1. AI in Agriculture

Agriculture and farming are one of the oldest and most important professions in the world. More than 60% of the world's population depend on agriculture for their livelihood. Worldwide agriculture is a 5 trillion dollar industry. This shows that agriculture is the most promising investment. However, food production and management have become one of the most crucial challenges of global concern.

According to recent UN forecasts, the global population will grow from 6.8 billion to 9.1 billion by 2050 demanding a 60% increase in global food. With the increase in population, starvation, hunger and famine are the challenging concerns of the food industry. According to FAO, A total of 842 million people are estimated to be suffering from chronic hunger and one-third of the developing world's population suffers from insufficient nutrients leading to various kinds of diseases and even early deaths.

Another alarming challenge for the food industry is global warming. Climatic factors such as rainfall, temperature, and humidity are changing day by day, deforestation aand pollution are increasing that result in climatic changes and global warming.

Down the ages, agriculture has gone through many reformations with the advancement in agricultural technologies. The introduction of various technologies is tackling various challenges faced in the agriculture industry. Recently, with the commencement of Artificial Intelligence, the agriculture industry is undergoing a new phase of the revolution. AI along with new technologies show promising steps towards solving the global challenges of the agriculture industry.

Due to this reason, investment in AI in agriculture is increasing.

According to a report by Prescient & Strategic Intelligence, AI in agriculture market share generated a revenue of $672 Million dollars in 2019 alone and this is expected to increase up to $11.2 Billion dollars by 2030 with a compound annual growth rate of 30.5%.

The highest CAGR for AI in the Agriculture market is expected to be shared by drone analytics. However, AI can be implemented in various agriculture lifecycle processes.

Most of the recent development in AI has been driven by Machine Learning and Deep Learning. Both Machine Learning and Deep Learning allows a computer to learn from data. Machine learning is the subset of AI that involves the use of statistical algorithms to allow machines to learn patterns from data. Deep learning is a subfield of machine learning that uses neural networks to find patterns from data. Neural networks are just an interconnected structure of nodes aimed to simulate the operations of a human brain.

Agriculture Life Cycle

The agriculture life cycle includes various steps from the preparation of soil to the storage of the crops. AI along with emerging technologies can enhance the overall process of the farming industry.

Figure: Agriculture Lifecycle

The first step in farming is the preparation of soil to make the field cultivable. Soil DNA analysis can help farmers to analyze the status of the soil, advanced driverless tractors can automate the task of preparation of soils. With modern tools and technologies, farmers can check the quality of seeds and identify the sequence of seeds for planting in the fields.

These plants need 3 main nutrients: nitrogen, phosphorus, and potassium in the soil. The deficiency of any of these can lead to poor quality of crops. It is necessary to add the right amount of fertilizer to the crops.

These crops need irrigation facilities at a specific period of time. The robotic automation system can manage when and where to irrigate and how much depending on the type of crop.

Uncontrolled weeds in the field absorb nutrients from the soil causing nutrition deficiency for the plant. Hence it can reduce the yield and increase the production cost.

Weed detection and robotic automation can help manage the process of weed removal in agricultural fields.

Finally, at the end of the season, the ripe crops should be collected and stored.

Robotic automation for crop harvesting can save time and manual efforts, improving the overall efficiency and cost reduction for harvesting of the crops.

The harvested crops are required to be stored in a proper place and proper condition so that it is suitable for distribution and future use.

We see that most of the tasks in the agriculture life cycle can be enhanced with robotic automation systems and advanced AI techniques. We will discuss how AI can help in each of the agricultural lifecycle steps in more detail in the later sections.

Sensing Methods and Precision Agriculture

Inter and Intra field information helps farmers to know insights about their farmland and help them make better decisions. In this section we will discuss various kinds of sensing methods such as IoT sensors, satellites and drones and how they help in precision farming.

Obtaining different kinds of field information such as moisture content level, temperature, pH and humidity, etc are the key of smart agriculture. The Internet of Things encompasses various field sensors and distributes the data gathered by them on the internet.

IoT systems allow direct integration of field information into computer-based systems that enhance efficiency, maximizes crop productivity, minimizes waste of energy, and reduces human resources through real-time data collection, storage, and analysis of the data.

The investors in the agriculture industry find IOT to be a promising technology. **By 2025, IoT in the agriculture market is expected to reach 48.7 trillion dollars with an increase of CAGR of 14.7 percent.**

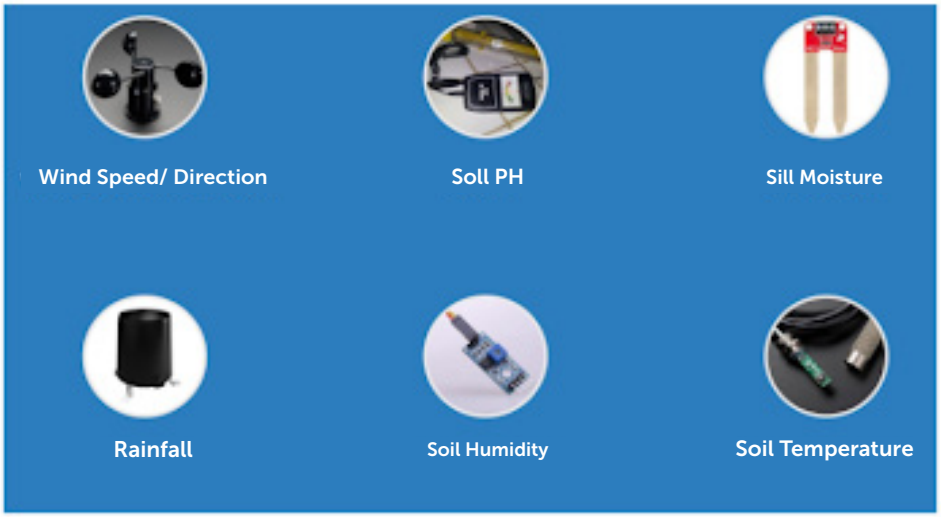

Figure: Different types of Agriculture sensors

For the agriculture sectors, there are various kinds of sensors available for farmers.
Some of them are as follows:

- GPS/Location sensors can track the position and location of plants
- Temperature sensors can get information about the soil temperature
- Wind/direction sensors can give information about the wind direction and speed
- pH sensors can give information about the soil pH.
- Soil moisture sensors track the information about soil moisture content.
- Rainfall sensors can track the rainfall information.
- And finally, smart cameras can capture the image and video of the field.

