



MAIZE YIELD CLASSIFICATION FOR ZERO HUNGER

**Data Science Solutions for
Sustainable Development Goals**

ToU Elevation Challenge



Presented By.

**Jana Deghid, Lennart Reh,
Thanujan Sribaskaran**

Introduction

Global hunger remains a critical global challenge, with nearly one in ten people lacking access to sufficient and nutritious food. Addressing this crisis is central to the United Nations' Sustainable Development Goal 2 (SDG 2), which calls for ending hunger, achieving food security, and promoting sustainable agriculture by 2030. Maize, as a staple crop for millions across tropical and subtropical regions, plays a pivotal role in combating food insecurity. However, its yields are highly variable due to climatic extremes, soil fertility issues, and limited access to modern farming inputs. These disparities are especially pronounced in low-income countries, where even minor crop failures can threaten livelihoods and exacerbate hunger.

Significance and Relevance to SDG 2

To meet the targets of SDG 2, it is imperative to boost agricultural productivity in regions most vulnerable to food insecurity. Effective classification of maize yields into actionable levels—"low," "medium," and "high"—serves as a cornerstone for developing targeted interventions such as fertilizer subsidies, irrigation development, and policy reforms. These measures not only address immediate food security needs but also contribute to long-term agricultural resilience, a key factor in sustaining local economies and reducing malnutrition. By tackling regional yield gaps, this project directly supports the broader goal of eradicating hunger and fostering sustainable agriculture.

people
worldwide are
affected by
hunger

773 million

Project Goal and Specific Challenge

The primary objective of this project is to address yield disparities and optimize resource allocation in marginalized areas. By leveraging historical yield data, climatic indicators, and agricultural inputs, we propose a robust classification framework to identify regions at risk of low productivity. This framework will pinpoint the drivers of yield variability, enabling policymakers, NGOs, and farmers to implement evidence-based strategies that enhance productivity. These strategies directly contribute to SDG 2 by fostering climate-resilient farming practices, closing yield gaps, and securing food supplies in the most vulnerable regions.

Research Question

How can historical maize yield data in tropical and subtropical climate zones be classified into actionable levels, and how can these insights guide sustainable agricultural practices to improve food security and resilience against climate extremes?

Hypothesis

Classifying maize yields in tropical and subtropical regions using climatic and agricultural indicators (e.g., temperature, rainfall, and fertilizer use) can accurately identify areas at risk of low productivity.

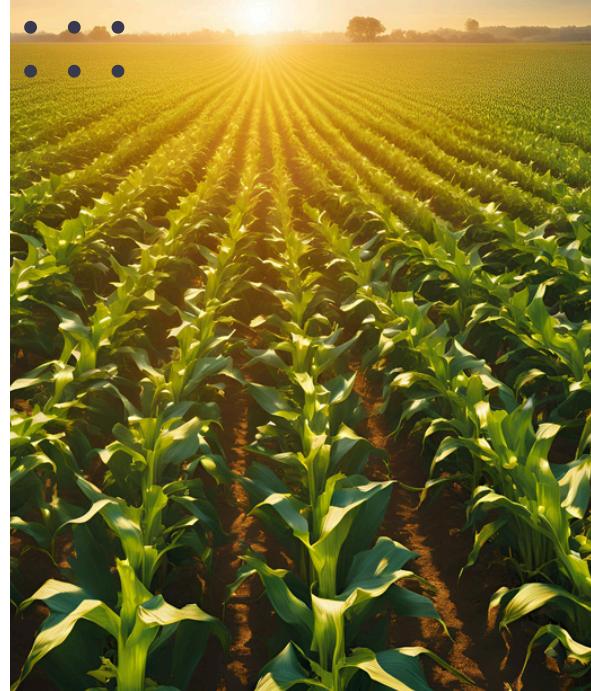
This approach will reveal actionable interventions to reduce hunger, improve resource efficiency, and support farmer livelihoods, particularly in regions most affected by food insecurity.

Methodological Note

For comprehensive details on data collection, preprocessing, and modeling, please refer to the accompanying Jupyter Notebook. It provides an in-depth discussion on data sources, preprocessing steps, key trends from EDA, model rationales, and evaluation metrics.



