IAT 814 - VISUALIZATION AND VISUAL ANALYTICS

Final Project Report

Investigating Environmental and Economical indicators of Canadian Agriculture

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Introduction

Agriculture in Canada is a vital industry that has a significant impact on the country's economy, environment and society. It is very essential to understand the complex interplay between agriculture and these three factors to ensure the sustainable growth and development of the sector. The farming industry is not only responsible for providing food for the population, but also for generating income and employment opportunities for millions of Canadians, particularly in rural areas. However, the sector faces numerous challenges such as land-use pressures, soil erosion, and water pollution etc., which can have negative impacts on both the environment and the economy. In this report, we use different visualization techniques to explore the current state of agriculture in Canada and its impacts on the environment and economy. Through these visualizations, we aim to provide a comprehensive understanding of the complex relationships between agriculture, the environment, and the economy in Canada.

Target Audience

Through this project we hope to raise awareness about the importance of sustainable farming in Canada. By identifying trends of the agriculture industry, and highlighting challenges faced by the sector, we hope to inspire all stakeholders to work together and take action to ensure its long-term viability. The interactive dashboard we have designed is an invaluable resource that will facilitate collaboration between the government, industry stakeholders, and farmers to work together to promote sustainable agriculture practices that can help mitigate the challenges while also maintaining productivity and profitability.

Domain Questions

By harnessing the power of data visualization and adhering to the principles of expressiveness and effectiveness, our objective was to create an informative and visually appealing dashboard to find answers for important questions that would be difficult to obtain through other means.

- How did change in Residual Soil Nitrogen affect the water quality?
- How does pesticide/fertilizer usage impact surface water runoff concentration?
- How has agricultural revenue changed with respect to land usage?
- How does soil erosion, greenhouse gas emissions, and soil organic matter compare in Canadian agricultural areas?

Datasets

- **Name:** Residual Nitrogen Content in Soil
  Source:https://open.canada.ca/data/en/dataset/ca874ba4-e459-48c3-9f13-2dc443c97750

Attribute	Data Type
SOIL_LANDSCAPE_ID	Ordinal
YEAR	Ordinal
LATITUDE	Spatial
LONGITUDE	Spatial
PROVINCE	Nominal
RSN_VAL	Quantitative
RSN_CLASS	Ordinal

- **Name:** Water contamination by Nitrogen
  Source:https://open.canada.ca/data/en/dataset/86e8b75b-f95c-4068-a34d-aa448c4c1131

Attribute	Data Type
SOIL_LANDSCAPE_ID	Ordinal
YEAR	Ordinal
LATITUDE	Spatial
LONGITUDE	Spatial
PROVINCE	Nominal
NCONC_VAL	Quantitative
RWCN_CLASS	Ordinal

- **Name:** Water Contamination by Pesticides
  Source:https://open.canada.ca/data/en/dataset/28baefcf-7036-4959-8ded-86371578c7bd

Attribute	**Data Type**
SOIL_LANDSCAPE_ID	Ordinal
YEAR	Ordinal
PROVINCE	Nominal
RWTR_PSTD_CC	Quantitative

- **Name:** Greenhouse Emissions
  Source:https://open.canada.ca/data/en/dataset/d8e94369-43ad-4fee-a9e9-57901906cc99

Attribute	**Data Type**
SOIL_LANDSCAPE_ID	Ordinal
YEAR	Ordinal
PROVINCE	Nominal
POLYGON_WEIGHT	Quantitative
GHG_VAL	Quantitative

- **Name:** Risk of Soil Erosion
  Source:https://open.canada.ca/data/en/dataset/b52b3c91-e0eb-47d1-aea5-fa5428254512

Attribute	**Data Type**
SOIL_LANDSCAPE_ID	Ordinal
YEAR	Ordinal
PROVINCE	Nominal

ERI_WATER_VAL	Quantitative
ERI_TILL_VAL	Quantitative

- **Name:** Soil Organic Matter
  Source:https://open.canada.ca/data/en/dataset/7a31d717-529f-45c2-9273-e7ddfb767331

Attribute	**Data Type**
SOIL_LANDSCAPE_ID	Ordinal
YEAR	Ordinal
PROVINCE	Nominal
SOCC_VAL	Quantitative

