MONASH University

FIT5147 Data Visualisation Project

Topic: Agricultural Dynamics Explorer

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Submitted To:
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Contents

1. Introduction

The Agricultural Dynamics Explorer is an interactive visualization platform designed to unravel the relationship between agriculture, climate, and economic resilience. Motivated by a profound connection to agricultural practices cultivated over generations, the platform aims to provide an understanding of how these dynamics influence crop yields and economic investments on a global scale.

Through a series of interactive visualizations, the Agricultural Dynamics Explorer illustrates the impact of various climate variables, such as temperature, precipitation, humidity, seal level rise, CO2 emissions and economic indicators, such as development aid, foreign investments, and loans on agricultural productivity. The visualization also highlights the critical role of government investments in supporting or hindering crop yields across different regions and the impact it has on economic contribution by the agricultural sector.

The primary audience for this platform includes individuals with limited knowledge of agriculture and government investments, as well as children and educators. By making complex data engaging and accessible, the Agricultural Dynamics Explorer serves as a tool that fosters a deeper appreciation for the factors that shape agricultural outcomes and economic resilience.

The narrative aims to address key questions such as:

- How do changes in temperature, precipitation, and other climate variables affect crop yields?
- What role do economic factors play in supporting or hindering agricultural yield and agricultural contribution to economy?

Through this exploration, users are invited to uncover the stories behind the numbers, gaining a comprehensive understanding of the interconnectedness of climate, economy, and agriculture.

2. Design Process

The design process for the Agricultural Dynamics Explorer visualization followed the Five Design-Sheet (FdS) methodology, which allowed for a structured exploration of ideas and a convergence towards the final design solution. The five sheets are included in the Appendix, and each sheet played a crucial role in shaping the narrative visualization.

Sheet 1: Brainstorm

This initial sheet showcases a diverse range of ideas, including various chart types (bar charts, line charts, scatter plots, and maps), color palettes, and layout arrangements. The brainstorming process was guided by the project's objective of making complex data engaging and accessible to a broad audience, including individuals with limited knowledge of agriculture and government investments.

Justification: The initial sketches emphasized clear and straightforward visualizations to ensure that the information is easily accessible to the intended audience. This aligns with Munzner’s what-why-how framework, focusing on the “why” aspect, which emphasizes the importance of clarity and effectiveness in visual communication.

Sheet 2:

In the second design sheet, the visual elements were refined, and interactivity was introduced. This included the use of a world map to show crop yields and government investments, with interactive elements allowing users to click on countries for detailed information. The bubble chart uses size to

represent the yield of crops with interactive elements such as tool tip on click that gives more information on the area harvested and production. Different climate variables can be selected using the drop down.

Justification: Incorporating interactive elements, such as clickable maps and sliders, enhances user engagement and allows for a more personalized exploration of the data. This design choice is based on the principles of interaction, which highlight the importance of user control and flexibility.

Though it uses sliders, tool tips and dropdown menu, it does not really analyse the overall effect of climate all together.

Sheet 3:

The third design sheet is focused on analysing crop yield in relation to climate variables and economic indicators. The visualizations proposed include a line graph to display crop yield over time, a scatter plot to analyse the relationship between crop yield and GDP, and a bar chart to visualize economic investments.

Justification: Tooltips and Hover Effects: Consistent use of interactive elements like tooltips and hover effects enhances user engagement and provides additional information without cluttering the visuals.

Munzner's What-Why-How Framework:
What: Data includes crop yield, GDP, and economic investments.
Why: The task is to understand the relationship between crop yield and influencing factors.
How: Line graph for temporal analysis, scatter plot for correlation, and bar chart for categorical comparison.

Sheet 4:
The fourth design sheet emphasizes analysing crop yield variations in relation to climate variables and GDP across different crop types. The visualizations include a correlation matrix and a scatter plot with interactive tooltips.

Justification: Consistent use of tooltips across the scatter plot enhances the interactivity and provides users with additional context about GDP and crop yield without overwhelming the main visualization. Dropdowns allow users to select different crop types, making the visualization dynamic and user-specific.
Munzner's What-Why-How Framework:
What: Data includes climate variables, crop yield, GDP, and different crop types.
Why: The task is to understand how climate variables and GDP affect crop yield across various crop types.
How: Correlation matrix for an overview and scatter plot for detailed analysis.

Sheet 5:
The final design sheet consolidates the visual elements from previous designs into a cohesive and interactive dashboard. It incorporates a bubble chart, world map, and various interactive elements such as tooltips, dropdowns, and sliders.

Justification:

Tooltips and Hover Effects: The consistent use of tooltips across the bubble chart and choropleth map enhances interactivity and user engagement by providing additional context without cluttering the main visualization.

