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Use of GIS, Remote Sensing and Artificial Intelligence in Smart Agriculture

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Abstract

Smart Agriculture or Precision Farming is a modern-day innovation to optimally utilize the resources such as land, water, fertilizers and pesticides to reduce the cost of farming while also increasing the crop yield and therefore increasing the farmer's income. GIS and Remote Sensing aid in Smart Agriculture by pin-pointing the areas where certain action, such as irrigation or levelling, needs to be taken. Artificial Intelligence increases the decision-making potential by analyzing the data and generating and predicting results.

Key Words: Smart Agriculture, Precision Farming, GIS, Geographic Information System, Artificial Intelligence, AI, IoT, Internet of Things, Sensors

1. INTRODUCTION

Agriculture is the backbone of many Asian and European nations, including India. As the problems such as population explosion, shrinking of farmland areas, increased frequencies of natural disasters such as floods and droughts and other geo-political reasons are disrupting the global supply chains, the global food crisis is tightening its grip globally.

Smart agriculture steps in as a silver lining to answer such problems. While farming is limited to the growing of foodgrains, smart agriculture addresses the efficiency of an end-to-end process starting from acquiring seeds to the selling of foodgrains.

Geographic Information System and Remote Sensing employ modern-day satellite images, aerial drone images and other sensors to minimize the resources used and maximize the yield.

Artificial Intelligence (AI) and the Internet of Things (IoT) help in precise calculations and predictions, such as, calculating the time and amount of irrigation needed in different grids of the same field. This approach is far superior to the traditional approach of irrigation i.e. the flooding method of irrigation, which does not consider the parameters such as the slope of the ground and relative wetness and dryness of different grids or areas of the field.

GIS (Geographic Information System) can be understood as a system that creates, analyses and manages all kind of maps [1]. AI (Artificial Intelligence) can be defined in number of ways. One of the most popular definitions of AI is " It is the science and engineering of making intelligent machines, especially intelligent computer programs. It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to methods that are biologically observable."[2]. Smart Agriculture refers to the use of modern technologies such as IoT (Internet of Things), Sensors and data driven approaches including satellite images or drone images to maximize the yield and minimizing the inputs. Combining Smart Agriculture with AI and GIS may further refine the outcomes and result in increased crop yield and increase the farmer's income.

Smart Agriculture is a relatively new philosophy in the field of agriculture. This is quite optimistic approach which can revolutionize the world by fighting global food crisis as well as increasing the farmer's income. The current approach in smart agriculture is confined to the use of smart sensors which employs the connectivity between them to transfer data and infer the analysis, The whole environment is known as IoT or Internet of Things. This approach, however, efficient and accurate, is not cost effective. Usage of satellite data can significantly reduce the cost of smart agriculture.

Implementation of Smart Agriculture in a cost-effective and simple way can be achieved via the use of GIS and AI. Current scenario only enables rich farmers to employ such methods and are more focused on setting-up sensors, which can only serve a limited area. GIS and AI, increses the accessibility of Smart Agriculture. This can be done by focusing more on satellite images rather than expensive sensors. By following such method, large areas can be covered at a time. Large group of farmers can pool the expense, making this method more affordable and accessible. GIS and AI also helps in conserving the environment by reducing the exploitation of natural resources and minimizing the use of pollution causing agents. Employing

modern engineering and management tools, such as AI and GIS may further maximize the output and profit margin. Hence, maximizing the yield and minimizing the use of resources.

1.1 TECHNOLOGIES USED

GIS and Remote Sensing go hand in hand. With the aid of Artificial Intelligence, which encompasses data analysis and IoT, it becomes extremely efficient system which can single handedly eradicate the menace of global food crisis. World population is projected to grow to 10 billion and is expected to consume 50% more food than used to be consumed in 2013 [3]. Artificial Intelligence can help us achieve this goal by efficiently utilizing the computational power to detect changes in the terrain by optimum usage of change detection algorithms. Remote sensing data collected from sensors and satellite images can be mapped precisely to identify the minute details such as the problem of weeds, pests, water-logging, sodicity, unwanted slope and lack of fertility.

1.2 GIS APPLICATIONS

GIS applications help us create and edit maps and satellite images. These functionalities can be used in smart agriculture. Temporal satellite images can be fed into the system and change detection algorithms can be applied. This will enable the user to identify the problem areas and to analyze the corrective actions needed. It can also apply various indices

1.3 ARTIFICIAL INTELLIGENCE

Artificial intelligence leverages computers and machines to mimic the problem-solving and decision-making capabilities of the human mind [4]. It can harness the capabilities of computational powers to analyze the changes in the satellite images of the same area taken over the period .

2. METHODOLOGY

Modern day satellite images can be used to detect temporal changes on the given landscape, which can further be used to generate patterns.