Figure: Data Analytics and Field Insights

The sensor data collected by different sensors are sent to cloud storage for further processing with the help of cellular or wireless technology. The data stored in the cloud are analyzed by data analysts using different AI tools.

- Based on weather data along with other climatic data, farmers can predict weather
- Based on moisture and soil temperature data, they can get insights about irrigation status for the plants
- Based on pH data, farmers can get insights about the fertility of the soil.
- Smart cameras enable monitoring of farm 24/7 and alert farmers in case of anomalies.

Smart Greenhouse is an example of AI and IoT based farming. In a greenhouse, farmers optimize plant growth by regulating heat, humidity, and light. It is also necessary to supplement all plants with accurate amounts of water and nutrients so that all plants are grown at a faster rate increasing productivity and efficiency. AI can give accurate results and can monitor the plant status from plant cultivation to harvesting.

The other type of controlled farming is vertical farming. Vertical farming is a method of producing crops vertically in stacked layers inside a building using artificial lights instead of sunlight.

According to Research and Markets forecast, vertical farming will grow to a value of 3 billion dollars by 2024. Vertical farming shows a promising future of investment because vertical farming is more popular in urban areas than in rural areas. There is a demand for fresh crops for consumers in urban areas and much time and effort is needed to meet the supply needs. Vertical farming is a solution to that problem. Furthermore, vertical farming requires much less land than conventional farming and indoor farming can be controlled using smart farming technology which can create perfect environments for plants that can improve overall efficiency.

Plenty, a vertical farming company claims their smart indoor farming is 350 times more efficient than traditional farming.

Similar to greenhouse and vertical farming, aeroponics, aquaponics, and hydroponics farming is getting popular. They all operate in a controlled environment thus sensing and monitoring the system is much easier with recent technologies. In a controlled setting, it is easier to implant IOT sensors and to monitor plants, however in the large outdoor fields, this is not feasible. Remote sensing methods are a rescue in such conditions.

Remote Sensing

Remote sensing methods allow farmers to collect and map information about topological, spatial patterns, and temporal variability of the crops of a large field.

Spatial variability measures the changes in the land and its properties. Spatial variability helps to identify the patterns in the crop fields and the areas that are of economic importance to crop production. This information can be used to customize the rate of fertilizers, herbicides, and pesticides in response to these patterns.

The farming area also changes across time due to various seasonal changes such as weather patterns throughout the year, changes in temperature and differences in total rainfall each growing season. These kinds of changes within that area is known as temporal variability. Temporal variability helps the farmers to plan the crops according to the seasonal changes.

Satellites can detect seasonal changes such as weather forecasting in the crop fields which are crucial for the farmers as they allow farmers to plan irrigation, pest controls, and application of fertilizers. These reports combined with machine learning techniques allow farmers for a robust forecasting and planning. Satellite imaging helps to create a yield map that can detect crop health and crop yield prediction. Artificial intelligence helps to enhance the information of satellite imaging which allows farmers for the targeted use of fertilizer, pesticides, etc.

Satellite sensors and imagery along with Artificial intelligence are being integrated with different agricultural companies that are helping farmers in various use cases. For instance, Farm shots is an agriculture company that uses satellites to monitor crop health. It measures the field variability and detects damages in the crops. It captures the field imagery and monitors them, recommends the treatment in case of any changes or anomalies and analyzes the results with artificial intelligence.

Another company that uses the satellite in agriculture is awhere. Awhere uses machine learning algorithms in connection with satellites to predict the weather. They also analyze crop sustainability and evaluate the farms for the prediction of disease and pests.

However, satellites have many limitations.

- They are costly.
- They require processing of a huge amount of data.
- And they give low resolution images.

Drone Mapping and Precision Agriculture

The alternative solution for satellites is drones.
Drones have many advantages over satellite images. They are.

- Drones are equipped with standard cameras that can capture high-resolution images

- Drones can also be equipped with multispectral cameras which can capture images that are beyond the visible spectrum.
- Due to higher resolution and lack of atmospheric distortions drone images will be better than satellite images.

Figure: Drone (Src: *pixabay*)

Drones are the major breakthrough in precision agriculture. Precision as the dictionary meaning is the quality of being exact and accurate. Precision agriculture is an agriculture management system that observes, measures and responds to the field variability for precise and accurate analysis of the crops.

Precision agriculture benefits the use of drones along with GIS technology to locate and the crop field which allows farmers to enable the optimal use of inputs such as water, fertilizer, pesticides, etc, and maximizes the yields from the farm.

Drone mapping is a method of precision agriculture which provides clarity to images. Drone mapping is a technique of acquiring hundreds of images and stitch them together to make a composite image. This mapping technique can be used to get insights about the crop field and crop health in a precise way.

Drone mapping techniques such as NDVI, Orthomosaic imaging, Prescription map and Surface model are used for various agricultural use cases. Softwares like Pix4D, Dronedeploy and agremo etc provide mapping from drone images. These kinds of drone mappings can be used for plant stress analysis, plant disease analysis, weed detection, drought analysis, water logging

analysis or to count the number of crops.