Dropdowns and Sliders: These interactive elements allow users to filter data dynamically based on climate variables and time ranges, making the visualization adaptable to user preferences and needs.

The layout separates the bubble chart and map, reducing cognitive load and guiding users through the data in a logical and structured manner. The use of dropdowns and sliders further enhances the user experience by allowing seamless interaction with the data.

The inclusion of a graph to show statistical data on click provides users with a deeper understanding of the relationship between crop yield, climate variables, and government investments.

Munzner's What-Why-How Framework:
What: Data includes climate variables, crop yield, GDP, and various government investments.
Why: The task is to understand how these factors influence agricultural productivity and economic resilience.
How: Bubble chart and choropleth map for an overview, with detailed information provided through tooltips and interactive elements.

The final design sheet successfully integrates various visual elements and interactive features to create a comprehensive and engaging narrative visualization. The design choices, grounded in theoretical principles, ensure that the visualization is consistent, informative, and user-friendly. This final design effectively communicates the complex relationships between climate variables, crop yield, and government investments, making it accessible and understandable for a diverse audience.

3. Implementation

Technical Implementation

Libraries Used

- shiny: To create the interactive web application.
- leaflet: For creating interactive maps.
- ggplot2: To generate visualizations.
- dplyr: For data manipulation and wrangling.
- plotly: For creating interactive plots.
- shinyjs: To add JavaScript functionalities for enhanced interactivity.
- rnaturalearth: To access country geographic data.
- rnaturalearthdata: Provides additional natural earth data.
- sf: For handling spatial data.
- htmltools: To enhance the HTML content within the app.

These libraries were chosen for their compatibility with Shiny, making them ideal for creating interactive and visually appealing data applications.

References to External Code Sources

- Shiny Gallery and Tutorials: The Shiny official gallery and tutorials were instrumental in understanding and implementing interactive features and custom UI elements.

- Plotly Documentation: The Plotly documentation provided comprehensive guidance on creating interactive plots and customizing tooltips.
- Leaflet Documentation: Used extensively for implementing the interactive map functionalities.

Implementation Details and Challenges

Data Wrangling:

- Merging Data: Combining crop yield data with government investment data and geographic information required extensive data wrangling. This process involved cleaning and transforming the data to ensure compatibility across different datasets.
- Handling Missing Data: One of the primary challenges was dealing with missing data. In some cases, government investment data was not available for certain years. This required implementing conditional checks and providing informative messages to users about the lack of data.

Interactive Visualizations:

- Dynamic Plotting: The app needed to dynamically update plots based on user input. This involved using reactive programming principles in Shiny to ensure that visualizations were updated in real-time as users interacted with the app.
- Custom Tooltips: Implementing custom tooltips in Plotly to display detailed information on hover was challenging but essential for providing context and enhancing user experience.
- Map Integration: Integrating the Leaflet map with Shiny to display geographic data interactively posed several challenges, particularly in ensuring that the map updated correctly based on user selections.

UI Design and User Experience:

- User Guidance: Adding hover information and interactive elements to guide users through the visualizations and help them understand the data better was a key focus area.

Differences Between Design and Implementation

- Additional Interactivity: additional interactivity features, such as informative user guidance messages were added to improve user engagement.

Conclusion

Overall, the technical implementation of the Agricultural Dynamics Explorer was a challenging yet rewarding process. It required careful integration of various data sources, extensive data wrangling, and the creation of interactive and informative visualizations. The final product effectively communicates the relationships between agriculture, climate, and economic resilience, making it accessible and engaging for a diverse audience.

Interactive Narrative Visualisation Implementation

The application consists of multiple sections, each focusing on a specific aspect of the relationship between crop yield, climate variables, and government investments. The user interface is designed to

be intuitive and visually appealing, ensuring that users with varying levels of expertise can navigate and understand the insights presented.

Main Features:

- Welcome and Introduction

The homepage introduces users to the Agricultural Dynamics Explorer. It provides a brief overview of the purpose of the application and sets the context for the subsequent visualisations as shown in Figure 3.1.

