# Crop Yield Forecasting: Using Artificial Intelligence to Feed the World

## OUTLINE

1. Introduction (5 minutes)

- Start with an attention-grabbing opening statement.

- Introduce the topic of the presentation: the problem with agriculture and how there are too many people to feed sustainably.

- Explain the importance of the problem and the need for a solution.

- Preview the structure of the presentation.

Part 1: The problem with agriculture (10 minutes)

- Discuss the challenges faced by modern agriculture, including population growth, climate change, and resource depletion.

- Explain why the current system is unsustainable and needs to be improved.

- Discuss the consequences of failing to address the problem.

Part 2: Introduction to machine learning (10 minutes)

- Define machine learning and explain its applications in various industries.

- Discuss the types of machine learning algorithms, including supervised, unsupervised, and reinforcement learning.

- Highlight the advantages of machine learning in solving complex problems.

Part 3: Machine learning as a solution for agriculture (10 minutes)

- Explain how machine learning can be used to improve agricultural productivity.

- Highlight successful applications of machine learning in agriculture.

2. The Project

Part 4: In-depth explanation of the project at hand (20 minutes)

- Explain the specific project being presented: selecting, tuning, and deploying a crop yield predictor model that uses weather data to infer crop yield.

- Discuss the steps involved in creating the model, including data collection, pre-processing, feature engineering, model selection, and hyperparameter tuning.

- Provide a detailed explanation of how the model works and its potential impact on agricultural productivity.

- Explain the limitations (DATA)

3. Conclusion (10 minutes)

- Summarize the key points of the presentation.

- Reinforce the importance of finding solutions to the problem of sustainable agriculture.

- Highlight the potential of machine learning to address the problem.

- Call to action for increased investment in research and development of machine learning solutions for agriculture.

## CONTENT

### Introduction

There are 8 billion people in the world right now. And by 2050, that number is expected to reach 9.7 billion.

That's a lot of mouths to feed!

The current agricultural system is already struggling to keep up, but what if I told you that we have a solution? In this presentation, I'll show you how we can use the power of artificial intelligence and machine learning to revolutionize agriculture and create a sustainable food system for generations to come.”

### The problem with agriculture

Agriculture is one of the most important industries in the world, providing food and raw materials for human consumption and industrial use. However, the current agricultural system is facing several challenges that threaten its sustainability, including population growth, climate change, and resource depletion.

According to the United Nations, the **global population is expected to reach 9.7 billion by 2050, and 11.2 billion by the end of the century** (UN, 2019). This exponential population growth poses a significant challenge to the agricultural sector, as it is estimated that **food production must increase by 70% to feed the world's population** by 2050 (FAO, 2009).

Furthermore, **climate change is exacerbating the challenge** of feeding the world's growing population. **Changes in temperature and precipitation patterns, extreme weather events, and rising sea levels** are affecting agricultural productivity, reducing crop yields, and threatening food security (IPCC, 2014).

**Resource depletion** is another major challenge facing the agricultural industry. The excessive use of **water, land, and fertilizers has led to soil degradation, water scarcity, and pollution**, jeopardizing the long-term viability of the agricultural sector (FAO, 2019).

These challenges call for urgent action to find sustainable solutions to the problem of feeding the world's growing population. One potential solution is the use of artificial intelligence and **machine learning** in agriculture, which has the **potential to increase productivity, reduce waste, and optimize resource use** (FAO, 2019).

The problem of feeding the world's growing population sustainably is of utmost importance, as it has far-reaching implications for human health, social stability, and the environment.

Firstly, **food insecurity and malnutrition** are major global health challenges that affect billions of people worldwide. According to the Food and Agriculture Organization of the United Nations (FAO), 690 million people were undernourished in 2019, and more than 2 billion people suffer from micronutrient deficiencies (FAO, 2020). Malnutrition is a leading cause of **poor health outcomes, including stunted growth, developmental delays, and increased susceptibility to disease** (World Health Organization, 2021).

Secondly**, food insecurity and hunger** can lead to **social unrest and conflict**, as people compete for scarce resources. According to the World Food Programme, hunger and conflict are closely linked, with hunger being both a cause and a consequence of conflict (World Food Programme, 2021). Hunger and food insecurity can also exacerbate inequalities, as vulnerable populations, such as women and children, are more likely to be affected (FAO, 2020).

Thirdly, the **agricultural sector is a major contributor to greenhouse gas emissions**, **deforestation, and water pollution**, which have significant environmental impacts. According to the FAO, agriculture accounts for about 10% of global greenhouse gas emissions and is the main driver of deforestation and biodiversity loss (FAO, 2020). The excessive use of water and fertilizers in agriculture also contributes to water scarcity and pollution, affecting ecosystems and human health (World Wildlife Fund, 2021).

