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FEASIBILITY STUDY

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# Executive Summary

The product discussed in this feasibility study aims to use satellite data integration, machine learning, and an interactive dashboard. The main focus of this product is to provide farmers with accurate and timely information regarding droughts. The product uses AI and sensor-based drought monitoring systems, by collecting, processing, and analysing the data gathered from the sensors on farmers' lands and satellite weather tracking. Currently, there are a few competitors in this market such as African Drought Monitoring and Advisory, African Flood and Drought Monitoring, as well as ICPAC. The target audience for this product is firstly farmers but it is also targeted at policymakers and stakeholders.

The reason for developing this product is to improve and revolutionise drought monitoring and prediction in Africa to help farmers, policymakers, and stakeholders make better and more informed decisions.

# Description of Product

## Key Features

The final product aims to contain these features. **Satellite Data Integration** uses open-source satellite data from government agencies like NASA and the European Space Agency, focusing on multispectral and thermal imagery to assess vegetation health and water availability. We will then use **Machine Learning Models (more on this in the technical considerations section)** to develop predictive models that analyse historical and current satellite data to identify patterns indicative of impending drought conditions. Finally, an **Interactive Dashboard** will be built to offer a user-friendly web interface that displays drought monitoring data, historical trends, and predictive analytics in an easily digestible format. This dashboard is intended for use by policymakers, farmers, and researchers to help make informed decisions.

## User Goals

The primary value proposition is to enable farmers to receive timely and accurate forecasts about drought conditions to make informed agricultural decisions. Our secondary objective is to assist policymakers in planning and allocating resources efficiently based on data-driven insights about drought conditions.

## User Stories

1. **As a farmer**, I want to access real-time drought conditions so that I can plan irrigation and cropping patterns effectively.
2. **As a policymaker**, I need to monitor drought trends over time to formulate better agricultural policies.
3. **As a researcher**, I wish to analyse historical drought data to predict future environmental impacts.

## User Experience – Step by Step Flow

1. **Login/Registration:** Users access the system via a secure login or registration module.
2. **Dashboard**: After login, users are presented with a dashboard displaying current drought conditions, forecasts, and personalised alerts.
3. **Data Analysis Tools**: Tools for detailed data analysis are available, such as heat maps, trend lines, and predictive analytics.
4. **Report Generation**: Users can generate custom reports based on selected data points and time frames.
5. **Alerts and Notifications**: Users receive notifications based on specific criteria set for drought conditions.

## Narrative

Imagine a farmer in South Africa, previously reliant on conventional wisdom, now using our AI-driven platform to see real-time data visualisations of impending drought conditions. This enables precise water use planning and the potential saving of crops and livelihoods during critical periods. Policymakers, equipped with predictive insights, can allocate resources more effectively, ensuring food security and economic stability in the region.

## Feasibility Assessment

Multispectral and thermal imagery allows us to accurately monitor vegetation health and water availability. This is at the crux of forecasting drought impacts (Tian, 2018). Integrating this type of data with machine learning models improves the strength of our predictions, however, continuously calibrating the model and incorporating real-time data inputs are important for maintaining accuracy (Boegh *et al.*, 2004; Forkel *et al.*, 2014). Additionally, the interactive front-end dashboard designed for this system will provide a user-friendly UI that offers real-time data visualisations and predictive analytics, making it an invaluable tool for the stakeholders involved.

This project is not without challenges, however. For instance, regarding the accuracy and availability of the satellite data we will be gathering from APIs, the availability and reliability of our model may be affected since the accuracy of satellite data can be compromised by atmospheric conditions like cloud cover, which obscures the imagery. Also, the resolution and update frequency of data from generalised, unpaid APIs may not meet this project’s specific needs for detailed, local-scale analysis. This could affect the precision of drought predictions and how useful the system’s data is for our stakeholders.

Ultimately, this project would likely necessitate close collaboration with faculty advisors and possibly partnerships with external organisations for technical support and data access.

