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Prediction of Agricultural Factors Using Remote Sensing Data and GIS in the Context of Agriculture 4.0: An Analytical Review

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ABSTRACT

The current research study is related to farming 4.0 and its role in today's digital world. The agriculture 4.0 has revolutionized the farming processes that are used by the farmers for crop cultivation process. It has also enhanced their productivity levels to maximum levels and provided protection to environmental measures. The agriculture 4.0 provides various tools like remote sensing, Cyber-security, cloud computing, big data, digital twins, GIS to the farmers through which they are able to implement water saving procedures, produce high-quality yield, and adopt the non-polluting farming culture. It also helps the farmers to perform precision farming and adopt innovative methods of farming like vertical farming, hydroponics, greenhouse, and others. The present study aimed to determine the impact of Agriculture 4.0 using the concept of remote sensing data and GIS on the Indian Agriculture Industry. For that, a study on the existing models and theoretical concepts were studied based on the related theories and existing theoretical models.

1. Introduction

The agriculture sector is witnessing changes like other sectors such as hospitality, education, banking and retailing. Due to the adoption of innovative technologies, like cloud computing, big data analytics, artificial intelligence (AI), smart sensors, platform construction, Internet of Things (IoT) and agriculture 4.0, the agriculture practicesare converting into smart Framing Technologies. (Jithin Das, 2019) (Lee, Lee and Kim 2019).The agriculture 4.0 is termed as the farming management model that is based on observation, evaluation and responsible for producing more crops with less resource (Juan Perez-Bedmer, 2018). For example, Cloud Computing technology is used by Irish farmers to enhance agriculture productivity (Sharma and Kaushik 2019). The significance of agriculture 4.0 and its role in the today's digital world has led to the creation of digital farming, which has made the crop cultivation process more sustainable by converting the traditional farms into smart and digital farms. It has also encouraged precision farming, determining digital imagery of fields, use of self-driving tractors among the farmers (Teena Maddox, 2018). As a result, the farmers are able to make better farm decisions and efficiently exploit the operations and management systems. For example, Indian Government has initiated the National Mission on Sustainable Agriculture (NMSA)program to increase the agricultural productivity by adopting comprehensive soil health management, composite farming, and water management practices (Bock and Van Huik, 2007).

Looking at the industrial revolution, the first revolution took place in the year 1780, when the introduction of steam was done for the mechanical production process. The second revolution began 30 years later with the introduction of electricity, which led to mass production. In the third revolution, which began in late 1960, under this stage, the invention of the first programmable logic controller (PLC) took place, which brought automation and development of electronic and Information Technology (IT). The fourth revolution began in the year 2011 when the German government project introduced computerization and innovation, which extended to the production procedure. It brought Industry 4.0 concept into the limelight, which connects machines, work, and systems by intelligent networks like Internet of Things (IoT) and helps in increasing the value chain, bringing dynamic changes and high scalability (Zambon, Cecchini, Egidi, Saporito and Colantoni, 2019).

Similarly, the first agricultural revolution began with the transition of humans from hunting and gathering to settled agriculture. The second revolution took place in the 18th century with British agricultural reforms. The third revolution began post-war, which led to the Green Revolution and enhancement in agricultural productivity. The fourth revolution is referred to as the agriculture 4.0, which has begun with the use of technological innovations like the Internet of Things (IoT), Cloud Computing, Robotics, and Artificial Intelligence (AI), (Rose and Chilvers, 2018). It helps in the creation of an environment in which all the devices like cyber-physical systems (CPS) are linked together so that a high level of coordination is established. It helps in digitization and improvement of the supply chain management, optimizing enterprise-based production systems, creating real-time infrastructure, and establishment of constant communication (Zambon, Cecchini, Egidi, Saporito and Colantoni, 2019) (Türkeș, Oncioiu, Aslam, Marin-Pantelescu, Topor and Căpușneanu, 2019). The agriculture 4.0 will also ensuring food security, solving food scarcity issues, reducing dependency on imports, enhancing agricultural productivity and supporting the future shift towards innovation and knowledgeable economy (Anshu Vats, Matthieu De Clercq and Alvaro Biel, 2018).