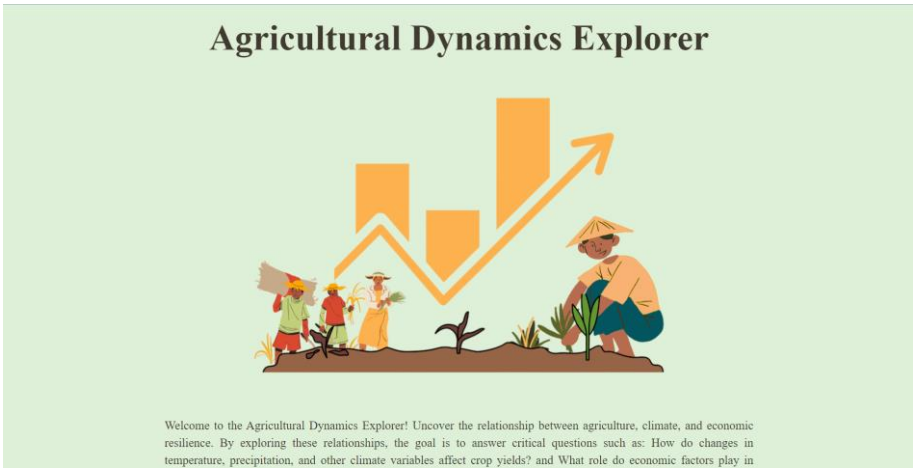


Figure 3.1: Welcome and Introduction to Agricultural Dynamics Explorer

- Understanding the Impact of Climate on Crop Yield

This section features a brief introduction on the impact of climate on crop yield as shown in Figure 3.2 and then a bubble chart that visualises the impact of different climate variables on crop yields across various countries. Users can select a country and a climate variable from the dropdown menus. It also has informative blinking messages for the user to navigate easily as shown in Figure 3.3.

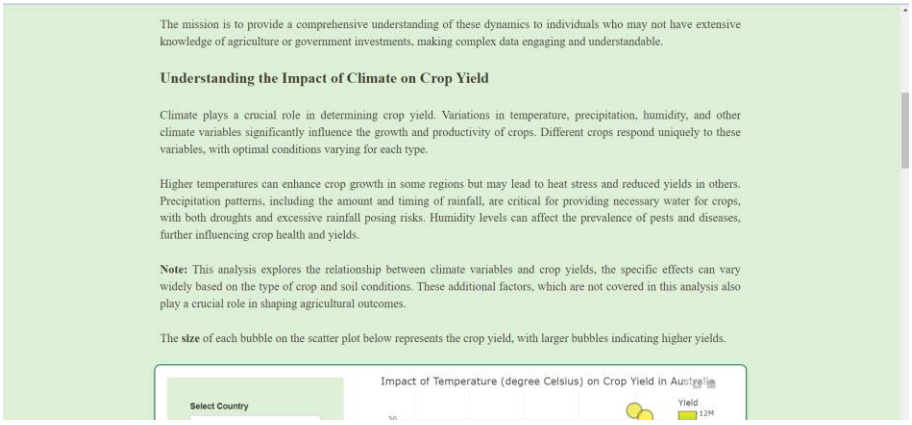


Figure 3.2: Brief introduction on the impact of climate on crop yield

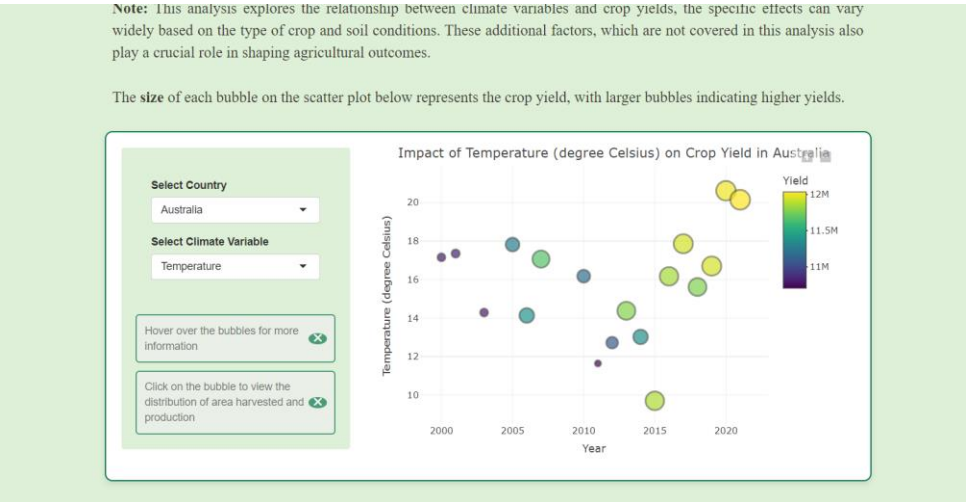


Figure 3.3: Bubble chart with drop down and informative message

- Interactive Bubble Chart:

The size of each bubble represents the crop yield, with larger bubbles indicating higher yields. Hovering over a bubble displays detailed information about the year, area harvested, production, and yield as shown in Figure 3.4.

