



# Sudan Agricultural Advisor Chatbot

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# The Problem/Motivation



- Agriculture has seen limited integration of artificial intelligence, particularly with large language models, compared to many other fields of study.
- Of the agricultural-based LLMs that do exist, most are recent and focus on regions such as the United States, Brazil, and India
- Sudan's agricultural sector serves as the backbone of its economy, employing a significant portion of the population and contributing substantially to the nation's GDP. However, persistent poverty persists among farmers due to various factors, including inefficient farming practices, inadequate access to market information + resources, and the adverse effects of climate change.
- In this context, leveraging advancements in deep learning technology presents a promising avenue to address these issues.



# Problem Statement/Goal

To integrate deep learning algorithms with natural language processing (NLP) techniques to create an intelligent and user-friendly interface for spreading agricultural knowledge

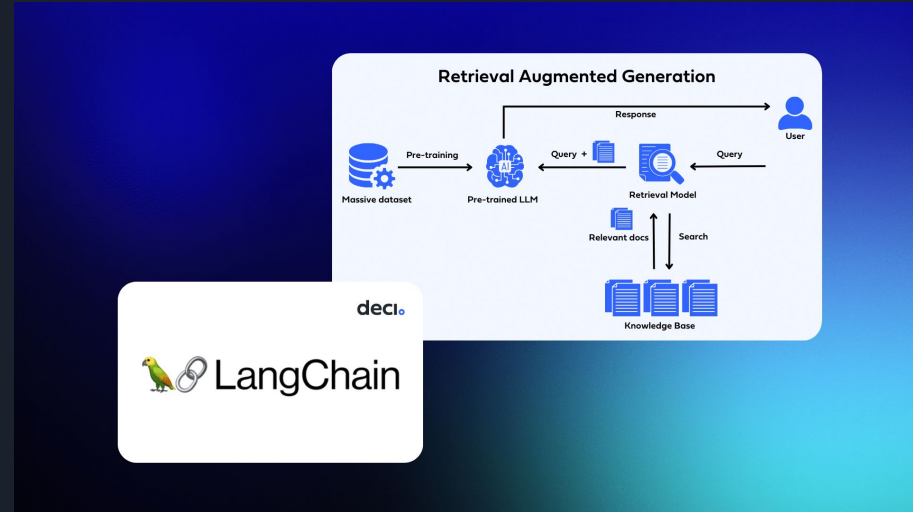


# Dataset

- 4 substantial PDF files ( > 100 pages of text each) containing textual Sudanese agricultural information → eventually converted to .MD
  - crop data (types, growth patterns), soil data (composition, fertility), market data (prices, demand), policy data, farm management practices, and historical data.
  - Public domain, provided by the World Bank, the Ministry of Agricultural and Food Security, the Organization of The United Nations, and the Agricultural Research Corporation (ARC) for Sudan

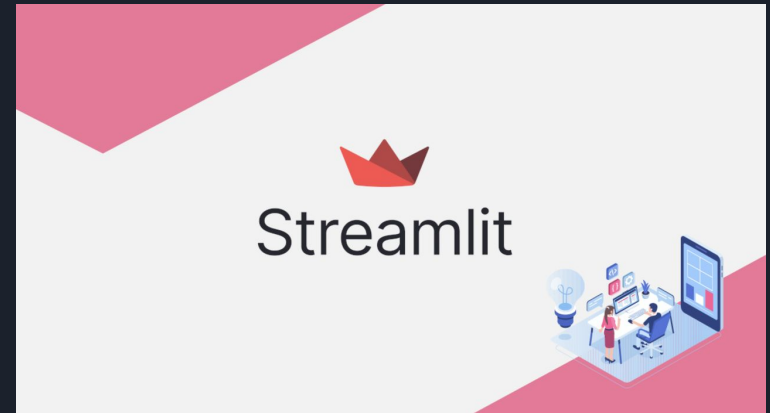
# Model/Architecture

- RAG with LangChain and OpenAI's GPT-4 Turbo model
- `chunk_size=500, chunk_overlap=100`
- Document chunks indexed/stored in Chroma vector store. Chroma converts text into vector embeddings, facilitating efficient similarity searches