The main challenges faced in implementation of advanced agriculture into Indian farming, it mainly includes political, economic, cultural, human and technology barriers, which has restricted the efficient growth of the farming sector in the country. For example, in India, due lack of propercommunication infrastructure, poor farm holding issues, absence of standardization, the implementation of agriculture 4.0 becomes difficult in different rural areas **(**Teja,Patil, and Sanjay Shekhawat, 2019).Whereas, some farmers face the pressure of increased production, lesser involvement of governments, lack of association among producers like small farmers also impact the supply chain process and introduction of new technologies into the agriculture sector (Naik and Suresh, 2018). Hence, it is recommended that adequate government interventions like standardization of agriculture 4.0 must be done to increase the adoption of digital technologies in the Indian farming.

2. Research aims and objectives

The present study aims to determine the significance of the implementation of Industry 4.0, considering the impact of digitalization on the Indian farming sector by identifying key merits and demerits. The study aims to compare the industrial revolution with the primary sector, viewing whether agriculture has been able to keep up with the times.The primary objectives of this research are followed as:

- To evaluate the role and impact of digitalization on the Indian farming sector
- To identify opportunities and challenges presented by digitalization in the Indian farming industry
- To understand the role of agricultural factors using remote sensing data and GIS in the context of Agriculture 4.0

3. Literature review

3.1 Agriculture 4.0

Shankar, Luo, and Chi, (2014) examined that agriculture 4.0 is referred to as the research, transfer and production activity that is conducted to achieve better yields from farming and livestock. It includes the use of IoT Sensors, Light Emitting Diode (LED), robotics, drones, satellites, and other farm technologies so that the precision farming, indoor farming, aquaponics (provides wellness and better nutrition), and hydroponics (process of growing crops without soil and using mineral and water solvent base to grow crops) will be done effectively. The effective application of the technology also helps in protecting the environment better, attaining higher farm productivity, and providing safety solutions. Agriculture 4.0 is highly useful in implementing different farming practices by using new technologies, increasing the food chain efficiencies, and incorporating cross-industry innovations or applications. For example, Scriber, (2017) Bonneau, Copigneaux, Probst, and Pedersen (2017) examined that due to the adoption of advanced technologies like sensors, Indian farm cultivators are able to conduct farming activities adequately. The sensor helps the farmers to measure soil texture, salinity and moisture content, which help them to perform farming process more efficiently. It also helps farmers to monitor, maximize and adapt to environmental changes.

Additionally, Jazarso, (2017) analyzed that the progressive shift has taken place from the first industrial revolution to the fourth revolution.In the first revolution, that is industry 1.0, invention of the steam engine took place, and in the second revolution, that is 2.0, the discovery of electricity happened. While in the third revolution, that is industry 3.0, automation took place, and in the fourth revolution, that is industry 4.0, technological advancements like the development of Smart Factories with the establishment of interconnectivity between machines and systems took place. The invention that happened in different revolution periods changed the farms into smart farms and digitalized the entire agriculture process. As a result, due to industrial 4.0, the optimum utilization of water, fertilizers and phytosanitary productionare done, which gives rise to the practicing of Precision Agriculture. Industry 4.0 also digitalized agriculture and transformed the farm production process, established connections between farms, and automated the agricultural production process. As a result, agricultural productivity increased, and the requirement of the human workforce of cultivation process reduced. For example, the use of digital equipment like connectivity and localization technologies (GPS) by the farmers in India helps in reducing fuel consumption, optimizing routes and reducing harvesting or crop treatment duration.Hence, the progress of agricultural practices takes place, which increases transparency in the industry.

3.2 Role of agriculture 4.0

According to Rose and Chilvers, (2018) agriculture is undergoing a new technological revolution, which was supported by policy-makersaround the world. To enhance productivity and eco-efficiency, various smart technologies such as Artificial Intelligence (AI), robotics and Internet of Things (IoT) are playing an important role. Due to the technological changes, societies are highly concerned about the radical new agricultural technologies for both the farming community and wider society. In the agriculture sector, the concept of innovation has not been widely adopted. On the other hand, various comprehensive frameworks have been developed, which are related to the fourth agricultural revolution, which in turn are driving innovation in agriculture by adopting a systematic approach that helps to attend the wider ecology of innovations.