Key Findings



1. Optimal Climate Parameters for Maize

- **Key Finding:** Maize thrives best within a 24–26°C temperature range and ~1,500 mm of annual rainfall.
- **Relevance to SDG 2:** Identifying climate “sweet spots” clarifies where to deploy targeted interventions (e.g., heat-tolerant seeds, improved irrigation). Regions nearing or exceeding 26°C now face heightened risks due to global warming, underscoring the urgency for climate adaptation within broader Zero Hunger efforts.
- **Supporting Research:** [Whitbread et al. \(2025\)](#) discussed the critical role of temperature and rainfall in maize productivity, highlighting the importance of tailored interventions for climate-risk regions.

2. Fertilizer and Pesticide Efficiency

- **Key Finding:** Balanced input use (particularly fertilizers, $r \approx 0.46$ correlation with yield) significantly boosts productivity, but overuse diminishes long-term returns and harms ecosystems.
- **Relevance to SDG 2:** Optimizing inputs is crucial to sustainably increase food production in resource-poor areas. This aligns with SDG 2’s emphasis on resilient agricultural practices that protect local environments while feeding growing populations.
- **Supporting Research:** [Zhang et al. \(2024\)](#) demonstrated how precision farming and optimized fertilizer use reduce environmental impacts while maintaining yields.

3. Regional Yield Disparities

- **Key Finding:** Advanced practices in regions like Bangladesh or Australia drive higher maize yields, whereas countries such as Chad or Angola remain constrained by limited access to modern agricultural tools.
- **Relevance to SDG 2:** Addressing these disparities through technology transfer, capacity-building, and financial support directly tackles inequalities in food security—one of the core concerns of SDG 2.
- **Supporting Research:** [Dossa et al. \(2025\)](#) analyzed regional inequalities in cereal production, linking disparities to access to agricultural technologies.

4. Yield Classification Framework (Low, Medium, High)

- **Key Finding:** Categorizing yields into three tiers offers a practical roadmap for pinpointing “hotspots” in need of immediate or specialized intervention.
- **Relevance to SDG 2:** This classification system enables policymakers, NGOs, and development agencies to prioritize their efforts effectively—fast-tracking interventions in low-yield areas to combat hunger and malnutrition.
- **Supporting Research:** Frameworks for drought index evaluations and their implications for prioritizing interventions in low-yield regions. [Source](#)



Key Themes and Controversies

1

A central theme concerns climate change and adaptation, particularly in regions already nearing the maize temperature threshold of 24–26°C. As global warming continues, these areas risk further yield declines. The core question becomes how best to allocate scarce resources between urgent hunger-relief measures and more expensive, long-term adaptation investments, such as specialized heat-resistant seeds or advanced irrigation systems. This tension often sparks controversy, as limited budgets must stretch to cover both immediate food security needs and infrastructural upgrades to cope with future climate shocks. [This study](#) shows the impact of summer climate changes on maize yields in Northeast China, providing actionable insights for adaptation strategies.

2

Another important theme addresses sustainable intensification versus environmental impact. While fertilizers and pesticides undeniably boost yields, their excessive use degrades soil health and contaminates water sources over time. Policymakers, then, must grapple with where to draw the line between maximizing short-term output and preserving ecological balance for subsequent harvests. Controversy arises from the clash between an agro-industry that promotes high input usage for quick gains and environmental advocates who call for stricter regulations to safeguard long-term agricultural viability. [This study](#) shows how precision management of agricultural inputs contributes to yield optimization while mitigating ecological risks.

3

A third theme centers on equitable resource distribution. Substantial inequalities exist between areas that have ready access to agricultural inputs and those that struggle to secure even basic resources like quality seeds or fertilizer. The main question is how to make subsidies, trade agreements, and financial mechanisms more equitable for smallholder farmers, who often operate at a disadvantage in global markets. Debates over the fairness and practicality of wealth or resource transfers from more developed to less developed nations shape this controversy, with competing views on how best to address worldwide hunger in a fair and sustainable way. [This study](#) analyzed how improved seeds and fertilizers close yield gaps in Tanzania, emphasizing the importance of equitable access.