- **Name:** Farm Income
  Source: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3210005201

Attribute	**Data Type**
DGUID	Ordinal
REF_DATE	Ordinal
GEO	Nominal
INCOME COMPONENTS	Nominal
VALUE	Quantitative

- **Name:** Land Usage
  Source: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3210015301

Attribute	Data Type
DGUID	Ordinal
REF_DATE	Ordinal
GEO	Nominal
LAND USE	Nominal
UNIT OF MEASURE	Nominal
VALUE	Quantitative

- **Name:** Pesticides and Fertilizer Usage
  Source: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3210016201

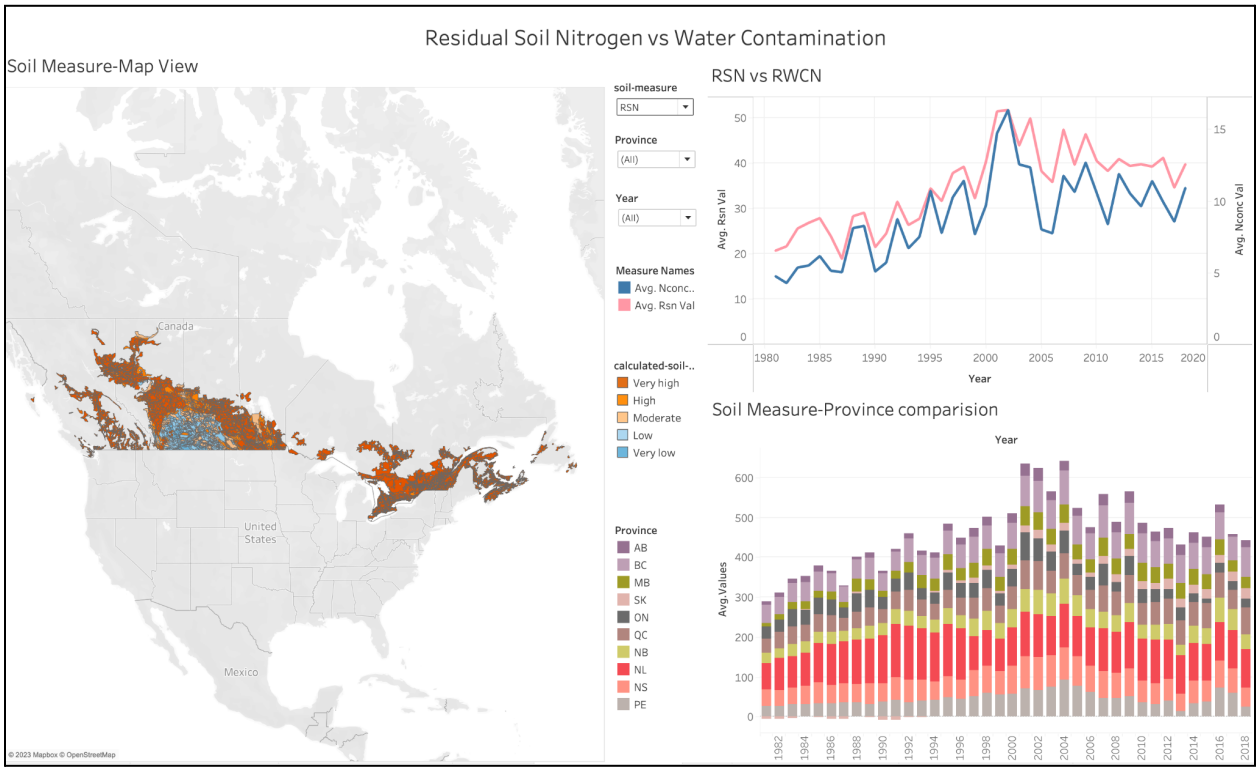
Attribute	Data Type
DGUID	Ordinal
REF_DATE	Ordinal
GEO	Nominal
LAND MANAGEMENT PRACTICES	Nominal
UNIT OF MEASURES	Nominal
VALUE	Quantitative

Process

After carefully examining the data, we removed any inconsistencies or anomalies. We then used Tableau to create dashboards that display each dataset feature and answer specific questions. To incorporate location-based data, we combined province names with spatial data. The dashboards are user-friendly, allowing for interactions and filters to enhance the user experience.

