable science to be more applicable in real life by allowing scientific discoveries to go beyond the improvement of human knowledge, hence helping to make decisions regarding various objectives [18]. A study by Bayo [19] noted that statistical techniques are used in agriculture to ensure efficient planning of experiments and for interpreting experimental data. Statistical techniques are also used for economic analyses and future predictions of different businesses of great value to human development [20]. Statistical analyses are considered in various agricultural sciences to respond quickly and efficiently to an existing problem for future solutions [21]. This has been the result of the integration of various statistical tools and models into agricultural science and is considered part of active research

in agronomy, animal, extension, fishery, forestry and soil for many years [22]. The computer has become the role model in achieving many statistical analyses in the field of agriculture [2]. Various analyses have been employed for agricultural analyses. These analyses include descriptive data analysis, farm business analysis, financial analysis, cash-flow analysis, livestock productivity analysis, comparative analysis, and statistical analysis, among others [22].

The application of statistics in agriculture has dominated most commonly used analyses in agriculture [23]. Many agricultural studies have used statistical analysis for interpretations and discussions of the results obtained [7, 11, 18, 24, 25]. The FAO noted that the basic statistical tools commonly used for agricultural analyses in various statistical software are the sum, mean, standard deviation, coefficient of variance, confidence limit of a measurement, and propagation of errors, while the statistical tests included two-sided vs. one-sided tests, F tests for precision, t tests for bias, linear correlation and regression, and analysis of variance (ANOVA) [26]. Typically, the basic hypothesis to be made regarding a set of data information, obtained by repeated analysis of the same analyte in the same sample under the same conditions, is that it has a normal or Gaussian distribution; however, when the distribution is skewed, the statistical treatment is more complicated, and in this regard, the primary parameters to be used are the mean (or average) and the standard deviation, while the main tools to be considered are the F test, the t test and regression and correlation analysis [26]. The common statistical software used for this purpose are Excel spreadsheet, SPSS (Statistical Package for Social Science), SAS (Statistical Analysis Software), GENSTAS, Stata, Minitab, R, Epi-info, Epi-data, NVivo and ATLAS.ti. These specialized programs are designed to perform complex statistical analyses, assist in the organization and interpretation of the results, and calculate and present the overall results for present and future use [20]. A brief summary of these software programs is given below for easy reference.

a. *SPSS is a statistical software designed for advanced statistical analysis developed by IBM 56 years ago (from 1968). It is used for data management, advanced analysis of results, multivariate analysis, business intelligence, and criminal investigation [27].*
b. *JMP statistics software is a collection of computer programs for statistical analysis and machine learning developed by JMP as a subsidiary of SAS Institute. The latest version (v17.2) was released in March 2023 and is intensively used for statistical evaluations of studies in the fields of crop science and horticulture.*
c. *GENSTAS is a statistical software used for analysis, primarily to provide a range of tools, including model relationships between variables by linear or nonlinear regression, particularly in agriculture. These common model types include generalized linear models, generalized additive models, generalized linear mixed models and hierarchical generalized linear models. The package provides a wide range of statistical procedures with the design and analysis of experiments, a major strength, facilities available, statistical modeling, time series, and spatial analysis, among others [28].*
d. *R Statistic: This is domain-specific statistical software designed for statistical computing and graphic visualizations.*
e. *Stata: This statistical software was first released in 1985 for data science analysis. It is designed for general purposes – data manipulation, visualization, statistics and automated reporting [29].*
f. *SAS is an artificial intelligence and data management software for statistical analysis. The SAS was developed in 1972 (51 years ago) by the SAS Institute at North Carolina State University for advanced analytics, multivariate analysis, business intelligence, criminal investigation and predictive analysis [30].*
g. *Minitab: This statistical software was developed at Pennsylvania State University by a group of researchers headed by Barbara [31]. This software performs various common statistical analyses, such as t tests, ANOVA and regression analysis.*
h. *Epi info: This is a public domain statistical software package designed for public health researchers and practitioners that provides easy questionnaire and database construction, data entry and analysis with epidemiologic statistics, graphs and maps [32].*
i. *Epi data: This statistical software application was first introduced in 2007 for data entry and data documentation, as well as for quantitative data analysis [33].*
j. *NVivo: This qualitative data analysis computer software package was produced in 1997 by Lumivero and is specifically used across a diverse range of fields, such as agriculture, sociology, criminology,*

anthropology, and communication [34]. The software is used for qualitative and mixed methods research and can allow researchers to manage, organize, visualize, store and analyze data.