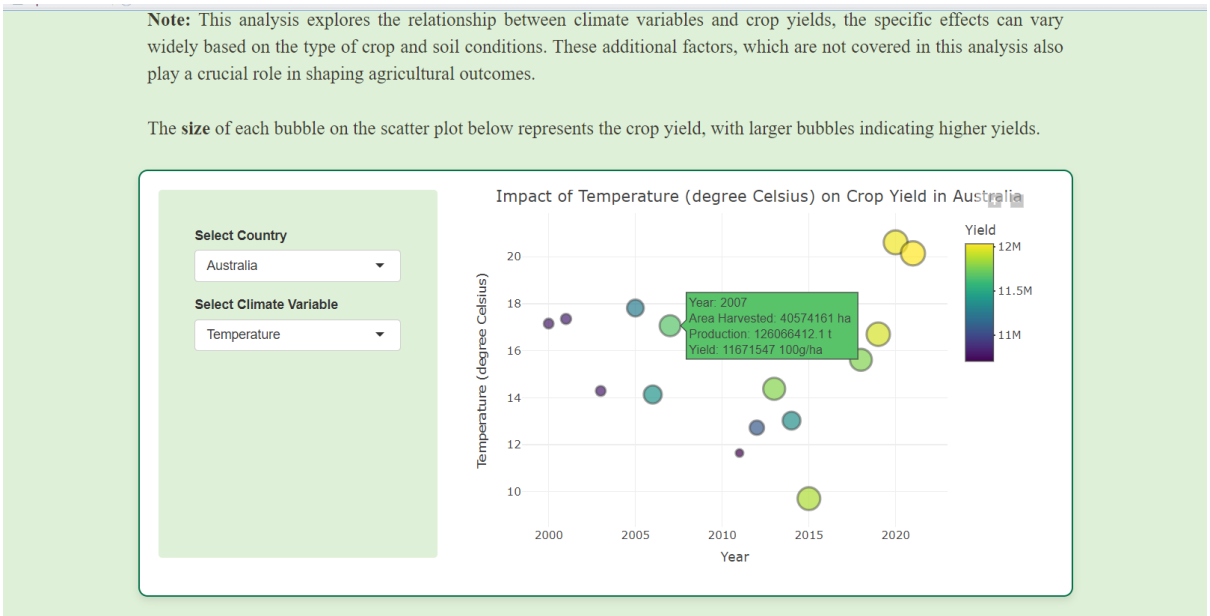


Figure 3.4: Tooltip on hover over the bubbles

On clicking the bubble, a new dialog opens, which gives us more information on the distribution of area of harvest and production as shown in Figure 3.5.

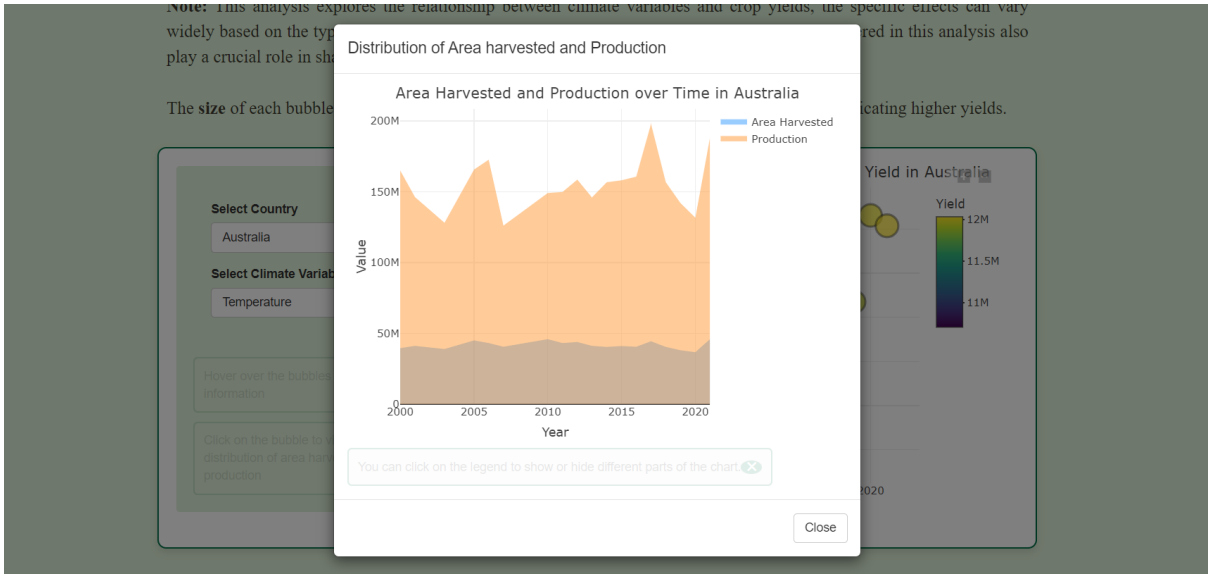


Figure 3.5: Dialog showing distribution of area of harvest and production

- Crop Yield, Government Investment, and Economic Contribution

This section focuses on the relationship between crop yield, various types of government investments, and the economic contribution of agriculture.