In the next section, we will discuss how we can generate these kinds of imaging and mapping techniques with Artificial Intelligence techniques.

Imaging and Mapping Techniques

Standard cameras can only capture visible light ranging from 400 nanometers to 700 nanometers. However, they may not always contain all the information about the particular object. There are cameras that can capture the colors which are beyond human vision. They are called multi-spectral and hyperspectral cameras.

A multispectral camera captures image data within specific wavelength ranges typically of 3-15 spectral bands across the electromagnetic spectrum. However, there are cameras that can capture hundreds contiguous spectral bands - such images formed by hyperspectral cameras are called hyperspectral images.

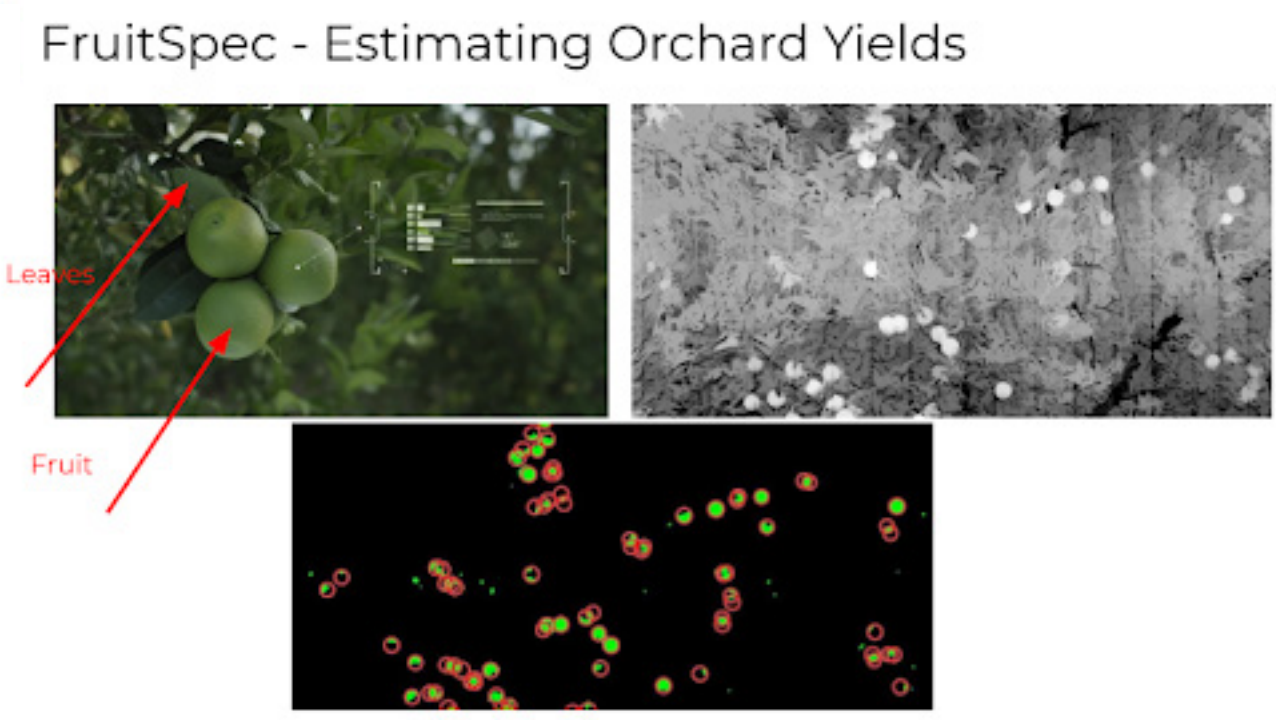

Figure: Hyperspectral Imaging

One of the applications of hyperspectral images is in crop yield prediction. In an orchard field, the fruits and leaves are both green in color. So, it is very difficult to distinguish between fruits and green leaves. FruitSpec is an innovative technology based on hyper-spectral imaging and deep learning algorithms. These methods enable farmers to distinguish between green leaves from green fruits in an orchard field and predict the orchard yield.

This helps farmers to generate meaningful information about the yield estimation at the beginning of the season and helps them to win the market. NDVI imaging can be used to measure the vegetative greenness of the plants.

It is observed that in a green vegetation chlorophyll absorbs most of the visible red and blue to make food and much of the near-infrared is reflected. In a stressed vegetation, plants not making food reflect more red and blue only less near-infrared is reflected back.

NDVI compares the reflectivity of NIR and red wavelength bands.

