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AI Use Case: Addressing Agricultural Deficiency After Disaster

We will be discussing using AI to address agricultural deficiency in the aftermath of natural disasters.

Background

To give some insight on this topic, Hurricane Helene, a recent Tampa Bay hurricane, resulted in agricultural production losses ranging from $40.3 million to $162.2 million. Vegetables, melons, and potatoes *alone* are estimated to have an annual production loss of $10.5 million to $38.2 million, and all of these estimates do not even include the value of damage to agricultural-related infrastructure.

Natural disasters like Hurricane Helene are just *one* example of how natural disasters damage the agricultural field. Unpredictable weather patterns, such as erratic rainfall, prolonged droughts, rising temperatures, as well as sweeping wildfires are creating an environment of uncertainty for farmers. These shifts disrupt crop growth cycles and lead to widespread yield reductions that threaten global food security. Crop yields for staples like rice, wheat, and maize could decline globally by 10–25% by 2050 due to climate shifts.

Adding to this, crops are struggling to adapt to rapidly changing conditions. These challenges force farmers to make tough decisions—whether to adjust planting schedules, switch to more resilient crops, or even leave fields fallow. In many cases, their efforts fall short, and entire growing seasons are lost, leaving communities without food or income.

These issues are compounded by resource scarcity. Water and fertile soil, essential for agriculture, are under constant strain as climate conditions worsen. Prolonged droughts dry up water supplies, while floods and soil erosion degrade farmland, making recovery after disasters even harder. These shortages expose the systemic vulnerabilities of agriculture worldwide. When crops fail, the effects ripple far beyond the farm. Food shortages drive up prices and destabilize markets and these localized shocks demonstrate how climate events can escalate into global crises, threatening not just food access but economic and social stability.

All of this points to the urgent need for proactive and innovative solutions. The agricultural sector, already under immense pressure to feed a growing population, now faces the additional burden of adapting to an unpredictable climate. Without intervention, these challenges will only escalate, putting more communities at risk of poverty, migration, and food insecurity.

The challenges facing agriculture today make it clear that we need advanced, data-driven solutions to adapt and thrive. Traditional approaches tend to be reactive, focusing on damage control after disasters strike, rather than helping farmers prevent losses in the first place.

Why is AI needed?

This is why artificial intelligence is so important. AI has the ability to process vast amounts of data. It can predict extreme weather events, highlight vulnerabilities in crops, and recommend strategies to prepare before disaster hits. Additionally, by providing farmers with these kinds of insights, AI enables them to make smarter decisions about planting, resource use, and disaster planning.

While there are systems in effect, like from NASA, that utilize real-time data to craft disaster management, response, and relief, they cover a huge scope that is not just focused on agriculture. Although this is needed, we are still experiencing huge losses in this sector that must be alleviated.

Therefore, we propose creating an app that utilizes artificial intelligence to address these needs. Our idea is niche because it will allow for a targeted, personalized approach that not only focuses on post-disaster help but also preventative measures.

Take wildfires, for example. In the aftermath of such a disaster, there is ash in the sky that prevents sunlight and soil depletion that continues to lead to agricultural loss. We want to be able to account for those second and third-level losses that are often overlooked.

Our new AI application will enter this space of extreme weather and disaster to help farmers take preventative measures to optimize crop management and improve agricultural efficiency in the fight against food deficiency, ultimately aiming to minimize damages to society in the aftermath of natural disasters.

When it comes to the developmental stage of the app, we will work alongside farmers to get their opinions on the user interface and cater the app towards their vocabulary in an effort to ensure familiarity and ease of use.

We will essentially be providing tailored recommendations on how to proceed in the event of a natural disaster approaching or in the aftermath. The recommendations will be split into the crop cycles, essentially the early, middle, and end of a crop cycle.