Interactive Map: A Leaflet map allows users to select a country and view detailed insights into government investments in agriculture as shown in Figure 3.6. Clicking on a country updates the bar chart and the area chart accordingly. Also, clicking on the country, scrolls the page down to the charts.

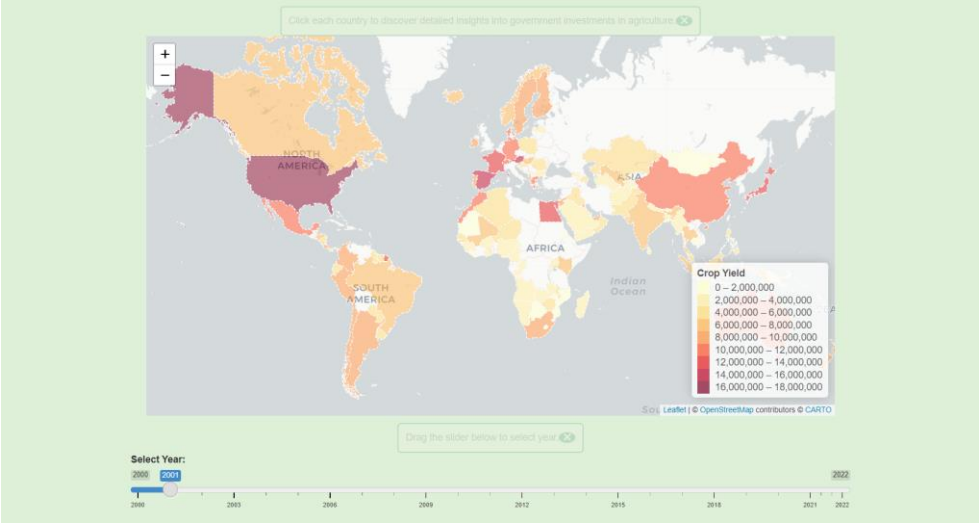


Figure 3.6: Leaflet map showing crop yield for the selected year

Interactive Bar Chart: The bar chart displays different types of government investments for the selected country and year. Users can see the value of each investment type, with tooltips providing detailed information on hover as shown in Figure 3.7.

Figure 3.7: Bar chart for different types of government investments for the selected country and year

Economic Contribution vs. Government Investments: An area chart shows the relationship between the economic contribution of agriculture and the sum of various government investments over time as shown in Figure 3.8. This helps users understand how economic value generated by agriculture correlates with government support.

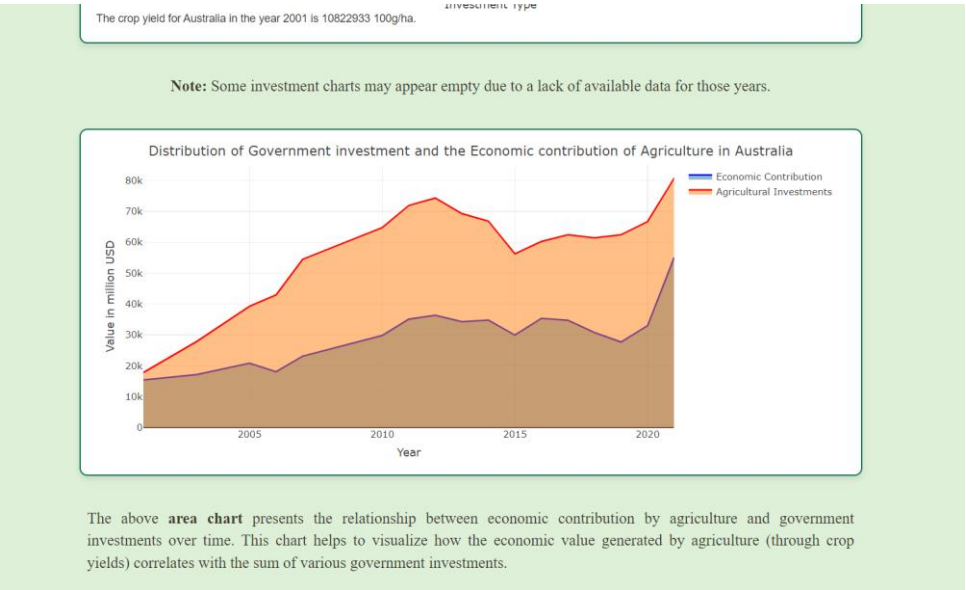


Figure 3.8: Distribution of economic contribution of agriculture and various government investments

- Additional Features

Year Slider: Users can select a year using the slider to view data for that specific year as shown in Figure 3.9. This feature updates all relevant charts and visualisations dynamically.