Visual Analytics

1. Risk of Water contamination by Residual Soil Nitrogen



Purpose:

The dashboard provides us an overall idea of Residual Soil Nitrogen levels across provinces and the risk of water contamination by nitrogen levels. It is divided into three sections along with some filters and legends.

Sections:

The spatial visualization in the left pane displays the farming landscapes across provinces in Canada and their aggregated residual soil nitrogen levels over time. This can be filtered to a specific province or a specific year using the filters. Moreover, this visualization can also help identify the overall risk of water contamination by nitrogen in the farming landscapes across provinces in Canada over the years based on the soil measure filter.

The top-right section displays a line graph that compares the changes in residual soil nitrogen values with the corresponding water contamination levels over time.

The stacked bar chart in the bottom right corner highlights the proportional contribution of each province towards the overall percentage of residual soil nitrogen levels in Canada over the years. This helps in better understanding the relative impact of different provinces on the overall nitrogen levels in the country's soil.

Visualization Design:

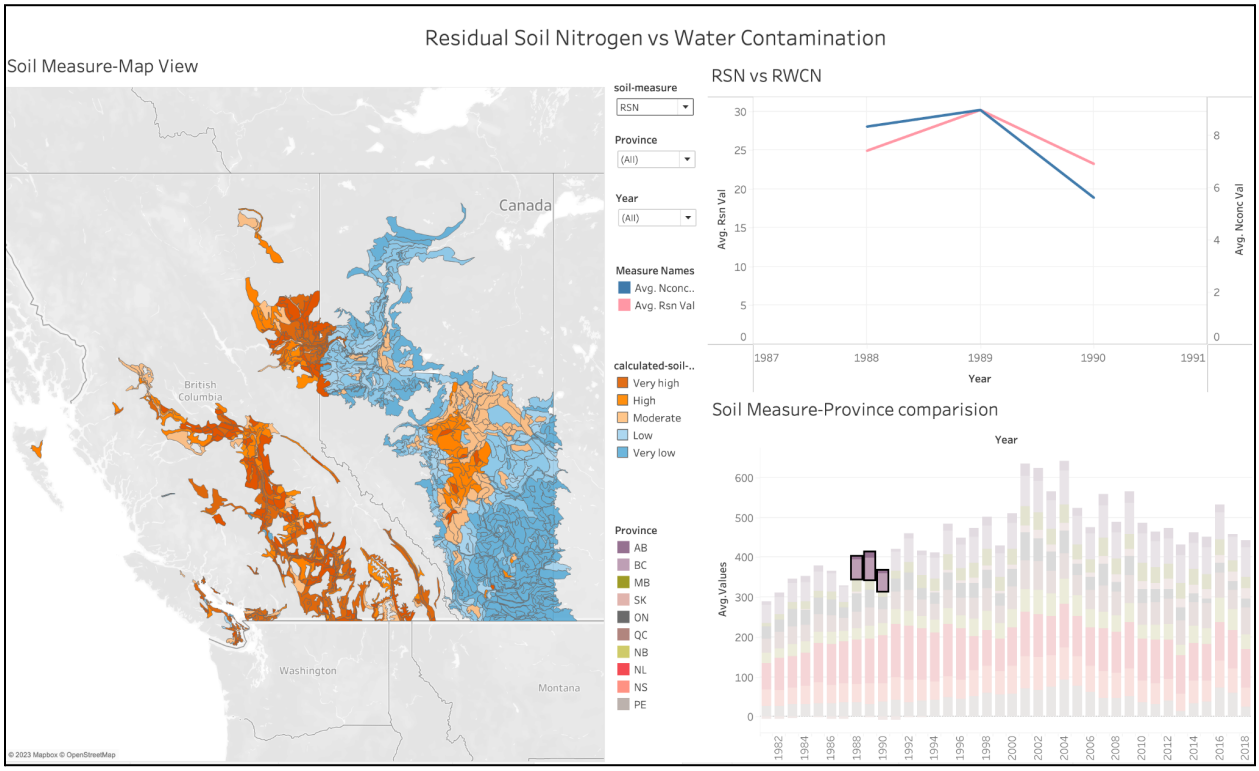
- Color hue as an identity channel is used to represent the various levels of residual soil nitrogen levels in the spatial map. The classification of each farming landscape helps us to understand the risk of water contamination and residual nitrogen levels at a granular level. The map also uses position on unaligned axes to represent the values.