# Technical Considerations

The effective use of AI and sensor-based drought management systems is essential for addressing climate change, particularly droughts and water scarcity in South Africa. This system aims to enhance South Africa's resource management by providing accurate, timely, and responsive drought predictions and modelling.

## Data Collection and Sources

The system will use sensor-based technologies and remote sensing to collect information on drought conditions and climate-specific parameters in South Africa.

The project does not currently include collecting data directly from field sensors. Given this, we want to evaluate and test the system using South African drought data (existing datasets) or remote sensing data.

## Data Processing and Analysis

Machine and deep learning models will be used to process and analyse the dataset, enabling accurate detection of drought conditions. By making use of these models, we can provide precise insights in terms of aiding stakeholders in making informed decisions to optimise productivity. Not only will these models ensure accuracy and reliability but can provide actionable insights for stakeholders.

**Machine and Deep Learning Implementation**

Machine learning and deep learning will play a crucial role in the development of our drought management system, specifically the advanced machine learning algorithms that will be employed in the future to process and analyse our sensor-based drought data. The implementation of these algorithms involves several key steps:

1. Data Collection: The first step is to gather relevant data on environmental variables such as temperature, humidity, and precipitation. This data will be retrieved from our sensor-based drought data.
2. Data Preprocessing: Once the data is collected, it undergoes preprocessing to clean and prepare it for analysis. This may involve removing outliers, filling in missing values, and normalising the data to ensure consistency and accuracy.
3. Feature Selection: In this step, relevant features or variables that are most informative for predicting drought conditions are selected. This helps streamline the model and improve its performance.
4. Model Development: This crucial step involves the actual creation and refinement of the machine learning model tailored to the specific requirements of the drought management system. Initially, the chosen algorithm, such as decision trees, support vector machines, or neural networks, is implemented and trained using historical drought data. During training, the model learns the underlying patterns and relationships in the data. The model is fine-tuned to improve its accuracy and performance in predicting drought conditions. Techniques such as parameter tuning may be employed to optimise the model's effectiveness. Throughout this process, rigorous testing and validation are conducted to ensure that the model meets the desired criteria for accuracy, reliability, and scalability.
5. Model Evaluation: Once development and training are completed, the model's performance is evaluated using data to assess its accuracy. This step ensures that the model can effectively predict drought conditions and provide reliable forecasts.
6. Deployment: After successful evaluation, the trained machine learning model is deployed within the drought management system.

Since sensors will not be employed at first the above steps will be done on existing datasets that collected data from sensors.

## Software Development and Delivery

* A user-friendly, web-based interface will be developed to provide stakeholders with access to drought forecasts, predictions, and relevant information.
* We will make use of Python and MATLAB during the duration of this project. By making use of these technologies, we can develop advanced algorithms for the processing and analysing of the dataset to detect drought conditions and develop early warning systems as well predicting land fertility and productivity.
* The software product will be deployed online via web servers, with mobile-based capabilities to ensure accessibility and usability for users in South Africa.

Below the system’s implementation can be seen:

1. System Architecture Design:
   1. Design the overall structure of the system and determine the roles and interactions of different components.
   2. Acquire relevant data from sensor-based data datasets.
2. Data Processing, Analysis, and Model Development:
   1. Process and analyse the collected data using advanced machine learning algorithms to detect drought conditions, predict future trends and assess productivity affected by drought and water scarcity.
   2. Develop machine learning models tailored to the specific requirements of the drought management system.
   3. Train the models using historical data and fine-tune them for accuracy and performance, employing techniques like parameter tuning and rigorous testing.
3. Interface Development:
   1. Design and develop a user-friendly, web-based interface to provide stakeholders with access to drought forecasts, predictions, and relevant information.
   2. Ensure the interface is intuitive and easy to navigate, to meet the needs of the stakeholders.
4. Model Validation, Testing, and Deployment:
   1. Validate the accuracy and reliability of the AI-driven drought forecasting models through historical data analysis.
   2. Test the system to ensure effective performance.
   3. Deploy the validated machine learning models within the drought management system to analyse data and accurately predict drought conditions.
5. Maintenance, Updates, and Integration:
   1. Perform regular maintenance activities, such as software updates, and bug fixes, to ensure the reliability and effectiveness of the system.
   2. Integrate the deployed system with existing infrastructure and systems, while keeping in mind server hosting, data storage, and network connectivity as needed.