k. *ATLAS-ti: This tool is a qualitative data analysis tool that enables the researcher to organize all the text data in one place. The software was developed by ATLAS-ti Scientific Software Development GmbH [35].*

4. COMPUTER APPLICATIONS IN AGRICULTURE

There are growing developments in the modern agricultural system, and this has affected almost all components of agriculture, namely, agricultural economics and extension, agronomy, animal science, forestry and fisheries, food science, and soil science. In the age of steam and the industrial age, computer use has advanced, and computer use has become a daily practice in many sectors of human development [2, 5]. The opportunity for computer application in agriculture has been investigated and studied in many aspects of the major components of agriculture. This computer application in agriculture has developed into more advanced technology in recent years [2, 36]. It has been regarded as a solution for a cultivated planet and helps achieve sustainable food security for the global population [1]. The results of technology advancement have led to the generation of large amounts of big data in agricultural farming systems through computer knowledge and analytical skills to provide suitable data, which in turn is beneficial to agriculturalists at the local, national and international levels [24]. This advanced technology has been developed for decision making about several essentials required for cultivation and includes various sensors that can convert information into digital data [24]. There is also the development of technical tools for registering the parameters of the environment and environmental processes, which are of interest to researchers, and the elaboration of software for specific goals in agriculture [11]. Computer technology has created the preconditions for modernizing scientific research and yielded new potential for working with information for many agricultural benefits [11].

Modern supercomputers can search for solutions to global environmental problems at a qualitatively new level [11]. Computer applications in agricultural environments address the influence of computers on the agricultural industry and focus on overall technological control, which includes climate control, greenhouse control, greenhouse climate feedback/feed-forward control, and glasshouse control [37]. Other technological controls included crop drying control, sulfur dioxide control, retort control, animal control, broiler house ventilation control, poultry house control, rainfall interception monitoring, grain drying, ammonia monitoring techniques, and various techniques for remote monitoring [37]. According to Day [38], computer application in agriculture can be grouped into three techniques, namely, image analysis, crop models, and information technology. Image analysis techniques are methods capable of coping with the variability typical of biological targets and have a great scope for use in robot control [38]. Crop models have been a continuing target for research, and in the greenhouse sector, they are being actively considered the basis of environmental control strategies [38]. Information technology provides opportunities for the use of computer technology throughout farming systems, from the selective control of field operations to the use of expert systems for crop and farm process management [38]. Therefore, computer reproductions make it possible to carry out numerical experiments on virtual objects that would represent a danger to real objects to develop forecasts for a wide range of situations, varying from ordinary to catastrophic ones, and to propose measures to minimize their effects [11]. There are three common elements in which these have achieved success in agriculture, namely, (a) resource-conserving technologies such as integrated pest management, nutrient recycling, soil and water conservation, water harvesting, and waste recycling; (b) groups and communities helping farmers become experts in managing farms as ecosystems; and (c) most of the policies are still actively encouraging fanning that is dependent on external inputs and technologies.