# Model/Architecture Continued

- Performs similarity search to find the 3 most relevant document chunks based on question. If a satisfactory match is found, the chatbot constructs a context window and uses the GPT-4 Turbo model to generate a contextually aware answer
- UI built with Streamlit, allows users to input questions and view both the chatbot's responses and the document context used for those responses more efficiently



# Methods

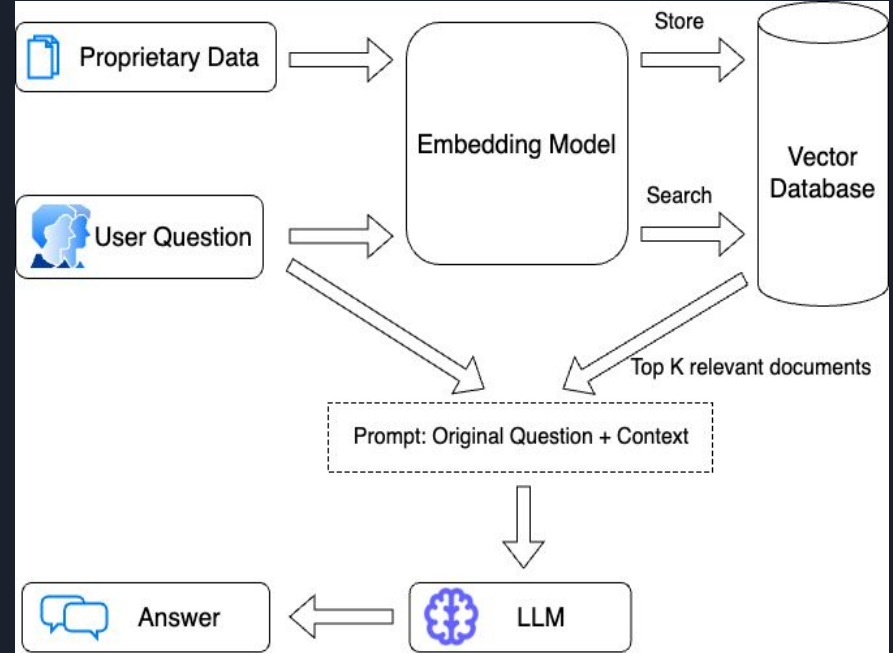
- Generated list of likely queries from Sudanese farmers via ChatPDF
- Posed questions to existing/pretrained LLM (GPT-4, GPT-3.5 and Llama 2)
  - Performed iterative prompt-tuning until responses were up to standard
  - Evaluated initial quality of responses quantitatively (agronomy LLM benchmarking repo: [GitHub - gbstox/agronomy\\_llm\\_benchmarking](#) and qualitatively (overall coherence, consistency, depth, and insight)

## Leaderboard

Model Name	Score	Date Tested	License Type
claude-3-opus	86.67%	2024-03-11	Proprietary
gpt-4	85.71%	2024-01-15	Proprietary
llama-3-70b-instruct	84.76%	2024-04-19	Open Source
centeotl	80.95%	2024-02-21	Proprietary
<a href="#">agronomYi-hermes-34b</a>	79.05%	2024-01-15	Open Source
mistral-medium	77.14%	2024-01-15	Open Source
nous-hermes-yi-34b	76.19%	2024-01-15	Open Source
mixtral-8x7b-instruct	72.38%	2024-01-15	Open Source
claude-2	72.38%	2024-01-15	Proprietary
yi-34b-chat	71.43%	2024-01-15	Open Source
norm	69.52%	2024-01-17	Proprietary
openhermes-2.5-mistral-7b	69.52%	2024-01-15	Open Source
gpt-3.5-turbo	67.62%	2024-01-15	Proprietary
mistral-7b-instruct	61.9%	2024-01-15	Open Source