For example, a farmer facing a natural disaster who has crops in an early phase may receive the recommendation to transplant their crops. This means that within 2 weeks to a couple of months of a crop being planted, they have the ability to potentially be dug up, moved, and

replanted elsewhere. Our app will be able to locate the closest unimpacted geographical area that mimics the current climate and needs of the farmer's crops.

While our recommendations are not a 100% foolproof solution, the idea is to help minimize the potential damages and offer personalized solutions to farmers in the midst of a crisis.

Now, our end product will heavily rely on historical data and when thinking of our data strategy, we decided that we not only need an understanding of crops within the US but also how weather and disasters interact with said agriculture. Therefore, we broke up our data collection into four categories: agricultural data, weather data, disaster data, and satellite imaging data.

Agricultural Data:

Our agricultural data stems from the National Agricultural Statistics Service. We will be utilizing their publicly available quick stats, which include over 100 years of agricultural information to understand current information about farms and their corresponding areas. Accompanying this will be data from the US Department of Agriculture about crop progress and condition layers in the form of geospatial datasets that span growing-season weeks for all years from 2015 to the present, which is meant to give useful insight into some crops' origin, as well as their characteristics and limitations.

Weather Data:

Turning to weather data, we will be utilizing data from the National Centers for Environmental Information, which provides comprehensive oceanic, atmospheric, and geophysical data.

Disaster Data:

Accompanying this will be disaster data, where we'll focus on risk management agency data from the US Department of Agriculture. This includes details like stages of crop, type of disaster, and acres of land impacted. We will also be pulling from the Federal Emergency Management Agency, whose data ranges from disaster information to hazard mitigation. Beyond this, just like we did with our agricultural data, we will once again pull from the National Agricultural Statistics Service - specifically their Disaster Analysis data.

Since 2017, the National Agricultural Statistics Service has been able to better monitor agricultural disasters in near real-time and provide quantitative assessments using remotely sensed data and geospatial techniques, which we believe will be particularly insightful when it comes to training our models.

Satellite Imaging Data:

Finally, the last bit of our data strategy revolves around satellite images and information. Particularly, NASA's Earth Science Data, which allows individuals to map natural hazards. Much of this data updates in real and near real-time which allows a more data-driven approach to disaster response. Leveraging satellite images can also conveniently provide a way to paint and gauge the true estimate of impact.

The reason for this extensive data strategy is to essentially craft our threat intelligence by training our models based on historical data. This will better predict and analyze areas that will be impacted by natural disasters in the future. We need to closely monitor and observe the real-time area of impact because accurate forecasts need good observations and are a huge part of AI model development.

AI Model Development

Our AI model development focuses on two key areas. The first one is Disaster Prediction and Impact Assessment. We're training machine learning models, such as Random Forest and Deep Neural Networks, using historical data. To enhance the spatial resolution and accuracy of our predictions, we're incorporating satellite data.

The second one is Resource Allocation and Crop Substitution Prediction. We're utilizing computer vision with deep learning, specifically Convolutional Neural Networks, to analyze satellite imagery for crop damage assessment. Ensemble methods like Random Forest are being applied to forecast resource allocation based on disaster type and scale. Additionally, we're developing an AI-powered recommendation system for alternative crops, considering post-disaster conditions, market demand, and economic factors.

Our application will include several key features like an Early Warning System, Impact Visualization map, Resource Allocation Dashboard, and Crop Substitution Advisor in the form of a chatbot.

We also plan to implement reinforcement-learning techniques to create feedback loops, comparing predictions with actual impacts. This allows us to regularly update our AI models with new climate and disaster data, ensuring continuous improvement.

Value Chain

Our value chain consists of Five main components. AI Model Development and Deployment involves training the machine learning models that we just went through. We're building and maintaining core platform technology while ensuring scalability and real-time data processing capabilities. We're designing intuitive dashboards for different stakeholders and creating visualization tools for impact assessment and resource allocation to enhance User

Interface and Experience. Our platform will facilitate connections between farmers, insurers, and government agencies ensuring a strong network and platform ecosystem. We plan to eventually scale our application to new geographies and offer it in native languages. We'll continue to actively implement innovative plug-ins to the application and integrate new AI techniques as and when the domain evolves.