The uses of computers in agriculture include detailed overviews of the following notions, which are more or less related to advanced computer technology in recent years [3]: (a) software that helps in the prediction of weather conditions and estimation of agricultural production; (b) computers that are primarily used for record-keeping of information related to costs involved in production, transport, agricultural processes, and in the estimation and calculation of profit and/or loss; and (c) the internet, which aids communication among farmers and between farmers and agriculture experts, leading to an exchange of knowledge and serving as guidance for farmers to improve production and earn profits. However, with the use of computer technology in agriculture, there are many benefits, which have helped both researchers and farmers. These benefits include (a) support with various options to identify problems and specific targeted locations, (b) support with big data processing technologies based on rough and random data collection on patterns, water management and requirements of pesticides, and (c) reinforcement to find a way forward to make suitable decisions for plant health protection. It is also able to increase the cultivation yield, (d) spraying pesticides at appropriate levels may increase productivity, (e) allow farmers to manage and help in decision making, (f) allow agronomists to improve their effectiveness by providing vital cues, and (g) help them to persistently adapt to the requirements and provide insights at each stage of the process [24].

In summary, computers can be used for various activities under commercial and noncommercial agricultural systems. An observation by Basharat [38] explained this overview to involve various farm sectors. This clarification has yielded the following points, which are worthy of consideration in agricultural systems. The graphical concept of these major points of consideration in agricultural systems is depicted in Figure 1.

a. *Keeping records: The application of computers in agriculture has led to the storage of vast amounts of agricultural information that can be used for the present and future. The computer is used to record the productivity of the crop and animal as well as the overall farm record. It is also used for budget information and equipment. Profits and losses can be understood, and records can make it possible to determine the key differences between the two. The inputs and outputs can be recorded from various components of farm activities.*
b. *Geography: Computer technology in agriculture can be used to map environmental factors, soil processes, and socioregional factors that can affect agricultural development in a given area. Typically, a global positioning system (GPS) has been used for geographical and geological practical surveys.*
c. *Geographical Information Systems (GISs): GISs have been widely used in the description, modeling, and prediction of spatiotemporal processes and phenomena, including those that are particularly urgent for humanity and related to environmental protection [11].*
d. *Farm software: Computer software applications have been introduced in various agricultural sectors, including soil observations, livestock farming, poultry production, cropping systems and forest management. Many of these farming software programs have been used for the detection of animal health and diseases, milk production, and feedings. Similarly, some of these methods are used to generate information on the reproductive cycle of animals and the egg incubation period.*
e. *Internet media: The advancement of internet libraries and various open access information on agriculture provides vital resource information regarding agricultural issues, practices, and technologies. Many farmers are generating resource information directly from the internet at home, on farms, and/or during journeys. Through this internet media, farmers are guided on how to farm in an advanced manner. Practical knowledge has been passed to farmers through internet development.*
f. *Communication: The application of computers in agriculture is also useful for communication between experts and farmers. Training and practices are given to the farmers via virtual conferences and workshops. Farmers communicate with each other to discuss the problems and possible solutions in all aspects of agricultural development.*
g. *Delivery of machinery: A computer has lessened the work of humans and provided a very easy way for farming systems to support the vastly growing population in the world. Farmers can easily purchase equipment online without much difficulty or delay.*
h. *Autonomous farm equipment: Computer technology has initiated the replacement of human activities on farms. With computer machinery, many farm activities can be carried out within a short period of*

time. Plowing, planting, watering, harvesting, processing, packaging, weighing and selling are important farm activities that can be performed with computer machinery.

i. *Agricultural robots: Agricultural robots are computer machines used for fertilizer and pesticide application. The risks of chemical hazards and human health protection have been addressed with these machines.*

j. *Data processing: Computers can be used as data processing tools for preparing agricultural development projects and establishing general agricultural principles [39].*