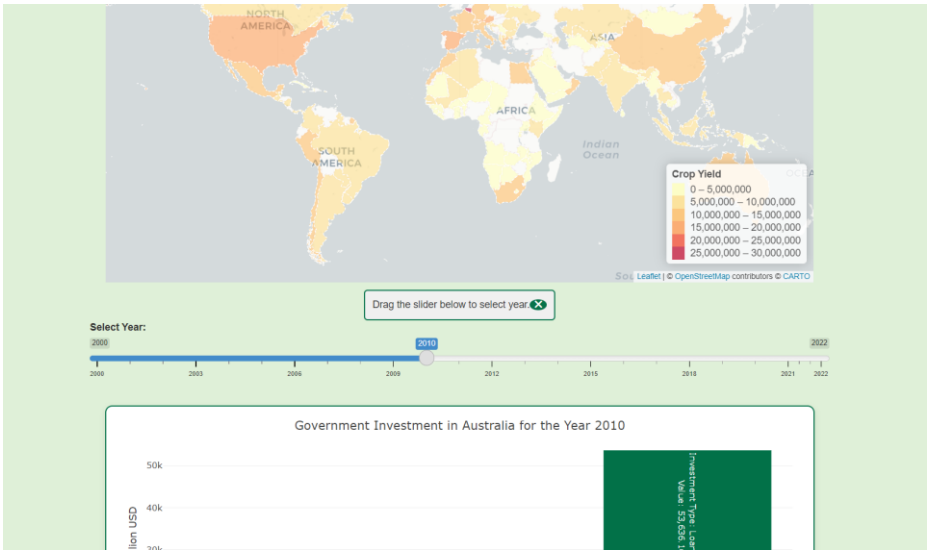


Figure 3.9: Year slider to select the year

Informative messages: These are included as shown in Figure 3.10 to guide the user accordingly.

Figure 3.10: Inormative messages to guide the user

Narrative and Data Insights

The narrative of the Agricultural Dynamics Explorer is crafted to guide users through a comprehensive understanding of the relationships between climate variables, crop yields, and government investments. Each visualisation is designed to answer specific questions and highlight key insights:

- Climate Impact on Crop Yield: Users can explore how different climate variables, such as temperature and precipitation, affect crop yields. The bubble chart provides an intuitive way to see these relationships briefly and provides insights on the distribution of area harvested and production on clicking the bubbles.
- Economic Contribution and Government Investments: The bar and area charts illustrate how government investments support agricultural productivity and how the economic value generated by agriculture relates to these investments.
- Geographic Insights: The interactive map allows users to explore data geographically, providing a spatial dimension to the analysis.

It provides users with valuable insights into the factors influencing agricultural productivity and economic resilience.

Using the Implementation

1. Running the Application
   - Install Required Libraries: Ensure you have the necessary libraries installed in your R environment.
   - Load the Shiny Application: Download the R script file containing the Shiny application code. Open the file in RStudio or any other R IDE.
   - Run the Application: Execute the script to start the Shiny application. You can do this by clicking the "Run App" button in RStudio.
   - View the Application: The application will open in your default web browser.
2. Navigating the Application
   - Homepage:
     - Welcome Message: The homepage provides an introduction to the Agricultural Dynamics Explorer. Read the brief overview to understand the purpose and goals of the visualisation.
   - Climate Impact on Crop Yield:
     - Dropdown Menus: Use the dropdown menus on the left sidebar to select a country and a climate variable. The bubble chart will update accordingly.
     - Bubble Chart: Hover over the bubbles to see detailed information about crop yield, area harvested, production, and the selected climate variable.

   Easily Missed Feature: The size of the bubbles represents the crop yield, with larger bubbles indicating higher yields. This helps in quickly identifying high-yielding years.

3. Crop Yield, Government Investment, and Economic Contribution:
   - Interactive Map: Click on a country to view its detailed investment and yield data. The bar chart and area chart will update based on the selected country.
   - Year Slider: Use the slider below the map to select a year. This will update the visualisations to show data for the selected year.
   - Bar Chart: Hover over the bars to see detailed information about different types of government investments.
   - Area Chart: The area chart shows the relationship between economic contribution by agriculture and government investments over time.