Cost Analysis

Now, let's look at the financial aspects of our solution. We plan to develop our product in stages starting with the United States and scaling it up globally. The overall Product Development Expenses are estimated at $4.9 million, including data collection and infrastructure and model development and deployment components. These expenses are ballpark estimates from the market and the numbers are fetched from previously developed AI Business platforms.

The annual agricultural loss due to natural disasters and the climate crisis in the U.S. is approximately $2.19 billion in 2023. Assuming a conservative 5% app adoption rate, a conservative 70% model accuracy, and an extreme 80% wastage or additional loss due to incorrect predictions, we project annual savings of $504.2 million in indemnity value.

Additionally, the app also saves crops from secondary and tertiary losses such as deterioration of soil nutrients and corn crop growth hindrance due to wildfires' ash and smoke. Such benefits are not accounted for in the prevented losses. Overall, the application outdoes the traditional existing solutions in the most reasonable possible way.

Market Potential

The market potential for our AI-driven agricultural solution is significant across three key stakeholder groups: Farmers will benefit from premium crop management tailored to their specific needs, accessing data-driven solutions for crop selection, and risk management. Government agencies will enhance their disaster response capabilities, leveraging our predictive analytics to allocate resources more effectively and support affected communities. Insurance companies can benefit from better risk assessment.

With U.S. agricultural losses reaching $21.94 billion in 2023 and the global agri-tech market projected to hit $49.2 billion by 2031, our solution is poised to make a substantial impact on agricultural resilience and food security worldwide

Application Impact

Our AI-powered application has the potential to make a transformative impact on agriculture by addressing immediate challenges caused by extreme weather and creating long-term benefits for farmers, businesses, and society. In 2023 alone, U.S. crop and rangeland losses totaled about $22 billion, with 75.6% of these losses—approximately $16.59 billion

—resulting from drought, excessive heat, and wildfires. An additional 18.2%, or $3.99 billion was caused by excessive precipitation, flooding, and hurricanes, and 6.2%, or $1.37 billion, stemmed from hailstorms. Our app leverages predictive analytics and historical data to prepare farmers and resource managers for these events, providing early warnings that could mitigate a significant portion of these losses.

Beyond disaster preparation, the app also addresses crop-specific challenges. In 2023, corn experienced the highest losses, followed by forage and soybeans. Fruit and nut losses increased dramatically, rising from $400 million in 2022 to nearly $1.6 billion in 2023. Specific examples include $350 million in losses for oranges, $220 million for grapes, and $200 million for almonds. By analyzing these patterns, the app can predict shortages and suggest appropriate food substitutions, ensuring supply chain stability and reducing waste.

Economic Impact

Moreover, from an economic viewpoint, the app could mitigate a significant portion of the 22 billion dollars in agricultural losses, which represented 23.6% of the $92.9 billion total economic impact of weather disasters in 2023. Even reducing a *fraction* of these losses would save billions of dollars annually. The global agri-tech market is projected to reach $49.2 billion by 2031, with AI playing a critical role in driving disaster resilience.

Over the last 30 years, disasters have caused $3.8 trillion in agricultural losses globally, averaging $123 billion annually, emphasizing the market's urgent need for innovative solutions like ours.

Our app can also enhance productivity by enabling precision predictions that allow proactive planning. For example, weather disasters in 2022 caused over $21 billion in U.S. crop losses. With AI-driven risk assessments, farmers can reduce these losses, improving profitability and lowering insurance claim payouts.

Social Impact

Socially, the app may address global food security. With 828 million people worldwide facing hunger, reducing agricultural losses and stabilizing supply chains can make a profound impact. Additionally, the app would create job opportunities across data collection, model deployment, and technical support, fostering growth in both new and existing markets. New players, such as sensor and IoT providers, can introduce real-time data collection tools while existing actors like agribusiness corporations and government agencies can optimize supply chains and enhance disaster response capabilities.