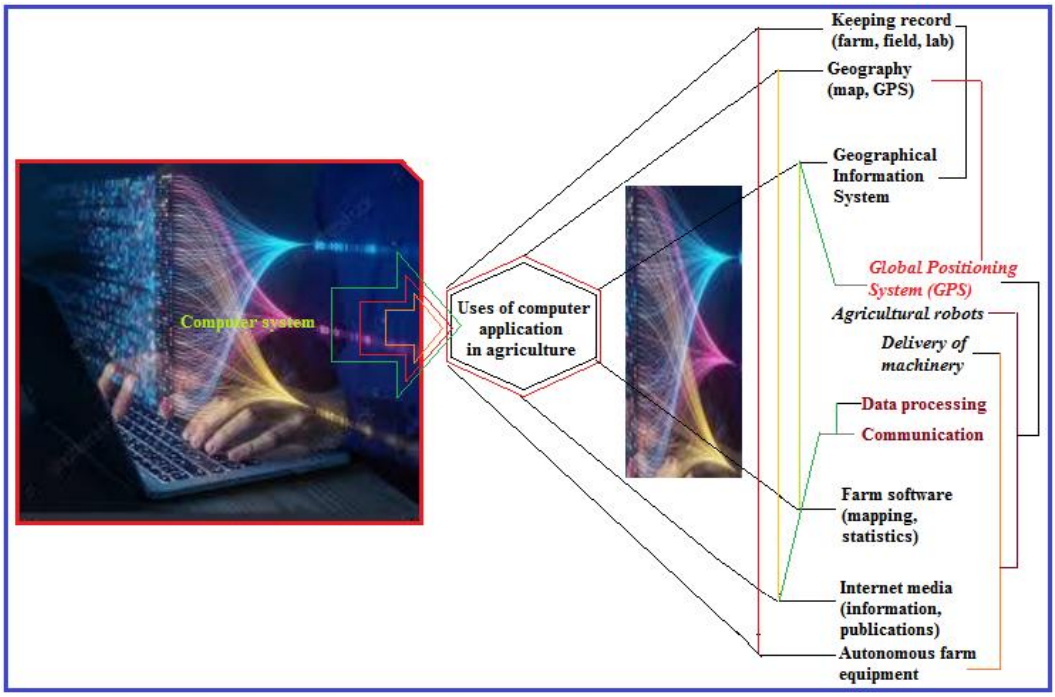

Figure 1: Computer applications used in agriculture

4.1. Studies: Classical Examples

The number of studies in agriculture using computer applications has increased in recent years. In soil science and ecology, computer use is usually related to the preliminary accumulation of information, its processing, subsequent analysis, and the visualization of results [11]. Many subject areas of interest in soil science have been studied, with advanced computer applications in the field. The subject areas included studies on soil erosion, water and soil conservation, and soil-crop relationships. Damene and Satyal [40] used the geographical information system (GIS) technique integrated with the revised universal soil loss equation (RUSLE) to generate data on slope gradient and length. They noted that the GIS technique and remote sensing data can be used in RUSLE-based erosion risk prediction for large areas even at the basin, sub-basin and macro-watershed levels. Some environmental studies have reviewed the current potential and prospects of information and computing technologies in soil science and ecology and suggested the use of computerization as a modern scientific methodology [11]. The application of liquid chromatography tandem mass spectrometry for the determination of polyoxin in cucumber and soil was described by Song et al. [41]. Similarly, gas chromatography–mass spectrometry has also been used for the analysis of aromatic organochlorines in soil [42]. Similarly, soil nutrients were assessed using spectroscopic computer methods [43].

A study by Vivek [44] noted that computer application in veterinary science employed the use of Geographic Information System (GIS), Remote Sensing (RS) and Global Positioning System (GPS) for rapid worldwide communication of data management of animal diseases. According to his observations, the advanced technologies used in animal science under these three areas are image intensifier TV system (IITV), ultrasound, computerized tomography (CT), magnetic resonance imaging (MRI), nuclear

scintigraphy, digital subtraction angiography (DSA), laparoscopy, endoscopy, and pulse oximetry. The use of remote sensing has revolutionized the way agricultural scientists handle and analyze geographic data [2]. Remote sensing, which refers to the acquisition of geographic data without physical contact with the area of study [44], has been noted to play a key role in soil and crop assessments, animal observations, forest assessments, pesticide applications and environmental analyses [45]. However, one of the important subject areas to consider for the detailed understanding of various components of agricultural science in advanced computer systems is the use of mobile applications [3]. Different apps have been developed for use in agronomy, soil studies, animal science, forestry, fishery, extension services and veterinary science. This development can be related to advancements in digital agriculture, where data are collected, stored, analyzed and shared electronically [5].