### The problem with agriculture

The current agricultural system is unsustainable for several reasons. Firstly, the system is heavily reliant on **finite resources**, such as water and fossil fuels. The intensive use of these resources has led to their depletion and has caused negative environmental impacts such as soil degradation and water pollution. This, in turn, has decreased the productivity and the quality of land and water resources, threatening the long-term viability of the agricultural system.

Secondly, the current system is **heavily dependent on chemical inputs**, such as fertilizers and pesticides, to increase productivity. However, these inputs have negative environmental and health impacts. For example, the excessive use of fertilizers can lead to soil degradation and water pollution, while the overuse of pesticides can lead to pest resistance, the contamination of water resources, and the loss of biodiversity.

Thirdly, the current agricultural system is **vulnerable to climate change**. Climate change has brought about unpredictable weather patterns, including droughts, floods, and extreme temperatures, which have negatively affected crop yields and food security. Climate change has also increased the incidence of pests and diseases that affect crops, making it more difficult for farmers to sustainably produce food.

Fourthly, the current system has created **economic and social challenges**. The concentration of agricultural production in large-scale commercial operations has led to the displacement of small farmers and rural communities, causing social disruption and economic inequality. Additionally, the current system is often characterized by market-driven policies that prioritize profits over sustainability, often leading to environmental degradation and social injustice.

Finally, the current agricultural system has led to **negative health outcomes**, both for workers in the agricultural industry and for consumers of agricultural products. Exposure to pesticides and other chemicals used in agriculture has been linked to a range of health problems, including cancer, respiratory disease, and birth defects. Additionally, the concentration of food production in large-scale commercial operations has led to the production of low-quality, processed foods that are high in fat, sugar, and salt, contributing to the global obesity epidemic.

In summary, the current agricultural system is unsustainable due to its heavy reliance on finite resources, its dependence on chemical inputs, its vulnerability to climate change, its economic and social challenges, and its negative health outcomes. It is clear that a more sustainable approach to agriculture is needed to ensure the long-term viability of the system and to meet the needs of a growing global population.

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Failing to address the challenges faced by modern agriculture can have significant consequences for both the environment and human society. Some of the consequences are:

1. Food insecurity: The increasing global population means that there is a growing demand for food. Without improvements in the agricultural system, food production will not be able to keep up with demand, resulting in food insecurity. The United Nations has estimated that by 2050, the world's population will reach 9.7 billion, which will require an increase in food production by 70% compared to 2009 levels (FAO, 2009). Failing to meet this demand can lead to food shortages, malnutrition, and hunger.
2. Environmental degradation: The current agricultural system is associated with high levels of environmental degradation. Unsustainable farming practices, such as excessive use of fertilizers and pesticides, monoculture cropping, and overgrazing, can lead to soil degradation, erosion, and loss of biodiversity (Steffen et al., 2015). Failing to address these practices can result in the degradation of natural resources, loss of habitats, and extinction of species.
3. Climate change: Agriculture is a significant contributor to greenhouse gas emissions, accounting for around 10-12% of global emissions (IPCC, 2019). The current agricultural system is also vulnerable to the impacts of climate change, such as droughts, floods, and extreme weather events (FAO, 2019). Failing to address these issues can lead to further emissions, exacerbate climate change, and lead to decreased agricultural productivity.
4. Economic instability: Agriculture is a major source of income for many people around the world. Failing to address the challenges faced by modern agriculture can lead to economic instability, particularly in developing countries where agriculture is a significant sector of the economy (FAO, 2020). Poor crop yields, low agricultural productivity, and environmental degradation can lead to poverty, unemployment, and social unrest.
5. Health problems: The current agricultural system is associated with several health problems. Exposure to pesticides and other chemicals used in agriculture has been linked to a range of health problems, including cancer, respiratory disease, and birth defects (Van Maele-Fabry & Hoet, 2012). Failing to address these issues can lead to further negative health outcomes for farmers and consumers of agricultural products.

In conclusion, failing to address the challenges faced by modern agriculture can have severe consequences for both the environment and human society. Addressing these challenges requires a more sustainable approach to agriculture that focuses on resource efficiency, reducing emissions, and enhancing ecosystem services.

### What is machine learning?

Machine learning is a subset of artificial intelligence that enables computers to learn from data without being explicitly programmed. It is a process of training algorithms to recognize patterns in data and make predictions or decisions based on that data.

The applications of machine learning are vast and varied, and have been adopted by various industries. Some examples of its applications are:

1. Healthcare: Machine learning is used to develop algorithms that can predict the likelihood of diseases, analyze medical images, and assist in drug discovery (Bzdok & Ioannidis, 2019).
2. Finance: Machine learning algorithms are used to detect fraud, analyze financial data, and make predictions about stock prices (Makridakis & Taleb, 2019).
3. Marketing: Machine learning is used to analyze customer data and predict customer behavior, allowing companies to better target their marketing efforts (Eriksson et al., 2019).
4. Manufacturing: Machine learning is used to optimize production processes, predict equipment failures, and improve quality control (Cai et al., 2018).
5. Transportation: Machine learning is used to optimize routing and scheduling of vehicles, predict demand for transportation services, and improve safety (Wang et al., 2018).
6. Agriculture: Machine learning is used to predict crop yields, identify pest and disease outbreaks, and optimize irrigation and fertilization schedules (Singh et al., 2017).