## Difficulties in Implementation

1. Infrastructure and Resource Constraints: Infrastructure, including server hosting, data storage, and network connectivity, to support the operation of the drought management system can be resource-intensive and may hinder the implementation of the system.
2. Data Integration and Compatibility: Integrating data from sources, such as existing data stores, can be challenging due to differences in data formats, and standards.
3. Model Generalisation: Ensuring that the machine learning models generalise well to unseen data is crucial for the system's reliability and effectiveness. Overfitting, where the model performs well on the training data but poorly on new data, is a common challenge that needs to be addressed through proper model evaluation and validation techniques.

## Implementation of Python and MATLAB

Selection of Python and MATLAB for the implementation of the drought management system based on their strengths and capabilities:

### Python

Versatility: Python is a highly versatile programming language that contains extensive frameworks for machine learning and data science. It is rich in packages and tools making it well-suited for implementing complex algorithms and handling large datasets.

Machine Learning and Artificial Intelligence: Given Python’s versatile nature, it offers a wide range of libraries such as ‘scikit-learn’, ‘TensorFlow’ and, ‘PyTorch’, these libraries provide a significant number of functional algorithms making Python an ideal choice for developing and implementing machine learning models.

### MATLAB

Computational Power: MATLAB is recognised for the powerful computing capabilities it provides, making it well-suited for scientific applications. It contains various functions and tools that provide extensive support for data analysis and modelling.

Simplicity: MATLAB's intuitive syntax and interactive development environment enable rapid prototyping and experimentation, allowing developers to iterate quickly on algorithm development and testing. Its visualisations also facilitate the exploration and interpretation of data, which is essential for understanding drought patterns and trends.

In summary, the use of Python and MATLAB for the implementation of the drought management system leverages their respective strengths in machine learning, and web development to develop a comprehensive solution for addressing the challenges posed by droughts and water scarcity in South Africa. By adapting the capabilities of these programming languages, the project aims to deliver accurate, timely, and actionable drought forecasts and modelling to enhance resource management across the country.

## Feasibility Assessment

The approach outlined above is feasible due to several factors. Firstly, the use of sensor-based technologies and remote sensing data sources allows us to work with reliable information on drought conditions and environmental variables specific to South Africa. While direct data collection from field sensors may not be feasible at this point, leveraging existing datasets allows for effective validation and testing of the system. Furthermore, the implementation of machine learning and deep learning algorithms enables the processing and analysis of large datasets, facilitating accurate detection of drought conditions and predictive modelling. The selection of Python and MATLAB for software development leverages their libraries and computational capabilities, ensuring efficient algorithm development and implementation. Overall, the combination of advanced technologies, and firm methodologies, allow us to address the drought management challenges in South Africa.

# Product/Service Marketplace

## Competitors

The competitors identified were African Drought Monitoring and Advisory (ADMA), African Flood and Drought Monitoring (AFDM) and ICPAC.

[African Drought Monitoring and Advisory (ADMA)](https://ada.acmad.org/) is a near-real-time system that uses Earth Observation and Weather information to monitor drought conditions in Africa (African Drought Monitoring and Advisory, 2024).