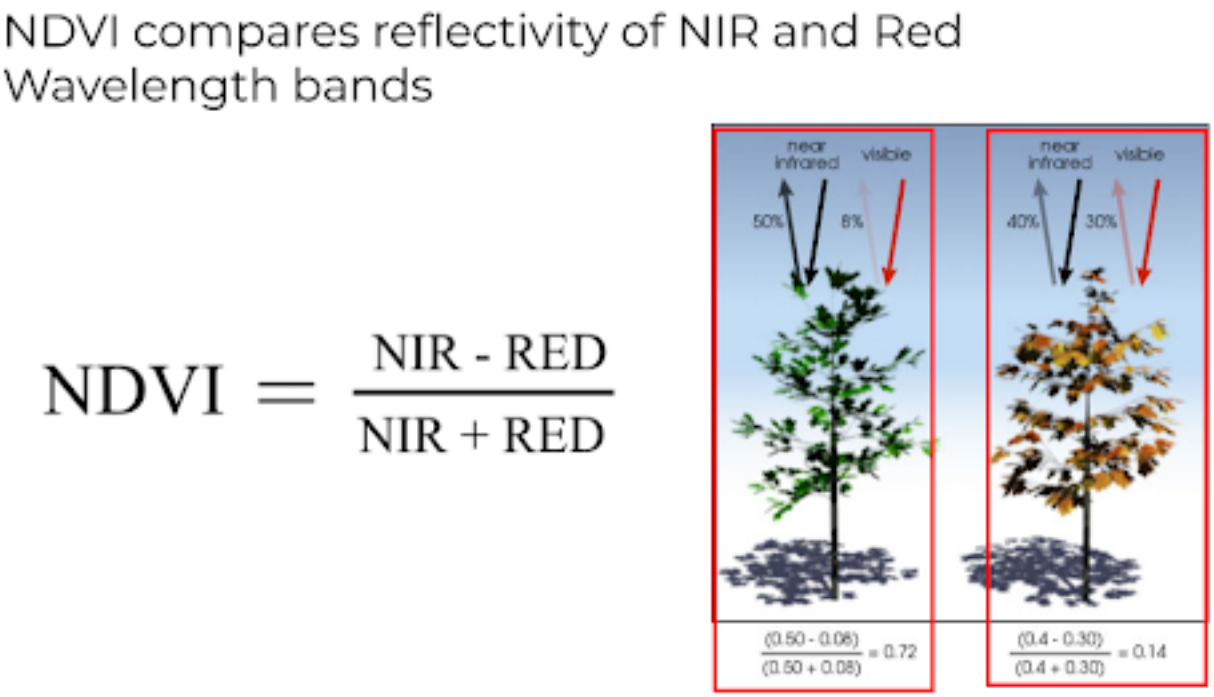

Figure: NDVI

In this image, we have two plants with their NIR and red wavelength, we can calculate NDVI for these two plants as follows.

In the Left image: There is a strong NIR reflection of 50% and Visible low reflection of 8% Therefore NDVI is close to 1 which shows the indication of a green plant.

In the Right image: There is a weak NIR reflection of 40% and strong Visible reflection of 30% Therefore NDVI is close to 0, which shows the indication of stressed plants.

We can use drones to create NDVI imaging of a field. NDVI imaging helps farmers to distinguish between a healthy plant and a stressed plant.

Orthomosaic mapping is an application of drones imaging where several images called orthophotos are stitched together. These images are much better than google earth images created

by satellites because drones provide better resolution images. These images can be processed with advanced computer vision and deep learning algorithms for the better understanding of the crops.
In the agricultural fields, different zones may have different requirements for fertilization. For example, there may be areas where there are enough soil nutrients and there may be areas where there are only little. So, variable-rate fertilization is required to solve this problem.

A prescription map allows farmers to get information about the soil requirements in the field. Prescription map takes in the geo-referenced data such as soil nutrient levels and historical yields and provides the variable-rate fertilization for the defined zones of a field. Drones can be used to create a prescription map for the given field. Different agricultural drone companies such as Delair, pix4D, etc are providing the prescription maps for the given field.

Land surface models (LSMs) are the key component of climate models. They are vital tools for understanding, projecting and predicting the dynamics of the land surface and its role within the Earth system, under global change.

Drone imagery can be used to develop Land Surface Models because drone images provide high spatial resolution data. And with improved data, models can be parameterized to reflect real-world systems.

The process of drone mapping with AI are as follows:

- At first, In data acquisition UAV multispectral images from drones are collected
- Then at initial Processing those Images Stitched together to make different types of map ping such as orthomosaic, NDVI or prescription maps etc.
- In the analysis part, information from those mapping are extracted to make classification, segmentation, and zonal analysis
- And finally, different kinds of visualizations are created for the inferred findings.

Disease and Pest Management

Disease and pest management is a crucial part of the agriculture lifecycle. In this section, let's discuss why disease and pest management is important and how AI can help in this regard.

Uncontrolled crop pathogens can lead to severe loss for farmers. According to the Food and Agriculture Organization of the United Nations (FAO), a plant pathogen named Xylella fastidiosa could cost nearly $104 million a year in wine losses in the California area alone.

Recognition and treatment of plant diseases thus crucial for farmers because it severely affects the crop yields. The population of the world is growing day by day. According to FAO, the population of the world is expected to be 9.1 billion by 2050 for which a steady increase in agricultural production of 70% is necessary.

However, between 20% and 40% of global crops have been lost annually to pests and diseases in the last 45 years.

There have been several approaches to address the plant disease diagnosis challenges. AI can help to tackle these challenges in the following ways:

- Computer vision-based smartphone application
- Drone mapping for identifying the area of crop disease.
- Satellite imagery analysis for a wider analysis

Computer-Vision based smartphone application

The recognition and treatment of plant disease are quite challenging because plant disease may erupt from different sources. One such case is because under or over-development of tissues or organs of the plants. The other may be due to necrosis or death of a plant's certain part.
And another could be the death of plant certain parts due to altered coloration in leaves and flowers.

It is inefficient for a JTA or a plant disease expert to go to the field and examine each plant disease separately. So, farmers need a generic and efficient method that can address the diagnosis of plant disease.

AI can solve the problem of identification and detection. The steps for plant disease detection using AI include:

- identification of a plant
- identification of a diseased plant and
- identification of the name of the disease.

At first, AI needs to identify the target plant for example: in these images, AI should separate the tomato, cabbage, and potato plant. So, data of different types of plants are to be collected and

trained for the identification of a plant.

In the second step, AI needs to differentiate between the healthy plant and the diseased plant.

And finally, an AI classification system can correctly detect the type of the disease.

A company named PEAT has developed an application for plant disease detection called plantix following this procedure.

Figure: Plantix - Plant Disease Diagnosis app

At first, the plantix application captures the picture of an infected plant. The advanced computer vision and deep learning techniques integrated in the application recognize the type of disease of the plant and list out its common symptoms. And furthermore, the application recommends the necessary solution for the disease based on the analysis of the symptoms.