Lejon and Frankelius, (2015) Frankelius et al., (2017) Wolfert et al., (2017) examined that the “Fourth Agriculture Revolution” is as radical as the transition from hunting and gathering activity to sedentary agriculture. Technological innovation in the agriculture sector with emergent technologies such as IoT, cloud computing, Artificial Intelligence (AI), robotics, have the potential to change in farming beyond recognition, which is evident from the shift towards agriculture 4.0.

Driessen and Heutinck, (2015), Carolan, (2016)analyzed that smart farming approach is being used to increase the precision of fertilizer, pesticide and herbicide applications. It also included, the use of Microsoft-Cortana-Intelligence-Suite, which is mainly used to determine optimal planting dates for crops around the world such as India and Colombia. In addition to this, agriculture 4.0 also includes unmanned aerial vehicles and drones, which are used in the identificationof weeds, and robots that help farmers to milk the cattle and remove weeds. As a result, agriculture 4.0 is increasingly growing its momentum, as it is found in India that businesses have recently announced investment of USD 9 million to develop technological capabilities so that Indian agriculture or business is able to transform food production effectively.

According to Eastwood et al., (2017) Stilgoe et al., (2013) the role of agriculture 4.0 is to ensure that the innovative design to improve the agricultural productivity and efficiency meets the needs of the society. It is also known as a responsible innovation, which is developed in the context of smart dairy farming with possible applicability to the other agriculture context. Agriculture 4.0, as a responsible innovation, is mainly anticipating effects on farms across the farming landscape throughout the food chain. It also measures effects on rural communities and the public as a whole, but sometimes it is difficult to analyze the anticipative impact because the responsible innovation process mainly includes the affected actors such as technology companies, farmers and local communities. The Agri-tech innovation project also adopts those structures that guide re-flexibility, which also include various opportunities to access mutually beneficial trajectories. The fourth agricultural revolution is also associated with many innovations, industrial farming inventions, and advanced agriculture. It is also an emerging field, which is interacting in a wider ecology of innovations.

3.3 Industrial Revolution

According to ErAnkurTyagi, (2017) the Indian agriculture has gone through major revolutions like the Green Revolution, which mainly focused on increasing the yield of rice and wheat. The sector also witnessed the White revolution for increasing the production of milk and the Yellow Revolution for enhancing the yield of oilseeds. The Blue Revolution also took place to increase the production of fish. As a result, India has become self-sufficient in the production of essential food crops and is importing vegetable oil and cereals. However, more advancement is witnessed in the agriculture sector in the form of Genetic Engineering, which has increased the agriculture production by using trans-gene crops, vertical farming, hydroponics, greenhouse, aeroponics, and improved hybrid crop varieties.

Martin, (2016) Zambon, Cecchini, Egidi, Saporito and Colantoni, (2019) propagated that the first industrial revolution took place during the period 1760-1840 or in the year 1780 with the invention of the steam engine. It highly helped the agriculture and numerous industries like the textile industry. The second industrial revolution began around 1870 to 1914 that is after 30 years from the first revolution and led to the innovation of electricity. It helped in electrifying the factories resulting in mass production, the introduction of railways, and the invention of synthetic dye. The third revolution began between 1950 and 1970 that is during the late 1960 era, and led to the introduction of first programmable logic controller (PLC). It helped in the automation of products using electronics and information technology (IT). The fourth revolution took place in the year 2011 when Germany introduced computerization into the production process, which brought digital culture and cybernetics. ManavGarg, (2019) examined that the industrial revolution 4.0 brought the digital revolution in the agriculture sector and has transformed the farming process everywhere including India. For example, the use of connected portals enables real-time communication and provides instant responses to farmer queries resulting in faster negotiations and ensuring the best deals to farmers.