[The African Flood and Drought Monitor (AFDM)](https://hydrology.soton.ac.uk/apps/afdm/) is a sophisticated system developed by the Princeton Climate Institute (PCI) in collaboration with the University of Southampton and Princeton University. It aims to provide early warning for flood and drought conditions across Africa. The system utilizes a combination of ground observations, satellite data, and modelled datasets to generate real-time hydrological assessments and forecasts (African Flood and Drought Monitor, 2024). PCI also offers other drought monitoring services covering other areas of Africa, such as the South Africa Flood and Drought Monitor (SAFDM).

[ICPAC](https://eahazardswatch.icpac.net/map/ea/?mainMap=eyJzaG93QW5hbHlzaXMiOnRydWV9&map=&mapMenu=eyJtZW51U2VjdGlvbiI6ImRhdGFzZXRzIiwiZGF0YXNldENhdGVnb3J5IjoiQWdyaWN1bHR1cmUifQ%3D%3D) is a service that provides climate services to Eastern Africa (ICPAC, 2024).

Table 1 illustrates relevant system features incorporated within ADMA, AFDM and ICPAC.

Table 1: Relevant system features

|  |  |  |  |
| --- | --- | --- | --- |
|  | ADMA | AFDM | ICPAC |
| Near-real-time Monitoring | Yes | Yes | Yes |
| Comprehensive Data Integration | Yes | Yes | No |
| Visualization and Analysis Tools | Yes | Yes | Yes |
| Web-based interface | Yes | Yes | Yes |
| Forecasting | No | Yes | Yes |
| AI | Experimental | No | No |
| User Configurability | Yes | Limited | Yes |

## Target Market

The product we are offering is a web-based drought monitoring system tailored for farmers, policymakers, and other stakeholders to track drought conditions. It is distinguished by using AI algorithms to process and analyse gathered data and employing AI machine learning models to interpret both sensor-based and remote sensing data. This enables the system to monitor and forecast agricultural land fertility and productivity effectively.

Our product is mainly targeting farmers, policymakers, and other stakeholders. However, it would be beneficial to understand our competitors' target audience to gain insight. Table 2 displays the target audience of each of the competitors. ADMA partners are ACMAD, European Union, Norwegian Capacity, and IGAD (African Drought Monitoring and Advisory, 2024). ICPAC partners were the European Union, the African Development Bank Group, the Norwegian Refugee Council, the Met Office, and NASA Harvest (ICPAC, 2024). African Flood and Drought Monitor has the following funding support from the UNESCO International Hydrology Programme (IHP) and the International Centre for Integrated Water Resources Management (ICIWaRM) (United Nations, 2024). Relevant partners discovered during the market analysis were between competitors where EU, and the Norwegian Refugee Council. The partners of each competitor can be grouped in the following areas: farmers, research and institutions, policymakers, governments, banks, and world health unions.

Table 2: Target audience of each competitor

|  |  |  |
| --- | --- | --- |
| ADMA | AFDM | ICPAC |
| European Union | UNESCO Internation Hydrology Programme (IHP) | European Union |
| Norwegian Capacity | International Centre for Integrated Water Resources Management (ICIWaRM) | African Development Bank Group |
| African Center of Meteorological Application for Development (ACMAD) |  | Norwegian refugee council |
| Intergovernmental Authority on Development (IGAD) |  | Met Office |
|  |  | NASA harvest |

### Condition

The market condition has proven fruitful since each competitor has more than one partner/sponsor. Some sponsors are members of the government, banks, or even high-market value organizations such as NASA. The reason why members of high power are aiding in these systems is that drought has an impact on the condition of the food supply, which is a necessity for human well-being.