# Methods Continued

- Implemented RAG of the source documents, repeated cycle of prompt tuning + response evaluation
- Compare to baseline and see how well the responses improved





# Evaluation

- TruLens Evaluation Metrics
  - Groundedness, Context Relevance, Answer Relevance
  - Each scored from 0 (worst) to 1 (best)
- Prompt/Response Evaluation
  - Compare baseline GPT-4 model to RAG model responses
  - Accuracy (ground truth), clarity, overall relevance

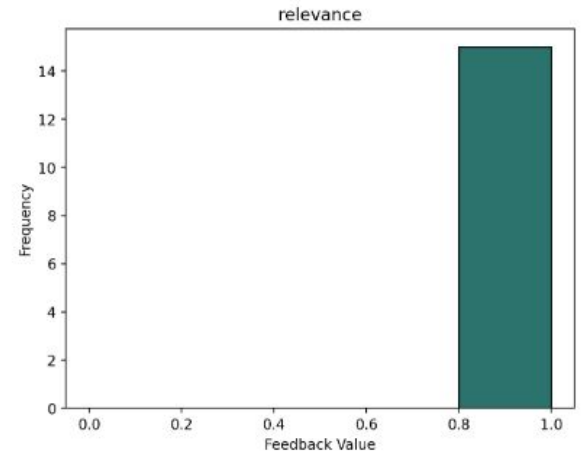
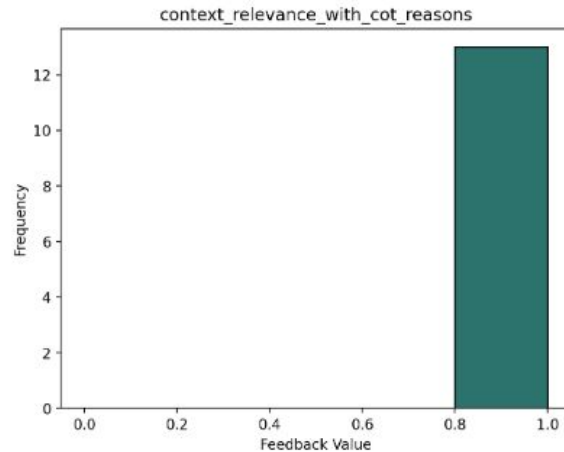
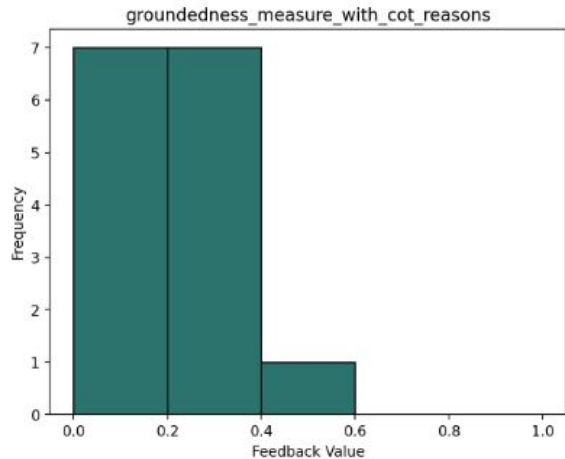


# Results (Quantitative)

## SudanAgri\_ChatApplication ©

Records	Average Latency...	Total Cost (USD)	Total Tokens	groundedness_...	context_relevan...	relevance
15	4.87	\$0	7.01k	0.18 ● low	0.85 ✓ high	0.8 ✓ high