3.4 Agriculture 4.0 and the Virtual Object Structure

As per Tom Gresham, (2019) points of view, corporate sponsorship is termed as the marketing practice through which a business provides financial aid to an event, institution or project related to the agricultural activity.Kimberlee Leonard, (2018) examined that the corporate sponsorship involves different types and formats and may be given to the beneficiaries in the form of tiers of sponsorship, which mainly involves the provision of monetary help by the business at different sponsorship levels. The sponsorship is also done by using cash sponsors in which the agriculture sector pay money to get involved in the events like the Agricultural Machinery Exhibition.The in-kind sponsor contributes towards the corporate-centeredservices or provides products in exchange for cash for promoting the agricultural events and agro-trade fairslike KisanMela. Additionally, agricultural sector media sponsoring activity is performed by the corporates to advertise the event through television, radio, print, and social media channels.Additionally, Zambon, Cecchini, Egidi, Saporito, and Colantoni, (2019) examined that the Cyber-security, cloud computing, big data, and digital twins are used as open source technologies and updated concepts in Agriculture 4.0. Erik Gillam, (2018) examined that cyber-security helps in protecting the information that is collected by the farmers regarding agriculture and provides protection from the hackers.

Choudhary, Jadoun and Mandoriya, (2016) analyzed that cloud computing provides relevant farming information to the farmers with the help of shared resources, software over the Internet, which results in the promotion of digital farming. For example, the use of agriculture 4.0 technologies like cloud computing has helped in the overall development of the Indian agriculture sector. Moreover, due to digital transformation technologies, food grain production has increased to 271.98 million tonnes in the year 2016-2017 from 252.23 tonnes in the year 2015-2016.Nick Piette, (2018) Verdouw, KruizeWolfert and Chatzikostas, (2017) examined that big data helps in the creation of digital information, which increases the volume, variety, velocity, and veracity of the farming process.

Verdouw, KruizeWolfert and Chatzikostas, (2017) examined that digital twins are technological applications, whichrepresent a physical object in a digital format. The application helps in removing constraints related to farm place, time and human observation. It also allows remote monitoring, supervision, and coordination regarding the conduction of farm activities. Additionally, Porter and Heppelmann, (2014) examined that the sensors, processors, digital communication, data analytics, large memory storage system, software-defined features, and other technologies are used in agriculture to help the farmers. As a result, crop cultivators are able to make better decisions regarding the farming process. AyushmanBaruah, (2019) analyzed that the companies in India are using sensors and different IoT tools for conducting crop monitoring and soil health maintenance processes.Demiryurek, Erdem, Ceyhan, Atasever and Uysal, (2008) examined that people form an important part of agriculture 4.0 to collect, process, transmit and disseminate data. It also involves the use of various processes like generation, conversion, storage, recovery, amalgamation, dissemination, and deployment so that the adequate systems of operations, control, and management related to agriculture are developed.

3.5 Concept and Evolution of Agriculture 4.0

Dung and Hiep, (2017) propounded that agriculture 4.0 plays a major role in farming growth, maintaining of environment and conducting other sustainable activities. It provides sustainable resources and is highly essential for agricultural advancements and progression. The evolution of agriculture 4.0 took place in five stages in which agriculture 1.0 is termed to be the first stage of the revolution. It began in the early 20th century and was recognized as a labor-intensive sector with low productivity levels. The second agriculture revolution 2.0 took place in the late 1950s and is mainly identified as the era of the Green Revolution. During this stage, agronomic management practices were done by using a supplement like nitrogen and new agricultural tools such as synthetic pesticides, fertilizers, and advanced machines. As a result, the production of the farm increased and growth was witnessed in the returns to scale at all the levels. The third revolution 3.0 mainly focused on reducing the cost and increasing the profitability, which resulted in the development of differentiated products and enhancement of quality of agricultural production. The fourth agriculture revolution 4.0 integrates internal and external networking operations of farming and provides a digital form of information to all the partners like suppliers and end customers. It also transmits process and evaluates the data so that farmers use relevant facts in the conduction of different agricultural processes. Among the major components that are used in agriculture 4.0, it mainly includes IoT sensors, which provide information about soil fertility and plays a critical role in the modern farming process. It also includes Light Emitting Diode (LED), which promotes indoor farming and another component such as Robotics, which accomplishes the tasks that are to be performed by farmers. It also includes analytics, which helps in evaluating and providing information about farming trends, solar cells, which derive power from solar panels, drones and satellites, which in turn collect data on conduction of farm vegetation. It makes way for Agriculture 5.0, which is mostly based on the use of robotics and artificial intelligence to enhance the agricultural processes. For example, the introduction of agriculture 4.0 has helped the farmers to conduct farm practices adequately with the help of innovative services provided by companies like Ecozen. The company provides Ecozen solutions to farmers, which are solar power based irrigation and cold storage devices. These devices help the farmers to conduct irrigation farming practices and store crops in cold storages without the use of electricity. As a result, the farmers are able to conduct farm practices adequately and store the farm production adequately (Seth andGanguly, 2017).