4.2. Mobile Applications in Agriculture

Digital transformation is acting as a total game changer in global agricultural systems, and this has led to the rise and development of many different mobile apps, which have been developed to support farmers in executing various agricultural activities on farms. Mobile apps can be used in agriculture to generate money and support programs to help ensure sustainable economic development [46]. They can be used to help existing government schemes and other agriculture-based information reach farmers in rural areas where cost implications and security challenges might be barriers. However, with the application of computer mobile apps in agriculture, rural farmers can access all necessary information with a button click [2]. Many mobile apps can be developed to match the common language of the user for ease of communication and understanding. According to the results of a simple basic survey conducted through an internet search and the use of the mobile Play Store app, approximately forty (40) different apps were identified for user benefit [Table 3].

Table 3: *List of 40 beneficial mobile apps for diverse agricultural activities*

	Name of App	Link (Approved for public use by the owners)	Purpose of used
1	Digital Agriculture 4 farmers	Can be downloaded and used from Google play via a Play store	Digital record keeping: fertilizer, pesticides, seeds
2	Agromedix	https://play.google.com/store/apps/details?id=com.iqra.agromedix	Agronomic functions
3	AgriApp	https://play.google.com/store/apps/details?id=com.criyagen	Agriculture
4	VOLEST	Can be downloaded and used from Google play via a Play store	Tree volume estimation
5	AgriApp	Can be downloaded and used from Google play via a Play store	Smart farming app
6	Farm Bee	https://play.google.com/store/apps/details?id=com.rml.Activities	Bee management and productivity
7	Plant App	Can be downloaded and used from Google play via a Play store	Education free plant identification
8	Crop Insurance	https://play.google.com/store/apps/details?id=in.farmguide.farmerapp.central&hl=en	Crop assessment
9	Agriculture Business	https://play.google.com/store/apps/details?id=com.AgriculturalBusiness3dsp	Business in agriculture
10	Zero Budget Natural Farming	https://play.google.com/store/apps/details?id=com.oyepages.zbnf	Farm budgeting and analysis
11	Plantix	Can be downloaded from Google play via a Play store	Crop doctor
12	Machinery guide	https://play.google.com/store/apps/details?id=hu.zbertok.machineryguide&hl=en	Farm machinery guide
13	Farmable	Can be downloaded and used from Google play via a Play store	Farm management app
14	Outgrow	Can be downloaded and used from Google play via a Play store	Farming solution app
15	Market yard	https://play.google.com/store/apps/details?id=com.globalfarm.marketyard	Farm marketing
16	Fieldmargin	Can be downloaded from Google play via a Play store	Manage your farm
17	Farm City	Can be downloaded and used from Google play via a Play store	Faming and building
18	Agri Live	https://play.google.com/store/apps/details?id=agri.live	Agriculture
19	Big Farm	Can be downloaded and used from Google play via a Play store	Mobile harvest
20	My Crop Manager	Can be downloaded and used from Google play via a Play store	Farming app
21	BigHeat	Can be downloaded and used from Google play via a Play store	Smart farming
22	My Poultry	Can be downloaded and used from Google play via a Play store	Poultry farming
23	Rock Identifier	Can be downloaded and used from Google play via a Play store	Rocks identification