Overall, machine learning has the potential to revolutionize industries by providing new insights and efficiencies. Its wide range of applications suggests that it will continue to be adopted by various industries in the future.

There are three main types of machine learning algorithms: supervised learning, unsupervised learning, and reinforcement learning.

1. Supervised learning: In supervised learning, the algorithm is trained on labeled data, meaning data that has a known output or outcome. The algorithm learns to identify patterns in the data and can then make predictions on new, unseen data. Examples of supervised learning include classification and regression tasks (Goodfellow et al., 2016).
2. Unsupervised learning: In unsupervised learning, the algorithm is trained on unlabeled data, meaning data that has no known output or outcome. The algorithm learns to identify patterns and structures in the data, such as clustering or dimensionality reduction. Examples of unsupervised learning include clustering and anomaly detection (Goodfellow et al., 2016).
3. Reinforcement learning: In reinforcement learning, the algorithm learns by trial and error, receiving rewards or penalties for certain actions it takes. The goal of the algorithm is to learn the optimal policy for maximizing long-term rewards. Reinforcement learning is often used in robotics, game playing, and decision-making tasks (Sutton & Barto, 2018).

Each type of machine learning algorithm has its own strengths and weaknesses and is suitable for different types of problems. By understanding the characteristics of each type, researchers and practitioners can select the most appropriate algorithm for a given task.

Machine learning has several advantages in solving complex problems, including:

1. Ability to handle large and complex datasets: Machine learning algorithms can handle large and complex datasets that may be difficult for humans to analyze.
2. Scalability: Machine learning algorithms can scale to handle increasing amounts of data and can be applied to a wide range of problems.
3. Speed and efficiency: Machine learning algorithms can quickly analyze large amounts of data and provide insights that would be time-consuming or impossible for humans to obtain.
4. Flexibility: Machine learning algorithms can be applied to a wide range of problems across different industries and domains.
5. Continuous learning: Machine learning algorithms can continuously learn and improve as they receive more data, allowing for ongoing optimization and better performance over time.

These advantages of machine learning have led to its widespread adoption across industries, from healthcare to finance to manufacturing. By leveraging the power of machine learning, organizations can gain new insights, improve decision-making, and optimize processes.

### Can ML save the world?

Machine learning can be used to improve agricultural productivity in several ways.

One key application is in predicting crop yields, which can help farmers make informed decisions about planting, harvesting, and crop management. By using machine learning algorithms to analyze historical data on weather patterns, soil conditions, and crop yields, researchers can develop models that accurately predict crop yields in real-time.

Another application of machine learning in agriculture is in precision farming. By collecting data from sensors and other sources, machine learning algorithms can help farmers optimize crop management, such as by adjusting fertilizer application rates or identifying areas of a field that require more attention.

Machine learning can also be used to detect diseases and pests in crops, allowing farmers to take proactive measures to prevent or mitigate damage. By analyzing images of crops, machine learning algorithms can identify signs of disease or pest infestation, alerting farmers to potential issues before they become widespread.

Cases of success

There are several successful applications of machine learning in agriculture that have already been implemented and shown promising results. Here are a few examples:

1. Crop yield prediction: Machine learning algorithms have been used to predict crop yields in real-time based on weather patterns, soil conditions, and other environmental factors. For example, a study by Kussul et al. (2017) used remote sensing data and machine learning algorithms to predict wheat yields with an accuracy of up to 86%.
2. Disease and pest detection: Machine learning algorithms can analyze images of crops to detect signs of disease or pest infestation. A study by Mohanty et al. (2016) used a deep learning algorithm to detect cassava disease with an accuracy of up to 98.7%.
3. Precision farming: Machine learning can be used to optimize crop management by adjusting fertilizer application rates or identifying areas of a field that require more attention. For example, Liakos et al. (2018) reviewed several studies that used machine learning to optimize crop management, resulting in increased crop yields and reduced resource consumption.
4. Livestock management: Machine learning algorithms can analyze data from sensors attached to livestock to monitor their health and well-being. For example, a study by Orlandi et al. (2019) used machine learning to predict the onset of heat stress in dairy cows, enabling farmers to take proactive measures to prevent negative health outcomes.
5. Water management: Machine learning can be used to optimize water management in agriculture, such as by predicting water demand and identifying areas of a field that require more or less irrigation. For example, a study by Yang et al. (2019) used machine learning to predict crop yields based on water availability, resulting in a more efficient use of water resources.

### My project: Crop Yield Forecasting

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