Another plant disease detection application which can identify diseases in plants and recommend the treatment for the detected disease is Agrio.

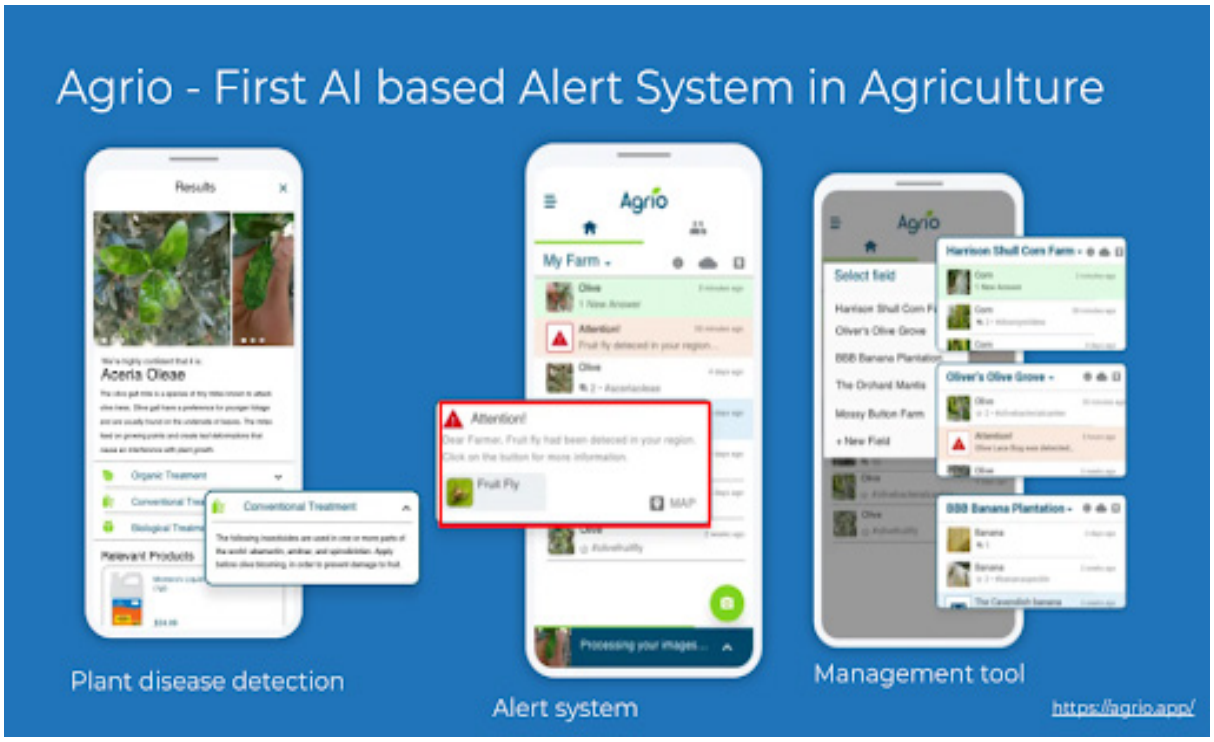

Fig: Agrio - Plant Disease detection and alert system app

Additionally, the application features an alert system to detect any insects or anomalies in the field. Furthermore, Agrio also introduces a management system for the entire crop field where the information can be easily distributed across the team of the farmers.

Drone and Satellite Based Plant Disease Management

The mainstream technology such as smartphone applications is focused on small scales where farmers can look after each plant separately. However, for a large-scale application, this solution is not feasible and farmers need advanced techniques.

One of such advanced methods is the application of multi or hyperspectral techniques with deep learning algorithms in drones or satellite imagery. Using integration analysis of satellite scales, plant disease detection can take effect on regional, national and global scales.

Agremo, is a leading drone company that uses drone mapping to detect plant stress and plant disease diagnosis.
Agremo disease detection analysis closely examines the entire vegetated area and evaluates its current condition. The report you receive will include the exact percentage and location of field zones affected by plant diseases caused by viruses, fungi, or bacteria.

The report you receive after performing plant stress analysis is a map that clearly indicates health and problem-causing areas of the field. By identifying zones of potential stress you get a chance to act timely with the most adequate measures and increase yield potential.

Pest Management

Now we will look into how we can manage pests with Artificial intelligence.

Figure: pest management

The approaches for pest control are physical, chemical, cultural, and biological methods.
In physical methods, farmers physically detect and manage pests.
In chemical methods, farmers use chemicals to control pests.
Land preparation or seed preparation can help farmers to manage pests culturally as well.
In Biological methods, insects such as beetles can be used as pest control for certain crops.

One example of a pest management system using AI is a company named Farmsence.io. Farmsense.io has developed a system that uses sensors in the field that detects insects in the field. If that insect is useful to the crop it does nothing. However, if that is a harmful insect, the system sends the data to the cloud, where it can be analyzed and take further action.

AI systems can help in the intelligent spraying of pests. In the next section, we will discuss how intelligent spraying can help in pest management.

Intelligent Spraying

Let's discuss how AI can help in intelligent spraying in the crops such as insecticides, pesticides, or fertilizers.

According to a research paper, An Autonomous UAV for Pesticide Spraying it is estimated that about 2.5 million tons of pesticides are used each year throughout the world and this amount is growing. In traditional agriculture, much of the pesticides are wasted during the spraying process.

The application of pesticides or insecticides causes soil and groundwater pollution, which is one of the most challenging global problems. Apart from that, spraying them has an adverse effect on farmers. Also, Traditional approaches of spraying pesticides can lead to over or under spray

ing for the crops and damaging the crop productivity.

The other challenging part of spraying is to tackle the problem of covering the large agriculture field and variable rate pesticide application.