3.6 Theories and models of Digital Farming

Ozdogan, Gacar, and Aktas, (2017) examined that the agriculture sector has been changing and becoming a knowledge-intensive industry by transferring from traditional production processes to the modern and innovative production processes. The farmers that are practicing farming activities have witnessed new paradigms in the agricultural sector in the form of water saving procedures, conduction of intelligent agricultural practices, production of high-quality, efficient and non-polluting farming culture. It has further led to the implementation of precision agriculture, which uses computer and communication technologies to enhance the profitability and sustainability factors in farming. It creates new opportunities and makes way for digital agricultural practices, which are also known as information-based agriculture model. It helps the process of interpreting the digital data related to farm production and administration.

Singh, Squire, and Strauss, (1986) examined that the models of agricultural evolution compromise of the frontier model, conversation model, urban-industrial impact model, diffusion model, and high-payoff input model. The Frontier model is based on the intensification of land by conducting pioneer settlement. It provides a shift of agricultural process from Neolithic forest fallow systems to short-fallow systems. The Conservation model of agricultural evolution describes the evolution of livestock husbandry and advancements in the crop in the English agricultural revolution to soils exhaustion represented by German chemists. It lays focus on recognizing local learning and conducting local resource management process. The Urban-Industrial Impact Model explains the geographical variations and provides information related to the farming system and productive labor in the industrialized sector. The Diffusion model is related to the land and labor productivity facts present between the farmers and different regions. The High Payoff Input Model is related to the conversion of urban-industrial impact and adoption of a new perspective in the 1960 era.

3.7 Opportunities for Farming 4.0

Von Braun, (2007)Verdouw, Wolfert, Beulens andRialland, (2016) analyzed that the agriculture 4.0 has been responsible for making provisions for the effective use of pesticides, fertilizers, water supply, which have increased the food supply chain value. The Internet of Things (IoT) has further allowed the virtualization of the operational management processes, which enhances the supply chain management in the food companies by providing food safety and sustainable food supply chain requirements. It also helps in conducting urban farming and produces 100 times more food in comparison to conventional farming methods. Additionally, with the help of agriculture 4.0, the framers will be able to produce 70% more food by 2050, which will resolve the problem of food scarcity and revolutionize the entire agriculture value chain. It will further lead to the automation of skills of the farmers through which they will be able to conduct farm activities remotely by using technological and biological information correctly. Additionally, the IoT technologies will help to establish a correlation between the various facts and provide relevant insights about the food production processes.

Ulysses Mello andSriramRaghavan, (2018) examined that IBM's 'Watson' has collaborated with The Weather Company and working groups from IBM Research-Brazil and IBM Research-India to develop agricultural based tools. These tools will be using Artificial Intelligence (AI) to provide farming solutions to the farmers and help them to make proper decision regarding the crops.