- The use of line graphs to compare and contrast the residual soil nitrogen and risk of water contamination by nitrogen helps us to understand the change in patterns over time. Dual y-axis is used to compare these values. Color hue as an identity channel is used to differentiate the nitrogen and water contamination levels. Mark type line shows the variations in the values.

- The stacked bar chart uses color hue as an identity channel to represent the part-whole relation of residual soil nitrogen/risk of water contamination by nitrogen values over time of various Canadian provinces. Position on the common scale is used to represent the values in y-axis and the time in x-axis.

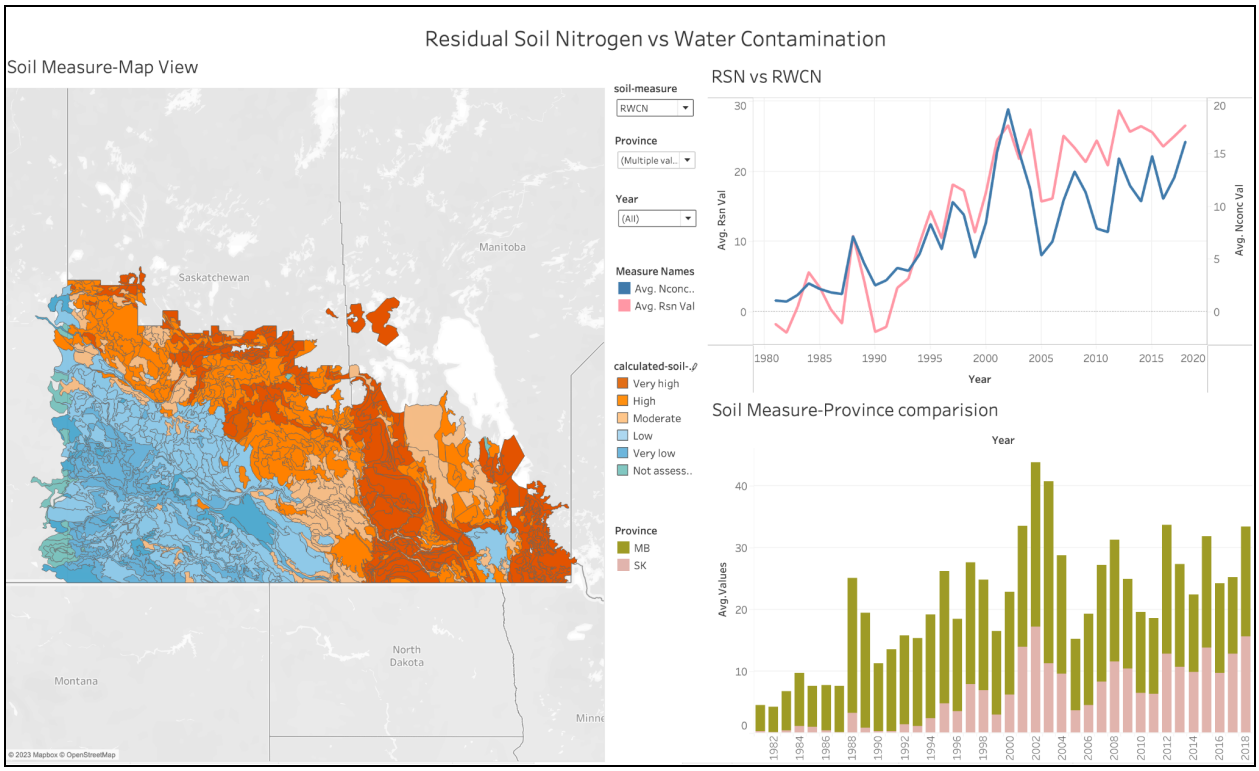
Interactions (Brushing and linking):

Users can brush and select an area in either the line graph or stacked bar graph to see the corresponding data for a selected province and selected year in the map, line/stacked bar graphs for comparison. Similarly, an area in the map can be clicked to select and display the corresponding values in the line/stacked bar graphs.