   Easily Missed Feature: Some bar charts may appear empty due to a lack of available data for those years. A note at the bottom of the section explains this.

4. Tooltips and Annotations:
   - Tooltips: Hover over data points in the charts to see tooltips with additional information. These tooltips provide context and make the data more understandable.
   - Annotations: Important notes and explanations are included in the visualisation to help users understand the data and the visualisation's limitations

By following these instructions, users can effectively navigate the Agricultural Dynamics Explorer and gain valuable insights into the relationships between climate variables, crop yields, and government investments. The interactive features and detailed tooltips ensure that users can explore the data in a meaningful way, enhancing their understanding of the dynamics in agriculture.

4. Conclusion

The Agricultural Dynamics Explorer effectively illustrates the relationships between climate variables, crop yields, and government investments, providing a comprehensive and accessible tool for understanding these dynamics. The visualisation demonstrates the significant impact of climate factors such as temperature, precipitation, and humidity on crop yields. Additionally, it highlights the critical role of government investments, including loans, development aid, and foreign investments, in enhancing agricultural productivity and economic resilience.

Key findings show that optimal climate conditions are crucial for higher crop yields, and sustained government investments contribute to increased agricultural output and economic stability.

Reflecting on the project, the importance of intuitive design and clear data representation was underscored. In hindsight, incorporating more detailed data on specific crops and soil conditions would have provided a more nuanced analysis. Future work could involve expanding the geographic scope and analysing different crops and soil conditions.

Overall, the Agricultural Dynamics Explorer has achieved its goal of offering valuable insights into the interplay between climate, crop yields, and government investments, paving the way for future enhancements and deeper analyses.

5. Bibliography

[1] Plotly R Graphing Library. (n.d.). Plotly.com. https://plotly.com/r/

[2] Leaflet package - RDocumentation. (n.d.). Www.rdocumentation.org. Retrieved June 6, 2024, from https://www.rdocumentation.org/packages/leaflet/versions/2.2.2

[3] Shiny - Welcome to Shiny. (n.d.). Shiny.posit.co. https://shiny.posit.co/r/getstarted/shiny-basics/lesson1/index.html

6. Appendix

Five Sheet Design

1. Ideas: Genres - Slide Show, Annotated Chart, Dashboard

User Group: 'Novices'

2. Filter

→ Use scatter plot but combine ①, ② & ③

→ Use ⑤ & ⑦ combined with slider for time & select crop-type drop down.

→ ⑧ can be used for analysing relatn. b/w crop yield & climate variables. → ④ can be used for more info on crop yield.

3. Categorise

→ ①, ②, ③ & ⑧ can be categorized to show how crop yield depends on climate variables.

→ ①, ⑤ can be categorized to show how GDP plays a role in crop yield.

→ ④, ⑥ & ⑦ can be categorized to show more info on crop yield only.

4. Combine and Refine

→ ⑤ & ⑥ can be combined into one to show the relation b/w GDP and crop yield by time and region.

→ ④ & ⑥ can be combined to focus on crop yield based on crop type.

→ ②, ③ & ⑧ can be combined to show crop yield vs climate.

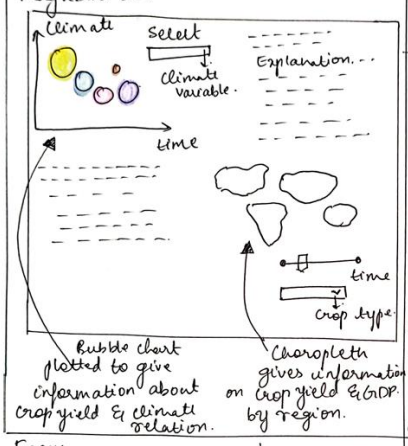
5. Question

→ Do these visualisations show the relatn. b/w crop yield, GDP & climate?

→ Does this visualisation give enough information?

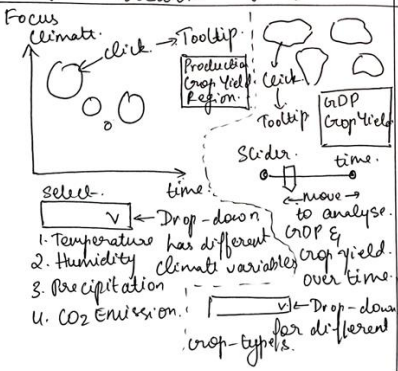
Layout

Magazine Dashboard



Bubble chart plotted to give information about crop yield & climate relation.

Choropleth gives information on crop yield & GDP by region.