Rai, (1999) Tian, (2016) examined that remote sensing presents a tremendous opportunity, which helps in establishing interactions between the farmers, marketers and farm experts by transmitting information using radiation through the atmosphere. Whereas, Geographical Information System (GIS) helps in manipulating the databases so that relevant information is gained in real time, another opportunity in the making is the use of Blockchain in agriculture, which helps in securing agriculture value chain by interlinking the farming and food supply chains. For example, AgriDigital in India conducted

23.46 tons of grain sales using Blockchain technology. Moreover, the use of technological advancements also helped in conducting desert farming and using seawater for agricultural purposes. Agriculture 4.0 also provides sustainable packaging options by making provisions for bio-plastics. It also enhanced other innovative procedures like 3D printing of foods, cultured meat and genetic modifications, which have made the farming processes more profitable, efficient, safe and environment-friendly.For example, due to the introduction of agriculture 4.0 into the Indian farming culture, the use of technology is done to detect animals by using automatic feeding machine, which is based on Radio Frequency Identification (RFID). The system allows the farmers to track, and position objects in the agriculture sector. The application is used by the farmers in India for tracking of Cereal Crops in the farming area. Additionally, farmers in India are using new technologies like drones and robotics to improve farming practices and tackle the climatic changes effectively. In respect to this, devices like Skymet Weather services are used to monitor and predict the weather so that agri-risk solutions are availed at a higher speed.

3.8 Challenges of Farming 4.0

Tejas Patel, Sanjay Shekhawat, (2017) propagated that adequate implementation of the digital framing 4.0 faces a number of challenges. The major challenges faced in the implementation of farming 4.0 include standardization issues in the different processes and systems in India in a unified process. Moreover, the inability of farmers in India to invest in the implementation of new technological process and adopt modern means of farming equipment lays hindrances in the adoption of farming 4.0.The implementation of the Internet of Things (IoT) applications in the rural areas and different regions of India in a uniform manner is highly difficult, which reduces the agriculture 4.0's ability to exchange and analyze data. Additionally, negative farm household characteristics in India, lack of education, large family size and gender discrimination affect the adoption of new technologies introduced by farming 4.0 unconstructively. The farm size also plays a direct impact on the deployment of modern advancements. If the farmers have large farms, they are interested in employing farming 4.0 technologies, whereas small size farmers do not prefer to invest more in the conduction of the agricultural process. The farmers in India also face issues related to climate change, stressed natural resources, and reduction in agriculture manpower, which impacts the adoption of farming 4.0 negatively. For example, 80% of the deforestation activities are done by taking agricultural concerns into consideration. The climate change affects the precipitation, drought, and flood, which reduces the farming yields and results in the depletion of groundwater, and soil degradation. Food wasting is also regarded as a major environmental threat, which makes 800 million people go to bed hungry every night. The survey reveals that about 33% to 50% of the food produced by farmers at global levels never gets consumed and is wasted, which accounts to more than $1trillion loss (Mena, Adenso-Diaz & Yurt, 2011).

3.9 Remote sensing and GIS application in agriculture

As per Patra, (2010)Kiffer and Lillesand, (1999)points of view, remote sensing is the science and art of obtaining information about an object area and phenomena with the help of analysis of data, which is acquired by a device. It is generally referred to as the use of aerial sensor technology to identify and classify objects on Earth, which are related to the propagated signal such as electromagnetic radiation emitted from the sun, and the satellite itself. In a modern era, remote sensing is referred as a center, which is used with the help of an optical instrument such as a camera that is placed at a satellite to revolving around the earth by taking the images after a specified period of time. It may also involve digital images, which will be transferred with the help of satellite to the receiving station at Earth. Remote sensing is a multi-disciplinary science, which mainly includes a mixture of various disciples such as optic photography, computer, electronic, telecommunication, satellite launching and many more. All these technologies are integrated and act as a complete system, which is known as a remote sensing system.

Sivakumar and Roy (2004) examined that remote sensing is digital imagery of the data and is available in a digital format, which plays an important role in the successful operation of the entire remote sensing area under the system. Focusing on components of remote sensing process, it mainly includes an energy source, radiation, and atmosphere, interaction with the target, recording of energy by sensor, transmission, reception and processing, interpretation and analysis and application.