Filters:

Users will be able to filter to see the Residual Soil Nitrogen (RSN) or Risk of Water Contamination by Pesticides (RWCN) using the soil-measure filter. Filters to select certain provinces or years are also enabled as a multi select filter to help with visualizing data easier.

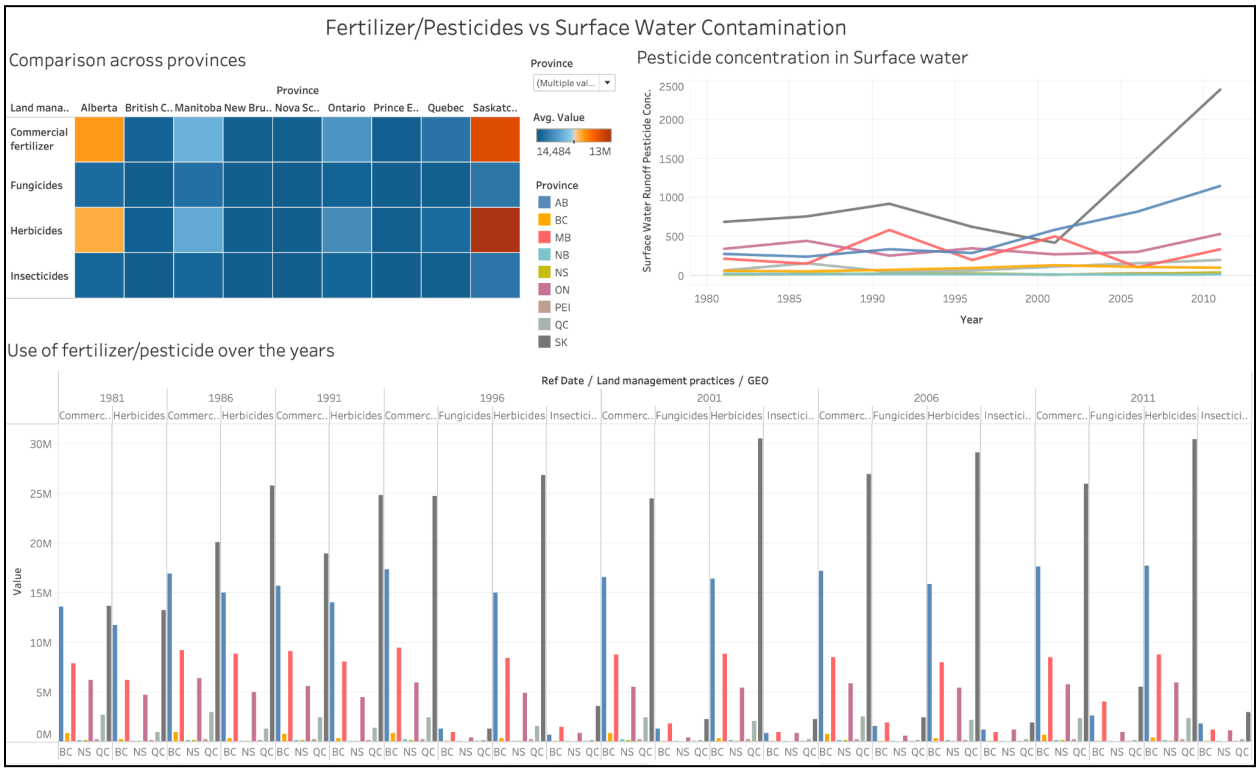


This example shows the comparison of Saskatchewan and Manitoba provinces in terms of risk of water contamination by nitrogen values using filters.

Takeaway:

This dashboard provides a clear visual representation of the changes in Residual Soil Nitrogen (RSN) and Risk of Water Contamination by Pesticides (RWCN) over the years in different Canadian provinces. As we can observe, the majority of the farming areas exhibit high RSN values, leading to a corresponding high RWCN. However, there are a few farming regions in Alberta and Saskatchewan that show lower RSN and RWCN values, indicating more sustainable farming practices. This dashboard enables us to gain a better understanding of the environmental impact of farming in different regions of Canada.