### Demand

The demand for drought monitoring services also proves to be fruitful:

* The competitors are funded, an example would be African Drought Monitoring which is funded by the UNESCO Internation Hydrology Programme (IHP) and the International Centre for Integrated Water Resources Management (ICIWaRM) (United Nations, 2024).
* Users of the systems require it to be effective in their career, the users of ICPAC said this:
  + “We appreciate ICPAC's timely forecasts. The monthly and seasonal forecasts are especially relevant to us to advise farmers” (ICPAC, 2024).
  + Another user in BBC Media Action stated this: “ICPAC has been very instrumental in breaking down weather information for our media partners using simplified visuals like maps and icons. This has in turn helped our media partners to better understand how to communicate and package weather and climate content to the end users. (ICPAC, 2024)”
* The government relies on these types of systems to predict drought, to effectively recover and prepare for these natural occurrences, for example, African Drought Monitoring which is funded by UNESCO (which is an intergovernmental Hydrological Program) (United Nations, 2024).

## Feasibility Assessment

The system we are proposing will be similar in functionality to the competitors mentioned with one critical distinction, the implementation of AI. The use of AI algorithms to process and analyse gathered data and employing AI machine learning models to interpret both sensor-based and remote sensing data could prove to be an advantage because of more effective and fast analysis and use of the data. The proposed system is feasible due to it incorporating standard features and also having an advantage by incorporating AI.

# Marketing Strategy

## Overview

We are dedicated to revolutionising the way drought conditions are monitored and managed. With a passion for sustainability and innovation, we leverage cutting-edge satellite technology to provide real-time insights into drought conditions, empowering our users to make informed decisions and mitigate risks effectively.

## Product/System Description

Our product is a state-of-the-art drought monitoring system that utilizes satellite imagery and advanced analytics to deliver accurate and timely information about drought conditions in Africa. By combining remote sensing data with powerful algorithms, our system offers unparalleled precision and reliability, enabling users to monitor drought severity, assess water availability, and optimise resource allocation with confidence.

## Unique Selling Proposition

What distinguishes us is our dedication to providing actionable intelligence that produces tangible results. Our system offers:

* High-resolution satellite imaging that allows for more detailed monitoring.
* Real-time data updates which enable fast decision-making.
* For convenience, the interface is user-friendly, and alarms can be customised.
* Advanced algorithms for detailed drought analysis and forecasts.

## Target Market

Our target market includes:

* Businesses within the agricultural sector as well as farmers who seek to improve water usage and crop yields.
* Departments that manage water resources.
* Environmental protection authorities who monitor drought conditions and implement mitigation strategies.
* Drought monitoring research institutions.

## Value Proposition

Our drought monitoring and prediction system enables users to:

* Detect drought conditions early and take proactive measures to reduce risks.
* Optimise water usage and resource allocation to achieve maximum efficiency and sustainability.
* Improve crop yield in response to shifting climate patterns.
* Improve environmental management by encouraging data-driven decision-making and conservation initiatives.

## Technology and Data Sources

We make use of satellite imagery from renowned providers, as well as proprietary algorithms and data processing approaches or techniques, to provide precise and reliable drought monitoring. Our system integrates existing infrastructure and data platforms, ensuring compatibility for our consumers.

## Business Model

We offer flexible pricing plans tailored to the needs of our customers, with options for individual users, enterprises, and institutional users. Our transparent pricing model includes tiered packages with scalable features and support options, ensuring affordability and value for all users.

## Future Plans

Our roadmap for continued innovation and evolution includes:

* Enhancement to our system's capabilities, such as increased geographic coverage and higher data resolution.
* Integrating complementary technologies, such as IoT sensors with weather forecasting models, can improve predictive capabilities.
* Collaboration with industry partners and stakeholders to solve new problems and opportunities for drought monitoring and management.

# Organisation

The organization is comprised of eight team members, which include Wilco Tromp, Rorisang Serapelo, Melissa Roodt, Oratile Seloro, Sarah Masu, Chriselda Mathebula, Mduduzi Msiza, and Jevon Gounden.