Select App



# Results (Quantitative) Continued

User Input	Response	relevance	context_relevance_with_co...	groundedness_measure_wi...
"Are there any specific polic...	"Yes, there are specific polic...	0.8	0.8	0
"How can I adapt to potentia...	"To adapt to potential climat...	0.8	0.9	0
"Are there specific recomme...	"To increase crop yields and ...	0.8	0.9	0.4333333333
"How can the findings and i...	"The document suggests tha...	0.8	0.8	0
"What support will be availa...	"Support for small farmers i...	0.8	0.9	0.3333333333
"Will there be training or cap...	"Yes, there will be training or...	0.8	0.8	0.2666666667
"How can small farmers leve...	"Small farmers can leverage ...	0.8	0.9	0.2333333333
"What steps can small farme...	"Small farmers can improve ...	0.8	0.8	0
"Are there examples of succe...	"Yes, there are successful ini...	0.8	0.8	0.3333333333
"How can small farmers eng...	"Small farmers can engage ...	0.8	0.9	0.1
"Are there any specific mark...	"Yes, the report highlights fiv...	0.8	0.8	0.3333333333
"How can small farmers acc...	"Small farmers can access fi...	0.8	0.9	0.3333333333

- Groundedness measure originally even lower, increasing chunk size and chunk overlap aided in producing greater values
- Utilizing the k=3 context chunks with the highest similarity search scores to formulate responses allowed for both convenience as well as overall balanced scores

# Results (Qualitative)

**Prompt:** “How can I adapt to potential climate change threats to safeguard my farming livelihood?”

## GPT-4 Baseline Model

### ChatGPT

Adapting to climate change threats to safeguard your farming livelihood involves several strategic and practical measures. Here are some key approaches you might consider:

- 1. Diversify Crops and Livestock:** Growing a variety of crops can reduce the risk of total loss from any single climate event. Crop diversity can also improve soil health and reduce pest and disease pressures. Similarly, diversifying livestock can help stabilize income as different animals may be more resilient to varying conditions.
- 2. Implement Water Conservation Techniques:** Water scarcity is a major concern under climate change scenarios. Techniques like drip irrigation, rainwater harvesting, and the construction of water storage facilities can help ensure water availability during dry spells.
- 3. Improve Soil Health:** Healthy soils retain water more efficiently and are more resilient to erosion and degradation. Practices such as cover cropping, reduced tillage, and organic amendments can enhance soil structure and fertility.
- 4. Adopt Climate-Resilient Varieties:** Some crops have been bred or genetically modified to withstand stresses like drought, heat, or salinity. Switching to these varieties can help maintain productivity even under altered climatic conditions.

## RAG Implementation Model



To adapt to potential climate change threats and safeguard your farming livelihood, consider the following strategies based on the provided context:

- 1. Access to Information:** Ensure you have access to the right information at the right time. This includes updates on weather patterns, pest attacks, and disease outbreaks. Utilize resources that provide emergency advisory services and improved weather forecasting systems.
- 2. Education and Awareness:** Increase your knowledge and understanding of climate change and its impacts on agriculture. Participate in educational programs at schools and universities, and seek information about agriculture best practices, including those related to climate adaptation.
- 3. Linkages with Experts:** Enhance connections with researchers, extension services, and other farmers. This network can provide vital support and share innovative farming techniques and solutions that are resilient to climate change.
- 4. Financial and Insurance Schemes:** Gain awareness and make use of available financial and insurance products designed to support farmers in times of uncertainty and loss due to climatic changes.
- 5. Risk Management:** Develop and implement a proper risk management system tailored to your specific farming conditions and potential climate threats.
- 6. Diversification:** Consider diversifying your crop types or farming activities to reduce dependence on a single crop or method susceptible to climate threats.

# Results (Qualitative) Cont.

## ChatGPT

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## Pros of RAG:

- More domain-specific
- More diverse within domain
- Greater accuracy rate



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## Cons of RAG:

- Less specific in practices
- Inconsistent clarity (for certain prompts)

# Discussion

- While the retrieval-augmented generation chatbot saw improvements in domain specificity, the advice for actions was often general. This could be improved by incorporating data with more/better contextual detail
- Larger chunk size and chunk overlap generally produced better results, however this may vary for other LLMs depending on the specific goals of the model and the nature of its data
- Future work will ideally focus on further refining the LLM's capabilities, expanding its reach, and evaluating its long-term impact on agricultural productivity and livelihoods in Sudan



**Thank you!**