2. Risk of Surface Water Contamination by Fertilizer/Pesticides



Purpose:

This dashboard visualizes the usage of fertilizers and various types of pesticides like fungicides, herbicides and insecticides and the concentration of pesticides in surface water runoffs. The dashboard is divided into three sections along with some filters and legends.

Sections:

The top left heat map illustrates the usage of commercial fertilizer, fungicides, herbicides, insecticides across the Canadian provinces. Meanwhile, the top right line graph provides us with the concentration of pesticides in surface water runoffs over the years across different provinces. Lastly, the bar graph in the bottom pane gives us the ability to compare the usage of pesticides and fertilizers over the years using side-by-side bars across various provinces.

Visualization Design:

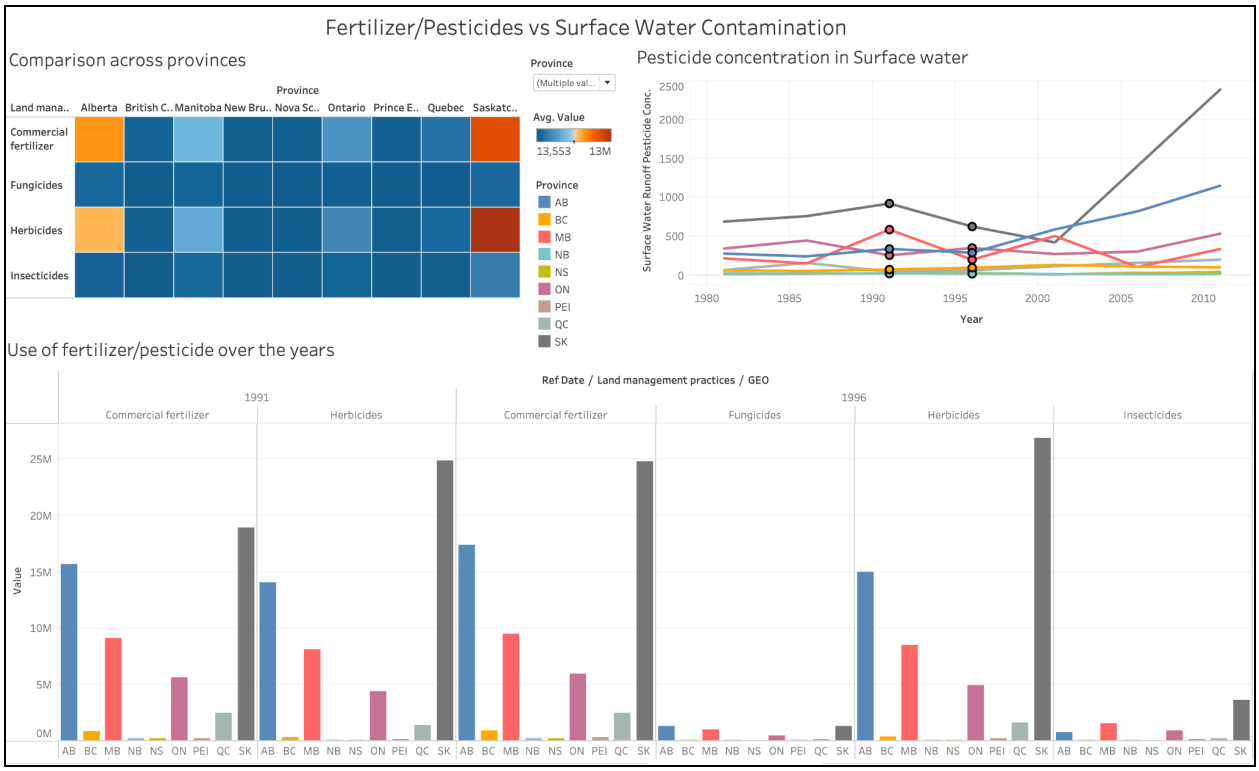
- Blue-red color luminance as a magnitude channel is used to represent the various levels of fertilizer and pesticide usage across provinces in the heatmap. The use of heatmap helps users to understand and compare the usage of fertilizers and pesticides in agricultural areas across the provinces.