According toLo and Dyueng, (2002) Sabins, (2007) Geographic Information System (GIS) was firstly developed in 1960 with the development of the computer. At this stage, it was no more than a set of innovating computer-based applications for processing the data, which was mainly used in a smaller number of government agencies and Universities. In the present time, GIS is known as an important field in academic, public utilities and industries. It is one of the fastest growing sectors along with the development of computer industry that mainly deals the issues of space and time. According to United State Geological Survey, (1997) the geographic information system is defined as a computer system, which mainly capable of assembling, storing, manipulating and displaying geographical information or data, which are identified based on their locations. As a result, geographic information system helps to collect, store, retrieve spatial information and display all these information with the help of shape and text to meet certain conditions by clarifying the relationship between the spatial data. The software that is used for GIS in India includes ArcGIS, SuperGIS, and Geomedia. To analyze the application of Geoinformatics with the help of remote sensing and GIS in the field of agriculture, it mainly analyzes and visualizes agriculture environment, which is beneficial for the agriculture community as well as the industry. It also plays an important role in agriculture by helping the farmer in increasing production by reducing cost and managing their land effectively. There are various natural parts in agriculture, which cannot be controlled, but they can be better understood and managed with the help of remote sensing and GIS for crop selection, soil amendment, requirements of water, estimation of crop yield, and analyzing the impact of disease, erosion identification and its remediation.

According to Rai, (2016)Geoinformatics such as remote sensing and GIS help in analyzing crop indices with the help of satellite imageries or pictures that are arranged in columns or rows but for this functionality, remote sensing data is most suitable for different operations between bands. Looking at the principles in these operations, it mainly performs mathematical and statistical expression on the pixel. Remote sensing and GIS also help in analyzing the growth of crop by effective utilizing of space borne multispectral data for effective estimation of crop and production. It also includes a hand-held sensor for crop growth modeling that has encouraged the use of remote sensing technologies. Furthermore, vegetation indices are determined with the help of spectral reflectance measure, which is the most reliable method for effective assessment total dry matter, leaf area index and health of vegetation and productivity.

According to Sultana, (2014) remote sensing and GIS also help in identifying the health of the crop and detecting the damages with remote sensing data by estimating the loss of leaf area. GISmainly uses land and land cover mapping, which compiles identification of surface feature at various scales such as forest, hills,and rivers. GIS and remote sensing also help in preparing land use and land cover. Remote sensing is better the manual survey in terms of cost and manual error. In addition to this, image collected from the satellite can be acquired by satellite at regular intervals, which cannot be analyzed by the survey on a regular basis. Remote sensing technology is also useful in carrying out crop survey mapping, which is strongly related to canopy parameters, which are represented as a growth stage of growth. GIS covers data layer, which is also helpful in analyzing the association among crop insurance companies, seed and fertilizer companies, farm chemical companies, libraries, universities, central and state governments.

3.10 Research Gap

Based on the above-detailed literature review given by many scholars and researchers, it was examined that the new technologies incorporated in agriculture 4.0 are revolutionizing the future of food. However, a number of challenges like lack of standardization, lack of financial resources to implement the advanced technologies and so on are found in the implementation of agriculture 4.0 in Indian farming culture.The current research helps in filling the gap that exists in the academic field and provide relevant insights into the industrial and agricultural revolution. The study also describes agriculture 4.0 and the Virtual Object Structure along with the concept of corporate sponsorship, people, process and system. It will also enable researchers to get more insights related to the theories and models of digital farming so that the lack of information in the previous studies conducted by researchers will be filled adequately.

3.11 SUMMARY

The research provides a brief overview of the different aspects of agriculture 4.0 and its relevance in the current digital world. The study also provides details about the significance of farming 4.0 and identifies the opportunities, and challenges faced by the Indian farming industry. The remote sensing in agriculture helps in forecasting the crop production, making an assessment of crop damage, conducting horticulture practices, analyzing crop systems and identifying plantation and harvesting dates. Geographic Information System (GIS) helps in the creation of visual form of data and performs analytical activities. It combines the hardware, software, and data so that relevant information is provided to the farmers. As a result, the farmers are able to take correct decisions regarding the conduction of farm practices. Additionally, the research also provided insights related to the issues of lack of finance, lack of knowledge or learning, negative farm household characteristics and others that are faced by farmers in India to implement farm 4.0 technologies. It also highlighted the opportunities and benefits provided by digital farming 4.0 like securing agriculture value chain, providing relevant insights about the food production process and others.

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