Intelligent spraying is the solution to these problems. Intelligent spraying drones can cover a large area. These drones equipped with mapping techniques can identify the zones for the variable rate application of pesticides which overcomes the challenges of over and under spraying. Drones replace humans which eliminates the adverse effect on the health of the farmers. And intelligent spraying can spray pesticides or insecticides which helps in reducing soil and water pollution.

There are many companies that are manufacturing drones for intelligent spraying. DJI is a leading company in making intelligent spraying drones. Other companies include Parrot S.A, Precision Hawk Inc. AeroVironment, Inc., etc.

The global agricultural drone market is expected to grow at a CAGR of 31.1 percentage from 2019 to reach 5.19 billion by 2025.

These agricultural drones save up to 30-50 percent of chemicals and are 40-60 percent faster than manual spraying. Also, they are capable of conserving 90% of water usage in agriculture.

Intelligent Weed Detection and Herbicide Spraying

In the past, weed detection and removal systems were manual and required much human resources and time. The weed detection system is one of the most important solutions for non mechanized weed control.

Weed detection system helps in reducing or eliminating herbicide use, mitigates agriculture environmental and health impact, and improves sustainability.

The process of detection of weeds in the crops is as follows:
At first we can train the AI on various samples of weeds and the crop.

After training is completed, machine learning algorithms can identify weeds and label them as targets for spraying.

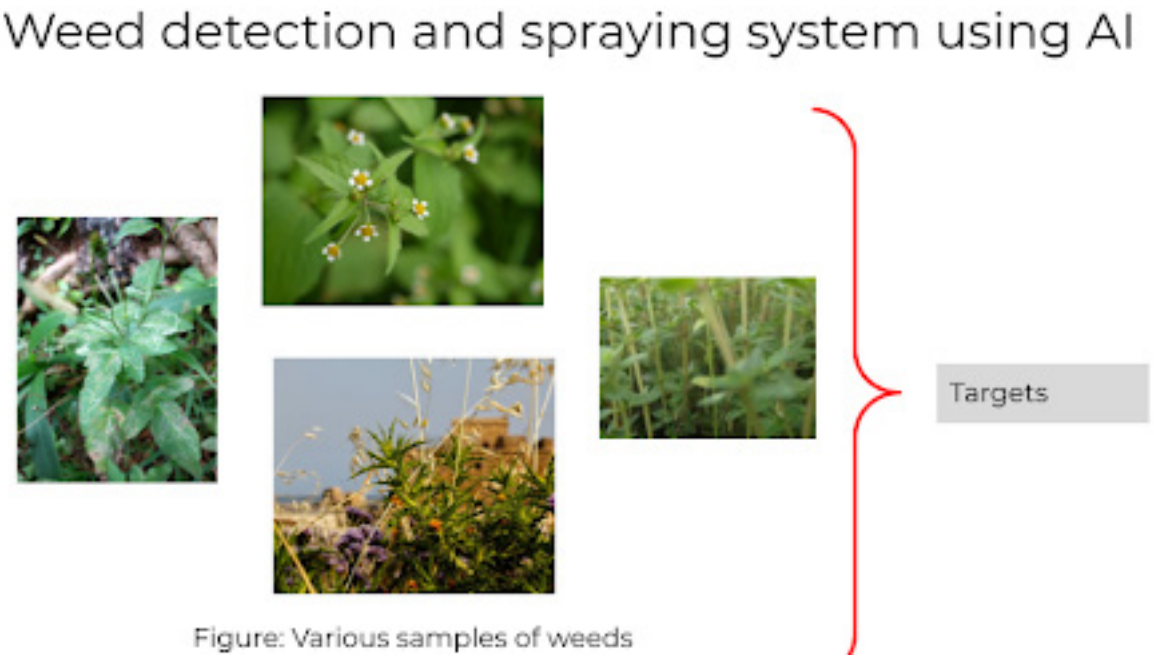

Figure: Weed detection and spraying system using AI

The intelligent sprayer equipped with cameras captures real-time images of the spraying area in the fields. And as soon as the camera captures an image, AI analyzes for the presence of the weeds and the robotic nozzles target those weeds with high precision and spray a herbicide dose that's adequate for the weed's age and size.

One of the applications of agricultural robots is in weed detection and removal. *Blue River Technology* has developed an intelligent precision weed control robot that can identify between weeds or crops. After identifying the target, it will then spray the appropriate herbicide to the weeds in a precise manner.

It is estimated that selective spraying of weeds can reduce the use of chemicals and it could potentially cut the global annual consumption of herbicides by up to 2.5 billion pounds.

Soil Monitoring and Preparation

Soil is a sink for heat, water, and chemicals and plays as an important medium for plant growth. It is a natural filter for water and it is a natural medium for the breakdown of wastes. The best soil is fertile, well-drained yet retains moisture, and gets enough air circulation which is needed for healthy roots. So the soil quality assessment is crucial in the agricultural process.

Soil degradation directly or indirectly degrades water and air quality and thus degrades the overall crop productivity and increase the cost of production of the crops
So sustaining soil quality is essential to improving agricultural productivity.

There has been various research on how to test the quality of the soil.

One of the measures of soil quality is Soil Quality Index. Soil Quality Index is used to access the soil capacity function. We can classify the soil as poor, good or very good on the basis of Soil Quality Index. To evaluate Soil Quality Index, we can measure soil physical and chemical parameters and screen them through machine learning algorithms such as Principal Component Analysis.

Another use of AI is in the identification of the right type of soil based on image analysis. Deep Learning can be used to classify the type of soil on the basis of images. Shinya Inazumi Ph.D. et all Developed an AI model that can be applied to make judgment on soil classification, that can identify images of clay, sand, or gravel.