Drawbacks and Considerations

While the impact is vast, we cannot forget to touch upon drawbacks. Our app's recommendations would follow environmental regulations that are already in place while providing suggestions to help farmers navigate severe weather that could damage crops.

Farmers have to follow several regulations concerning the usage of water, fertilizers, and pesticides, as well as food safety regulations, just to name a few. The app integrates these regulations into its suggestions, ensuring that farmers meet their requirements. The app can also track fertilizer and pesticide use, among other things, to document farmers' compliance.

For example, before a storm, the app might suggest postponing the use of fertilizer to prevent any runoff into nearby water sources. And this ensures that the farmers are complying with environmental laws, while also saving resources. If the data shows that there will be a lot of wind or rain, the app could recommend putting off the use of pesticides until conditions stabilize, which would reduce chemical loss and simultaneously comply with regulations.

Accountability for Error

Now, while our app tries to provide accurate recommendations, we know that it won't always be 100% accurate, and there are risks of incorrect predictions. As previously mentioned, as of 2023, total crop losses due to natural disasters are about $22 billion, which shows how high the stakes are for farmers. They could suffer financial losses and property damage if we warn about harsh weather that doesn't happen, or if we fail to warn about severe weather conditions.

Because of this, it's important to establish clear boundaries and regulations on who would be responsible for the applications' inaccuracies. These boundaries need to be very clear in every instance, like if the application gave a warning but the farmer decided to ignore it and ended up having to deal with severe crop damage.

Current insurance policies need to be expanded to include AI usage to ensure that farmers, app creators, and employees are protected in the event of inaccuracies.

AI's Environmental Impact

At the same time, while we want to use AI to help farmers understand the best course of action to take for their crops during severe weather conditions, it's important to consider that using AI to predict the severity of the conditions is simultaneously causing harm to the environment.

AI uses a lot of energy, creates e-waste, needs natural raw materials like lithium and cobalt, and requires a large amount of water usage.

Data centers that power AI require a large amount of computational power, which means they need a significant amount of electricity to run. If the electricity being used is

non-renewable, it increases the carbon footprint, contributing to global warming and climate change. They also emit a significant amount of heat.

As hardware becomes obsolete and ages out, the items are replaced, and electronics get thrown away. This can be dangerous because there are chemicals that are naturally released from the metals inside the hardware once they're buried in a landfill, sinking into the ground and running deep, until it reaches freshwater sources in the surrounding area.

Mining minerals like lithium and cobalt damage the Earth and pollute local water sources, not to mention the toxic chemicals that the people mining it are exposed to.

And lastly, AI uses a lot of water. According to The Times, Global AI water usage by 2027 is predicted to be 4.2-6.6 billion cubic metrics, which is equal to half of the UK's total annual water consumption.

The data centers that house AI technology, like large cloud computing providers, need to be kept cool at all times so that they do not overheat and catch fire. Data centers need to be properly cooled at about 75 degrees Fahrenheit to avoid overheating and potential outages. They also have to be ventilated 24/7, causing a lot of electricity to be used.

So, we see that reducing the environmental impact of AI in agriculture is crucial to ensure that we balance its benefits with sustainability.

One of the key ways to achieve this is by transitioning data centers to renewable energy. By moving away from non-renewable electricity, we can significantly lower the carbon emissions generated by these systems. Some major companies are already setting an example. Google aims to power all its data centers with 24/7 carbon-free energy by 2030, which will greatly reduce its environmental footprint. At the same time, Microsoft plans to use 100% renewable energy by 2025 and become carbon negative by 2030, meaning they'll remove more carbon from the atmosphere than they emit. Greenpeace has also pointed out that renewable energy is essential for cutting the carbon footprints of data centers and has been advocating for the use of solar and wind energy.