The members of the team divide up the tasks. Eight-day sprints have been developed to track the number of work hours spent on specific tasks inside a given sprint, to maintain scheduling alignment. Every task's assignee(s) will be noted. The sprints are as follows:

* Sprint 1: 23 Apr - 1 May
* Sprint 2: 2 May – 10 May
* Sprint 3: 11 May – 19 May
* Sprint 4: 20 May – 28 May
* Sprint 5: 29 May – 6 June
* Sprint 6: 7 June – 15 June
* Sprint 7: 16 June – 21 June

In the table below, an example of the sprint table is shown. It portrays the names of the members, the number of hours per sprint and the total amount of hours each member took during the process to produce the final product.

|  |  |  |  |
| --- | --- | --- | --- |
| Project Members | Sprint n (hours) | Sprint (n+1) (hours) | Total hours |
| [St. number] [Name and surnames] | [Date] | {Dates] |  |
| 35834609 Oratile Seloro | xxx | xxx | xx |
| 32850123 Sarah Masu | xxx | xxx | xx |
| 34250964 Chriselda Mathebula | xxx | xxx | xx |
| 26905647 Mduduzi Msiza | xxx | xxx | xx |
| 34531033 Wilco Tromp | xxx | xxx | xx |
| 37609866 Jevon Gounden | xxx | xxx | xx |
| 35406895 Rorisang Serapelo | xxx | xxx | xx |
| 33509735 Melissa Roodt | xxx | xxx | xx |

# Schedule

The project schedule is set within the last half of the first semester. It consists of tasks each having its subtask/s. The subtasks have start and end dates that fall with the tasks' start and end dates. The progress column, as its name suggests, shows the progress of the subtask. The schedule can be changed throughout the project period, allowing tasks/subtasks to be added, updated, or removed, and to change the start and end date.

The Gantt chart is used to help manage the schedule. On the chart we see the schedule (the first semester half), next to the schedule there is a chart with bars. The bars are the duration of the subtask, that can influence the length of the bar by changing the start and end date. the bars darken when the progress of the task is changed, the red column is the current date, and the column shifts when the day changes.

Figure 1: Gantt schedule chart

A screenshot of a computer

Description automatically generated

# Financial Projections

To successfully deliver this project/product a lot of factors must be taken into consideration, given the fact that this is not just a normal project with tangible expenses and fixed costs but one where costs fluctuate due to maintenance fees, boosted security, future developments, and ongoing developments.

A financial projection focuses on giving a comprehensive analysis of the financial aspect of developing and launching a project and ensuring that an informed decision is made.

## Cost Estimation

An estimation will be made with hypothetical values to give an understanding of what needs to be done and how much it will cost.

Figure 2: Cost estimation

A screenshot of a spreadsheet

Description automatically generated

As seen in (Figure 3), we are focusing on estimating costs per deliverable rather than hours which are subject to change depending on what is discovered in the ideas. The following costs were not included due to needing to plan on what needs to be used, Licensing Fees for third-party services, Salaries for Maintenance Developers, and ongoing development for adding new features and improvements.

Upon finishing a feasibility study, a more comprehensive financial projection will be created, factoring in Revenue as well as Return on Investment.

# Findings and Recommendations

The biggest hurdle for this product is the data that needs to be collected for processing, however in this case the use of open-source data from NASA and the European Space Agency makes that hurdle easy to cross. The use of Machine Learning will eventually help improve overall efficiency and accuracy, however, the training of the model will require intensive support and monitoring to ensure its accuracy. The physical implementation will probably go through many iterations to ensure user-friendliness, if there is good communication between user and developer this should not be a problem. There is mention of sensors in the fields of the farmers, this could be an interesting avenue to explore further down the line as more funds become available. The users will access the system online which will allow for accurate and timely data. There are competitors in this field already, but the use of AI could be promising, as long as the customers are also on board with using AI, as some could be very tentative since it is a relatively new field being implemented into the industry, thus this could be a key selling point.

The schedule looks a bit tight and does not allow all that much room for tasks exceeding due dates, this could be something that needs to be looked at. The cost estimation is also something that could be quite challenging as funds would need to be procured from external investors, this could be something that could stop the project from even starting.

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