Trace Genomics, a soil analysis company has come up with a solution for an in-depth analysis of the soil contents. In their approach, the users submit the sample of their soil to Trace Genomics and they provide an evaluation of pathogen screening focused on bacteria, fungi, and microorganisms. They have the interface to digitize the soil, decode the information from the soil patterns and make a concrete decision based on various machine learning analyses.

Soil Preparation

Soil quality assessment is necessary to measure the effectiveness of the soil in the field. However, soil preparation is necessary to make the field cultivable.

For plowing farmlands, tractors are widely being used as they make the whole process of land cultivation much easier for farmers. However, tractors have been driven by humans since their inception.

Self-driving tractors are a major breakthrough in the agriculture sector. AI along with a location tracking system can automate tractors to help them determine the path of the field and the efficiency they can be made more efficient without the need of drivers. Companies like John Deere, CHN, and Deutz-Fahr are already making big progress in the field of automation and self-driving tractors.

AI in Irrigation

Irrigation plays an important role in the agriculture lifecycle. Without irrigation, plants will lack water which is required for the plants to grow and overall crop yield is minimized.

Agriculture is estimated to account for over 70% of global water use. With food demands only rising, water use is expected to increase by 15% more to meet this demand.

The most popular irrigation techniques of today's era are:

- Localized irrigation
- Drip irrigation
- Sprinkler irrigation
- And center pivot irrigation

In localized irrigation, water is distributed under low pressure, through a piped network and applied to each plant.

Drip irrigation is a type of localized irrigation system in which water drops are dripped slowly to the roots of the plants.

In sprinkler irrigation, water is distributed in the field in the form of natural rainfall with the help of sprinklers..

And finally, in the center pivot irrigation water is distributed by a system of sprinklers that move on wheeled towers in a circular pattern.

In each type of irrigation system, there are few challenges that are of particular interest to farmers and can be improved with AI.

- One of such challenges is under and over watering in plants.
- The other is the management of optimal scheduling and distribution of water.
- The third challenge is automation.

There are various ways AI can tackle those challenges. One such application of AI is in the analysis of plant behavior which helps irrigation systems to allow fine-tuning and irrigates the area of particular interest.

The other way AI can help is by processing and analyzing data feeds from satellites, drone imagery or thermal imaging of the fields. These kinds of analysis combined along with soil and plant-based sensors can help farmers to identify the irrigation needs in the field at the plant level.

Another use of AI is in the assessment of evapotranspiration. Evapotranspiration is the sum of evaporation from the land surface and transpiration from the plants. The measure of evapotranspiration helps the irrigation system to address the needs of plants.

Modern satellite imagery and weather prediction help to improve the assessment of evapotranspiration.

In the case of drip irrigation, we can automate the effective use of water resources through the help of sensors.

Sensors such as soil moisture sensors, fertility meters, and pH meters can be set up in the field to determine the fertility and water level of the soil.

Then, automatic plant irrigators planted in the fields can distribute the appropriate amount of water-based on the needs of the individual plants or the nature of the soil.

AI shows potential help in the center pivot irrigation system as well. Valley Irrigation is one of the pioneers in the precision irrigation management and supply industry. It has been creating center pivot, corner, and linear machines for the agriculture industry. Valley irrigation analyzes new ways to get higher yields using less - water, chemical, fertilizers, fuel, effort, and time using various AI tools and smart technologies.

Irrigated agriculture represents 20% of cultivated land and accounts for 40% of global food production. However, rainfed agriculture covers 80% of the world's cultivated land and is responsible for about 60% of crop production.

So, this shows an immense possibility and challenges to manage rainfed agriculture.
AI and machine learning can help to manage rainfed agriculture by gathering seasonal and weather data and finding historic rainfall patterns using time series prediction. This can help farmers predict the time of possible rainfall conditions or situations and help tackle the drought situations.

Crop Harvesting and Crop Yield Prediction

At the end of the season when the crops are ripe, farmers cut and gather crops.

There are different ways of crop harvesting.
They are traditional harvesting methods such as manual reaping or threshing.
The other is semi-mechanical which uses both manual and machine harvesters.
And another one is the combine harvester.

Similarly, for harvesting vegetables and fruits, there have been manual and mechanical methods. The manual methods include picking fruits and vegetables with bare hands or hand tools. And in

the case of machinery harvesting, farmers use a harvesting rig, mower, or combine.

Figure: High-values crops

Crops like wheat, corn, and potato are ripened uniformly on the field, so mass harvesting of such crops is efficient with big machines at a single moment. However, high-values crops such as apples, tomatoes, and broccoli, etc are ripened heterogeneously and need to be harvested in a selective fashion by only harvesting the ripe fruits. Also, fruits like apples and grapes are multi-annual and farmers should be careful that the plant is not damaged during the harvesting process.

So, selective harvesting of such crops is labor-intensive and expensive. This stimulates the need for robotic systems for selective harvesting.

The benefits of harvesting robots include its operational consistency without temporal variations. Also, another is that these robots can simultaneously detect or monitor plant development lifecycle and optimize the food production chain.

Selective harvesting robots have been quite successful in their performance over the decades.

In a research article called Selective Harvesting Robotics: Current Research, Trends, and Future Directions by Kootstra, G., Wang, it was observed that on average, the selective harvesting robots of high-valued crops had a success rate of 66%. Also, the success rate for fruit localization and detachment were 85% and 75% respectively.

There have been several agricultural companies that are focusing on crop harvesting with AI.

Agrobot is the first pre-commercial robot for gently harvesting strawberries. The robotic bot is equipped with Artificial intelligence which can identify the ripeness of the fruits.

If the fruits are ripe the robotic harvester will cut the stem and put the ripe strawberry to the container without making contact with the fruit.

Root AI's intelligent robot is another example of a crop harvesting robot.