24	ZyAgric Farmer	Can be downloaded and used from Google play via a Play store	Business farming
25	e-Gram	Can be downloaded and used from Google play via a Play store	Agriculture
26	Soil Science and Technology	Can be downloaded and used from Google play via a Play store	Soil education app
27	Soil for Science	Can be downloaded and used from Google play via a Play store	Soil education app
28	Agricultural Science Textbook	Can be downloaded and used from Google play via a Play store	Agricultural books and references
29	Soil Sampler	Can be downloaded and used from Google play via a Play store	Soil sampling app
30	Soil Dictionary	Can be downloaded and used from Google play via a Play store	Soil terminology guide
31	Insect Spider and Bug identifier	Can be downloaded and used from Google play via a Play store	Social insect identifier
32	Animal Information	Can be downloaded and used from Google play via a Play store	Book and references on animal science
33	vet-Anatomy	Can be downloaded and used from Google play via a Play store	Education on animal health
34	Zoology	Can be downloaded and used from Google play via a Play store	Animal kingdom study
35	Forest Tree Identification	Can be downloaded and used from Google play via a Play store	Forest trees education
36	Forest Seed Science	Can be downloaded and used from Google play via a Play store	Education on forest seeds
37	Forest Engineering	Can be downloaded and used from Google play via a Play store	Forest education
38	My Fish Manager	Can be downloaded and used from Google play via a Play store	Fish farming app
39	FishBase Guide	Can be downloaded and used from Google play via a Play store	Fishery science education
40	Food Science	Can be downloaded and used from Google play via a Play store	Food science education

Overall, different mobile apps have been developed to achieve various objectives in agriculture. To demonstrate this concept of mobile apps in the present day's computer advancement, we verified the following components of agriculture based on their relevance to various apps highlighted in Table 2. This study aimed to show how mobile apps play a key role in supporting farmers to practice agriculture in the most advanced manner. It is also believed to provide the best way for advanced communication among farmers in agriculture [47].

a. *Crop Science: Crop science apps such as Digital Agriculture 4 Farmers, AgriApp, Plantix, Agromedix, My Crop Manager, Crop Insurance and Outgrow can help farmers monitor agronomic activities, from land use practices to planting and fertilizer application. The apps will guide farmers on the best time for planting, manuring, and weeding, among others. These apps are able to determine how much fertilizer a crop may require based on the information provided by the application contained in the apps.*
b. *Soil Science: This component of agriculture addresses the nature and condition of the properties of soils. Soil samplers, soil dictionaries, soil science and technology offer vital resource information for educating farmers and students to understand the soil and its natural conditions. The apps help farmers determine the fertility status of their soils and fertilizer requirements. They will guide students on the right point of sampling and right location for soil profile assessment. Soil moisture and water use efficiency are crucial to plants; soil apps can help farmers understand how to manage and improve the use of water by plants. The best irrigation time can be achieved with soil apps.*
c. *Animal Science: Animal and poultry health productivity data are needed all the time. The development of animal science mobile apps such as Animal Information, My Poultry, vet-Anatomy and Farm Bee is playing a key role in helping farmers with the most advanced information to improve the health status of their animals. The time of delivery, egg production and feeding can be easily understood with mobile animal apps.*
d. *Forestry: The management and maintenance of forest trees and vegetation can be achieved easily with mobile apps such as Forest Engineering, VOLEST, Forest Seed Science, and Forest Tree Identification. Estimations of tree volume, length, population density and classification of trees and various plants can be made instantly in the forest.*

e. *Fishery: My Fish Manager and Fish Base Guide are apps used for fish production, management and marketing. These apps can help farmers and commercial fish businesses improve the quality and productivity of their fishponds.*

5. CONCLUSION

The results demonstrate that computer application in agriculture has significant value for supporting agricultural development to ensure sustainable economic development. The resource information combined in this presentation can provide useful insights for a range of relevant guides toward better understanding the advanced relationship between computer technologies and agriculture. There is wide spatial knowledge that needs to be understood in terms of this relationship and how it can be used by local farmers to achieve more food, resources and money with agriculture as a business enterprise. The use of mobile apps may be an easy way for farmers to achieve some aspects of this development. However, in many instances, training and practice are needed. State and local government areas, particularly in sub-Saharan Africa, should use this opportunity to advance these trainings and practices to rural farmers. In this regard, computer application in agriculture is believed to help reduce farmers' workload and achieve maximum efficiency in all aspects of farming systems. This will significantly ensure holistic environmental security among rural citizens in the region.

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