Data collection can be done using the online web application, known as Landsat Explorer which is a module of ArcGIS online. This tool can access the satellite images of Landsat since 20th April, 1976 till present date. Image rendering can be done in several combination of bands, listed as agriculture, natural color, color infrared, vegetation index, moisture index, water index, burn index, SAVI etc.

Image analysis and change detection can be done using the built-in functionality named as “Swipe”, which interactively compares the two different satellite images of same area, taken on different dates. Use of artificial intelligence, enhances the capabilities of this tool which allows us to set the desired level of changes (both positive and negative) which needs to be highlighted. Repeating this process using the temporal images at regular intervals will highlight the area that need to be focused on.

The highlighted areas may represent the parts of the land that are experiencing dryness, excess moisture or waterlogging, weeds or scrubs etc.

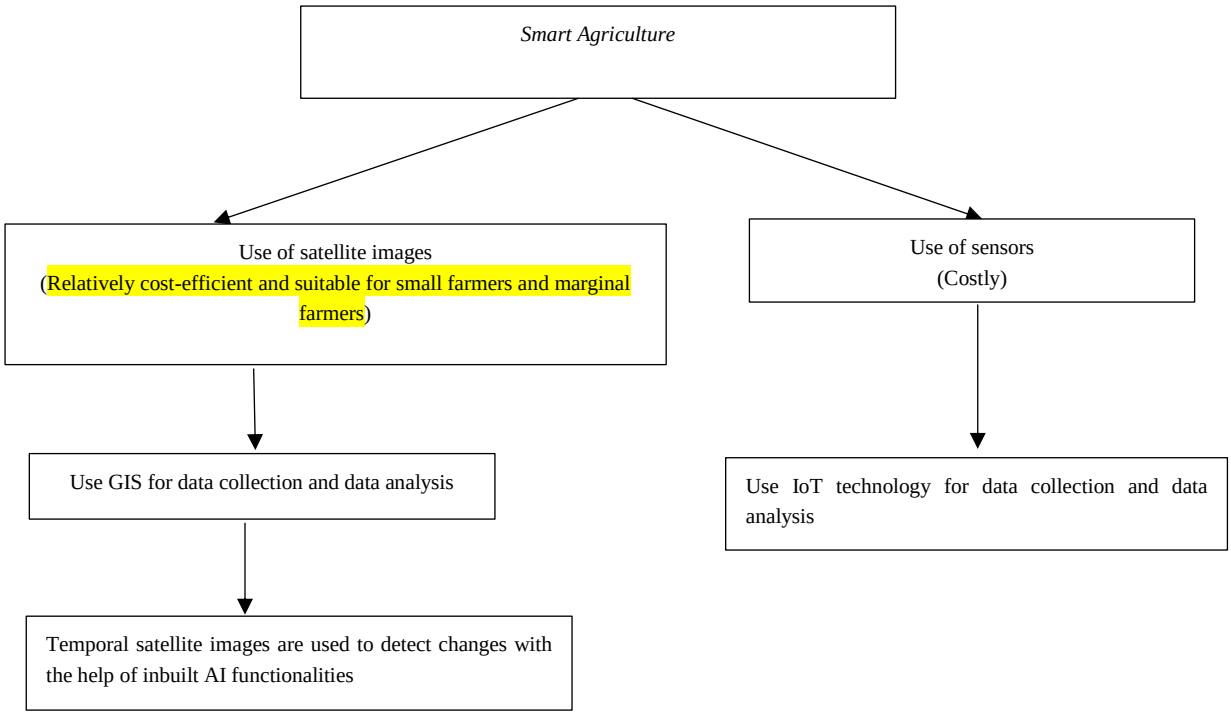

Fig: 1- Process of use of GIS and AI in Smart Agriculture

Conclusion

By repeating the above processes for 5 to 10 times, using different satellite images for the same location, a fairly good idea can be achieved regarding the changes in landscape and structures of a given land. These changes can be documented and used for the analysis of actions to be taken.

The corrective measures may include, calculation of amount of irrigation, calculation of amount of fertilizers, calculation of amount of pesticides, calculation of amount of levelling etc. that is needed.

Smart Agriculture is the need of the hour when the world is struggling with global food crisis. This is the answer to shortage of foodgrains due to increase in population and shrinking of farmlands.

With the efficient use of engineering, technology and management, the yield and income are increased and usage of natural resources and pollution is decreased significantly.

Present day's Smart Farming is rendered useless in developing countries like India as the small and marginal farmers are not able to afford expensive sensors. Satellite images can reduce the cost of Smart Agriculture by covering larger areas at a time and hence pool of small and marginal farmers can efficiently reap the benefits of modern technology.

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