The major technology is its real-time crop detection and ripeness identification with the help of computer vision. The robotic automation and gripping system are intelligent and are equipped with artificial intelligence.

There are several challenges as well as future challenges concerning the robotic harvesting system. The challenges of robotic harvesting system can be lessened by
Reducing plant environment and their population variations and uncertainty
Enhancement of robotic technology with most advanced AI systems
And by creating opportunities for human-robot interaction and collaboration.

Crop Yield Prediction

The manual prediction of crop yield results in a very high error rate. For instance, the founders of Bountiful, a grape forecast company saw a problem that farmers used a traditional approach to predict grape production with a huge error rate up to 30% which led farmers to waste and inefficiency.

An accurate crop yield prediction system helps farmers to make decisions about what crops to grow and when to grow in their fields. Artificial intelligence and Machine Learning techniques employed to predict the crop yield help farmers to make decisions during each part of the agriculture lifecycle process.

Bountiful solved this problem by making smart data-driven decisions by using advanced data science techniques to predict the forecast more accurately. They combined machine learning techniques with the weather, satellite, geographical and historical data. And furthermore, they further provided a platform that converts these agricultural data into actionable insights.

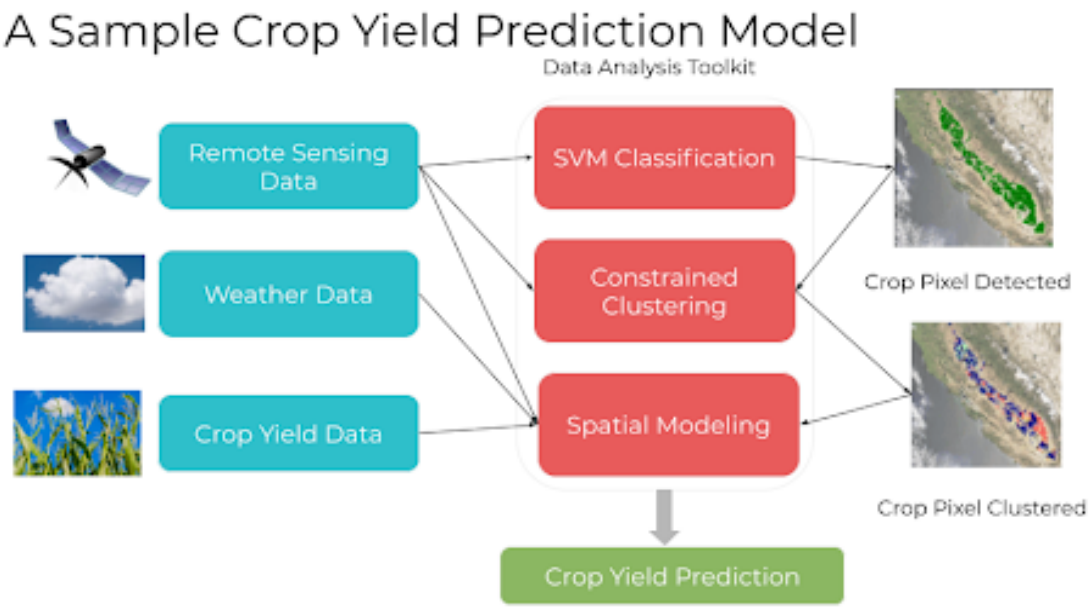

Fig: A sample crop prediction model

One such crop yield prediction model is given in the figure. It consists of remote sensing data, weather data, and crop yield data. These data go into the data analysis toolkit such as SVM classification, constrained clustering, and spatial modeling along with detected and clustered crop pixels. And finally, the model outputs the crop yield prediction.

There are various factors that affect the Crop Yield. The crop yield can be improved with the following strategies
By appropriate seed selection techniques
Appropriate use of fertilizer and pesticides
Accurate Plant Disease prediction and diagnosis and so on.

AI in Animal Husbandry

It is estimated that nearly 25.8 percent of the revenue comes from the livestock sector alone on the total output of the agriculture, fishing, and forestry sector.

As the global population is rising, it is estimated that it is necessary to increase the production of meat and animal products by 70% over the next 50 years to meet the global supply needs. So it is a challenge for the agriculture industry to meet the demands of the growing population.

Figure: Animal Husbandry (src: *pixabay*)

As the need of the time, new technologies should come forward to help tackle the challenges. Let's discuss some of the use cases of AI where it can be used in the animal husbandry sector.

In dairy farming, we can implement AI to track the movement of cows with the help of sensors and AI algorithms. AI can uniquely identify each cow based on its behavioral characteristics.

In meat farming, it is crucial to know about the distress of the animals before they are taken to the slaughter house. AI systems can monitor the sign of distress in animals and inform the farmers about their psychological conditions.

Facial recognition can be used to detect the severity of pain in sheep. AI-enabled robots can debone an animal accurately.

In poultry farming, drones can be used to detect nutritional deficiencies in chickens.
AI-enabled robots can help in feeding birds, collecting eggs, and removing manure.

Similarly, AI systems can be used to monitor the weight, temperature, and humidity of the beehive. AI can help adjust the environmental conditions according to the need of the insects.

There are various agricultural industries that are already leading in animal husbandry sectors with AI technologies. One of them is cowler.

Cowler is a wearable tech agricultural company that creates smart collars for cattle that are tied on a cow's neck. These collars are designed to comfortably fit around cows, which can measure temperature, activity, and cow behavior such as whether it is eating or sleeping or showing lameness. These data are analyzed and monitored to prevent diseases, adjust temperature and increase milk production.

Another agricultural company in Animal Husbandry is HerdDogg. HerdDogg is a leading global herd health company that uses a data science platform to track health and proximity data from their herd. The smart devices are attached to the ears as tags that can sense and track the herds and report directly to the application or web database.