4

Finally, data quality and local context emerges as a key issue. National-level averages can conceal significant variations in climate, soil type, and farming practices across different regions. As a result, broad-brush policies risk marginalizing communities that require more specific approaches tailored to their unique conditions. This reality raises the question of whether investment in detailed, granular data collection—necessary for precise, location-specific interventions—can be justified when funds are limited. The controversy here is that “one-size-fits-all” strategies may be more cost-effective in the short run, yet might fail to address the nuanced realities on the ground, undermining long-term success in eradicating hunger. [This study](#) evaluates the impact of using different seasonal climate data on crop yield simulations, emphasizing improved prediction accuracy in the Southeastern US





Actionable Recommendations

1. Precision Climate Adaptation

- **Action:** Develop and distribute heat-tolerant and drought-resistant maize varieties in regions where temperatures are rising above 26°C or rainfall is erratic.
- **Implementation Detail:**
 - Seed R&D: Public-private partnerships can accelerate breeding programs.
 - On-Farm Trials: Pilot new seed varieties with local farmers, supported by extension services.
- **SDG 2 Impact:** Safeguards yields under changing climate conditions, directly reducing hunger risks.
- **Supporting Research:** Developing heat-resistant maize varieties.

2. Integrated Resource Management

- **Action:** Encourage balanced fertilizer application and integrated pest management (IPM), leveraging local soil tests and precision-farming tools (GPS-enabled equipment, drones).
- **Implementation Detail:**
 - Training Modules: Government agencies partner with cooperatives to teach optimal fertilizer dosing.
 - Regulatory Incentives: Create tiered subsidy structures that reward ecologically responsible input use.
- **SDG 2 Impact:** Enhances yield without eroding soil health or overloading ecosystems—ensuring long-term food security.
- **Supporting Research:** Machine Learning Approach Leveraging Crop Datasets for Optimizing Crop Yield Production

3. Equitable Finance and Infrastructure

- **Action:** Provide low-interest loans, microfinance programs, and market linkages for smallholder farmers, especially in “low-yield” classifications.
- **Implementation Detail:**
 - Mobile Banking: Use digital platforms to reach remote farmers.
 - Cooperative Purchasing: Farmer collectives pool resources to buy inputs and storage facilities at bulk rates.
- **SDG 2 Impact:** Empowers marginalized farming communities to improve yields and livelihood security, narrowing global agricultural inequalities.
- **Supporting Research:** Supply Chain Finance: A New Means to Support the Competitiveness and Resilience of Global Value Chains.

4. Data-Driven Monitoring and Policy

- **Action:** Adopt the yield classification framework at national and regional levels, integrating real-time climate and yield data into policy decisions.
- **Implementation Detail:**
 - Open-Data Platforms: Governments and NGOs share yield maps, climate trends, and best practices online.
 - Localized Advisories: SMS or app-based alerts provide farmers with up-to-date planting, fertilizing, and harvesting guidelines.
- **SDG 2 Impact:** Ensures interventions remain dynamic and responsive to on-the-ground conditions, bolstering the resilience of food systems.
- **Supporting Research:** Tools and frameworks for machine learning and deep learning.



Real-World Applicability and Transformative Potential



Real-World Scenario

- In a drought-prone region of Sub-Saharan Africa, implementing drip irrigation and distributing heat-resistant maize varieties—while training local cooperatives on safe fertilizer usage—can increase yields in a matter of seasons.
- Transformative Outcome: Reduced vulnerability to climate shocks, improved household incomes, and a clear pathway out of cyclical hunger.



Scalability

- National Rollouts: Once proven at local scales, governments can integrate these practices into broader agricultural policies or national adaptation plans.
- Global Networks: South-South exchanges (e.g., between African and Asian nations with similar climatic zones) expedite the spread of successful models



Multi-Stakeholder Collaboration

- Public Sector: Provides regulatory frameworks and infrastructure investment.
- Private Sector: Supplies capital, innovation, and distribution channels for seeds and technologies.
- Civil Society & Academia: Engages in extension services, monitoring, and continuous improvement of yield models.