Another way to reduce the impact is by improving the efficiency of AI systems. Companies like OpenAI are working on developing energy-efficient AI models to lower the resources needed to train and operate them. Similarly, Google TensorFlow provides tools to optimize AI models so they consume less energy while maintaining their performance. This shows that technology itself can evolve to be more sustainable.

It's also important to minimize unnecessary AI usage. This means being strategic about where AI is applied to avoid wasting energy. For example, using pre-trained models instead of building new ones from scratch can save significant computational resources. Focusing AI on critical areas, like disaster prediction and resource management, ensures that the energy spent on AI has maximum impact.

By combining these approaches—adopting renewable energy, improving efficiency, and being thoughtful about usage—we can make AI more sustainable while still using it to support agriculture and tackle major challenges like climate change. This allows us to maximize the benefits of AI without putting extra strain on the environment.

Looking Towards the Future

Looking to the future, our application offers significant opportunities to transform agriculture and strengthen both individual farms and communities.

First, it helps farmers increase crop yields, even during extreme weather. By minimizing crop damage and reducing waste, farmers can use resources like seeds, water, and fertilizers more efficiently, leading to healthier harvests and more sustainable practices.

In addition to improving yields, the app empowers farmers to make better decisions. With real-time data at their fingertips, they can rely on actionable insights rather than guesswork. This not only boosts productivity but also gives farmers confidence in their choices, keeping them firmly in control of their work.

Over time, these insights can lead to the development of climate-resilient farming techniques. By understanding weather patterns and how to respond to them, farmers can adapt their methods and create long-term strategies for success, ensuring that their farms remain viable even in the face of increasing climate challenges.

The app also supports growth beyond the field. Integrated training programs offer farmers new skills in precision agriculture, helping them enhance productivity while opening the door to career development opportunities.

Beyond individual benefits, this approach strengthens local economies. By collaborating with regional suppliers and using AI for efficient inventory management and fair pricing, the app creates a marketplace that not only provides farmers with the resources they need but also boosts local businesses. This collaboration builds resilience within the community, especially during extreme weather events.

Future Applications

More specifically, in order to better support the local community and economies, in the future we aim to offer a built-in marketplace in the app to better leverage the power of AI. By combining real-time weather data, spatial analytics, and personalized agricultural inputs, the marketplace would help minimize losses, optimize resources, and build resilience in farming communities.

One key feature would be the emergency preparedness module. Using AI-powered climate models, the app predicts extreme weather events like floods or droughts and highlights essential supplies—like flashlights, water, and foods—directly in the marketplace. This ensures farmers can prepare in advance, especially in areas where access to resources might be limited.

The app also connects farmers with local stores and buyers, allowing them to sell surplus produce or unmatured crops during climate threats like early frosts or droughts. This prevents waste and keeps food systems stable even in adverse conditions.

Additionally, the marketplace fosters collaboration through a crop and seed exchange system, where farmers can trade seeds or partially grown crops. For example, a farmer facing drought might exchange water-intensive crops for drought-resistant varieties, promoting sustainability and adaptability. To make these exchanges seamless, the app would integrate AI-driven inventory tools. These tools would track stock levels, demand trends, and optimal selling times, helping farmers and suppliers plan effectively while reducing waste. Farmers would even be able to reach regional wholesalers and niche buyers, expanding their markets and diversifying revenue streams to weather economic uncertainties.

Beyond transactions, the app would empower users to prepare for climate impacts. This proactive approach ensures farming systems remain resilient and communities stay supported. Ultimately, this marketplace would be more than just a trading platform—it would be a hub for collaboration, innovation, and sustainability in an effort to reduce losses and secure the future of agriculture.

Conclusion

In general, these advancements together point to a future where farmers are better equipped, communities are more connected, and agriculture is more sustainable. It’s not just about weathering challenges—it’s about thriving in the face of them. Our app is designed to tackle the challenges farmers face in the event of disaster. By combining real-time weather data, spatial analytics, and personalized agricultural inputs, our app will help minimize losses, optimize resources, and build resilience in farming communities in the future.