Title: Magazine Dashb
Author: Divya H. Shetty
Date: 12-05-2024.
Sheet: 2
Task:

Operations

→ The bubble chart will have a drop down for different climate variables & a tooltip to give information about crop yield.

→ Choropleth will have slider to select time range & a drop down to select the kind of crop. It will also have a tooltip for GDP & crop yield.

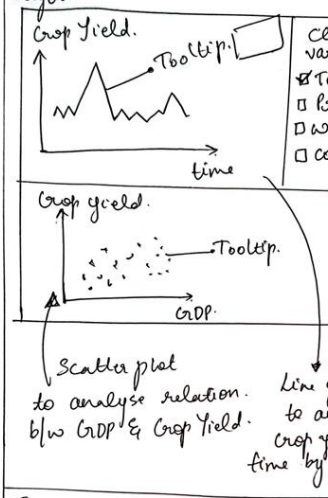
Discussion

+ The bubble chart give informal through size.

+ The sliders for time can give specific year inform

– The bubble chart cannot analyse the overall effect of climate together.

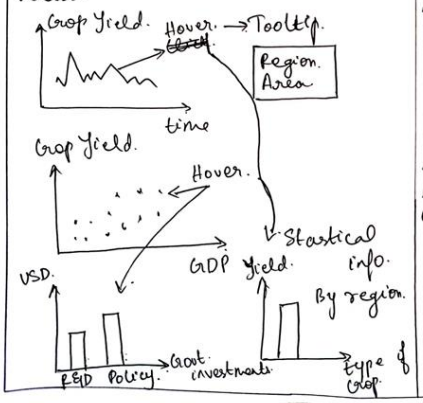
Layout



Title: Crop Yield Analysis
Author: Divya H. Shetty
Date: 12-05-2024
Sheet: 3
Task.

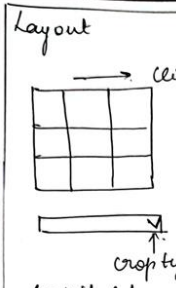
Operations:
→ The annotation. Chart gives information about crop yield. over time. On hovering it gives statistical information about different crop type & its yield.
→ Scatter Plot to show relation b/w GDP & Crop yield. On hover, it shows statistical information on the investments in USD.

Focus.



Discussion
+ Simple analysis with Scatter plot and line graph.
+ Both graph shows statistical data on hover, which is easy to read.
– Does not really use climate in any graphs, to show the relation b/w crop yield & climate in detail.

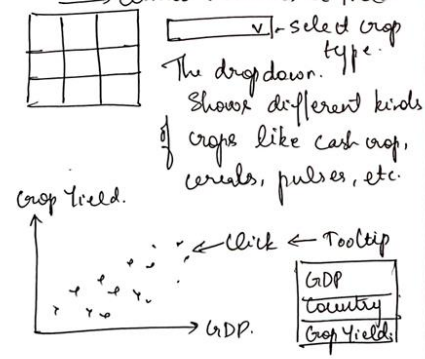
Layout



Title: Crop Yield Analysis
Author: Divya H. Shetty
Date: 12/05/2024
Sheet: 4
Task:

Operations:
→ The correlation matrix gives an initial view of how crop yield varies with different climate variables & for different crop-type via dropdown
→ The scatter plot has a tooltip which gives information about GDP by country

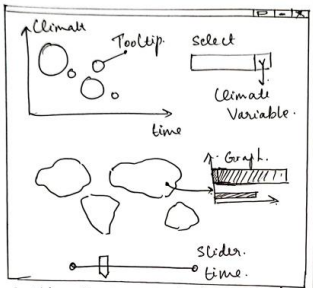
Focus



Discussion
+ Effect of climate can be analysed based on crop type.

– Time is not considered here to see the variation

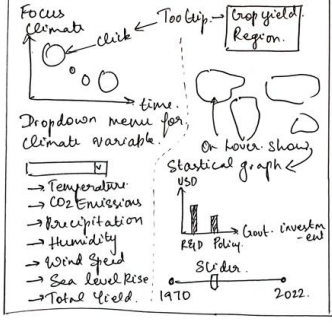
Layout



Bubble chart plotted to give information about crop yield & climate.
Choropleth gives information on crop yield and GDP.

Title: Crop Yield Analysis
Author: Divya H. Shetty
Date: 12/05/24
Sheet: 5
Task:

Operations
→ Drop down used to select climate variable.
→ Tooltips are used to give further details on crop yield.
→ Slider is used to select time range.
→ Graphs on hover to show statistical data.



Detail
→ There are 2 visualisations finalized.
→ Data for Crop yield & GDP from FAOSTAT.
→ Latest version of R-shiny & libraries will be used.