Future Roadmap

2025

Impact on SDG 2

- **Immediate Gains:** Rapid yield improvements in low-yield regions translate directly to better food availability and lower malnutrition rates.
- **Long-Term Resilience:** Balanced use of inputs, climate-smart techniques, and strengthened governance frameworks collectively foster sustainable agricultural ecosystems—ensuring the next generations inherit healthier soils and more stable harvests.
- **Supporting Research:**
 - i.[This study](#) demonstrates that increased agricultural productivity in low-yield regions leads to improved food availability and has the potential to reduce malnutrition, especially in poverty-stricken areas
 - ii.[This paper](#) outlines global research priorities, emphasizing governance and resource management in climate-smart agriculture for food security
 - iii.[This research](#) discusses innovative soil and crop management practices that integrate sustainable and climate-smart techniques for resilient food systems
 - iv.[This paper](#) connects sustainable intensification with climate-smart practices and governance, stressing the need for robust policies to

Innovative and Forward-Thinking Proposals

- **Precision Analytics:** Deploy machine learning models that incorporate real-time satellite imagery, weather forecasts, and local yield data to inform each season's planting and resource allocation.
- **Carbon Financing:** Encourage farmers to adopt agroforestry or no-till practices, which can store carbon, unlock carbon credits, and provide an additional revenue stream—merging climate objectives with hunger eradication.
- **Policy Integration:** Coordinate with health and education sectors. For instance, link school feeding programs to local maize production under the yield classification framework, creating stable demand that incentivizes farmers to adopt best practices.
- **Supporting Research:**
 - i.[This study](#) combines real-time data from satellites, weather forecasts, and soil sensors to develop machine learning models that optimize planting strategies and resource allocation
 - ii.[This paper](#) discusses practices like no-till farming and agroforestry, emphasizing their carbon sequestration potential and opportunities for carbon credits
 - iii.[This research](#) proposes integrated policy frameworks linking agriculture with sectors like education and health to improve food security and create demand-driven farming models

Future Research and Implementation Path

- **Localized Proof-of-Concept Trials:** Validate the recommended interventions across various agro-ecological zones.
- **Impact Assessments:** Conduct periodic evaluations (every 2–3 growing cycles) to measure yield gains, economic returns, and ecological outcomes (soil quality, biodiversity).
- **Scaling and Knowledge-Sharing:** Publish results in open-access databases and invite peer-to-peer learning (farmer-to-farmer mentorship, international workshops) to accelerate adoption globally.
- **Supporting Research:**
 - i.[This study](#) demonstrates the use of multi-environment trials to assess genotype-environment interactions and identify high-performing cultivars across various agro-ecological zones
 - ii.[This research](#) highlights the importance of long-term experiments to evaluate crop production, nutrient cycling, and environmental impacts
 - iii.[This paper](#) emphasizes sharing proof-of-concept results for broader applications and collaboration across disciplines



Conclusion

The challenge of achieving SDG 2 (Zero Hunger) in the face of climate change, environmental degradation, and persistent inequalities demands innovative, data-driven, and collaborative approaches. Through this comprehensive analysis, we have outlined actionable strategies that align with SDG 2's core objectives—ensuring food security, promoting sustainable agricultural practices, and addressing systemic inequalities in resource distribution.

Key Takeaways:

1. **Precision Climate Adaptation:** By identifying and mitigating the impacts of rising temperatures and erratic rainfall, we can safeguard maize yields and reduce vulnerability to climate shocks.
2. **Sustainable Intensification:** Optimizing fertilizer and pesticide use while leveraging precision-farming technologies enhances productivity without compromising long-term ecological health.
3. **Equitable Resource Distribution:** Empowering smallholder farmers with financial support, technology access, and capacity-building narrows yield gaps and fosters global food security.
4. **Data-Driven Decision Making:** Incorporating real-time monitoring, yield classification frameworks, and localized advisories ensures tailored interventions that are both effective and adaptive.

Achieving Zero Hunger is not merely a goal—it is a moral imperative. By leveraging data science, machine learning, and cross-sector collaboration, we have the tools to revolutionize agriculture, empower farmers, and transform food systems globally. However, this effort requires the unwavering commitment of policymakers, researchers, NGOs, and the private sector. Together, we can ensure that no one is left behind in the fight against hunger and malnutrition.

Future Steps: The road ahead calls for continued innovation, investment, and knowledge-sharing:

- **Proof-of-Concept Trials:** Validate proposed interventions in diverse agro-ecological zones to refine strategies.
- **Collaborative Research and Learning:** Build global networks for South-South knowledge exchange and farmer-to-farmer mentorship.
- **Integrated Policies:** Foster alignment across agriculture, education, and health sectors to create synergistic solutions.

By uniting expertise, resources, and technology, we can turn the vision of Zero Hunger into a reality—safeguarding food security for generations to come and contributing meaningfully to a sustainable and equitable future for all.