- The line graph employs color hue as an identity channel to distinguish between provinces concerning their pesticide usage and the resulting mix of pesticides in surface water runoffs, all presented through a common scale based on position. Furthermore, the use of line mark type enables the clear display of pesticide concentration values in surface water runoffs over the years, allowing users to easily observe trends in pesticide concentration across provinces.

- Bar graph uses side-by-side bars to easily compare the use of fertilizers and pesticides over the years with position on common scale. The different provinces are represented using color hue as the identity channel. The usage is sorted and grouped by years along the x-axis to facilitate simple comparison across the provinces.

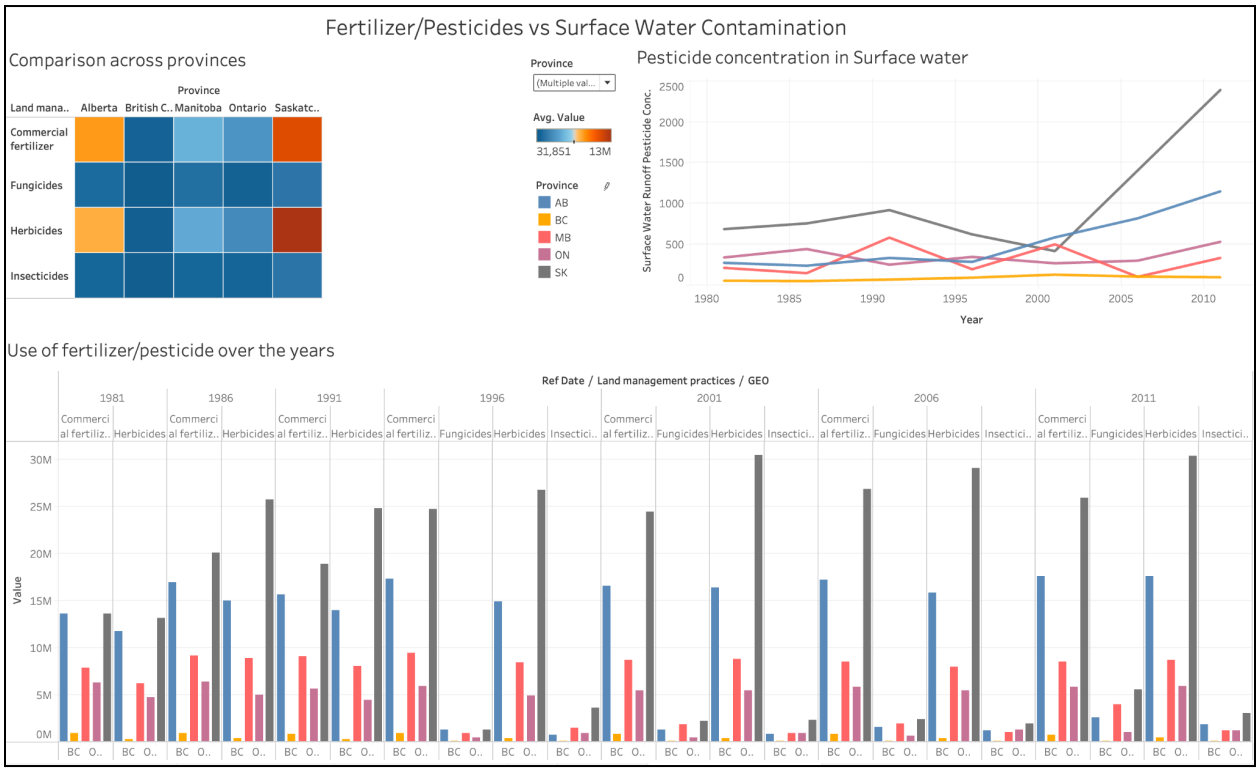
Interactions (Brushing and linking):

All the three sections of the dashboard are linked for easier understanding of the use of fertilizers and pesticides. Users can brush and select an area in any of the three graphs to see the corresponding data(selected province/years/category).



Filters:

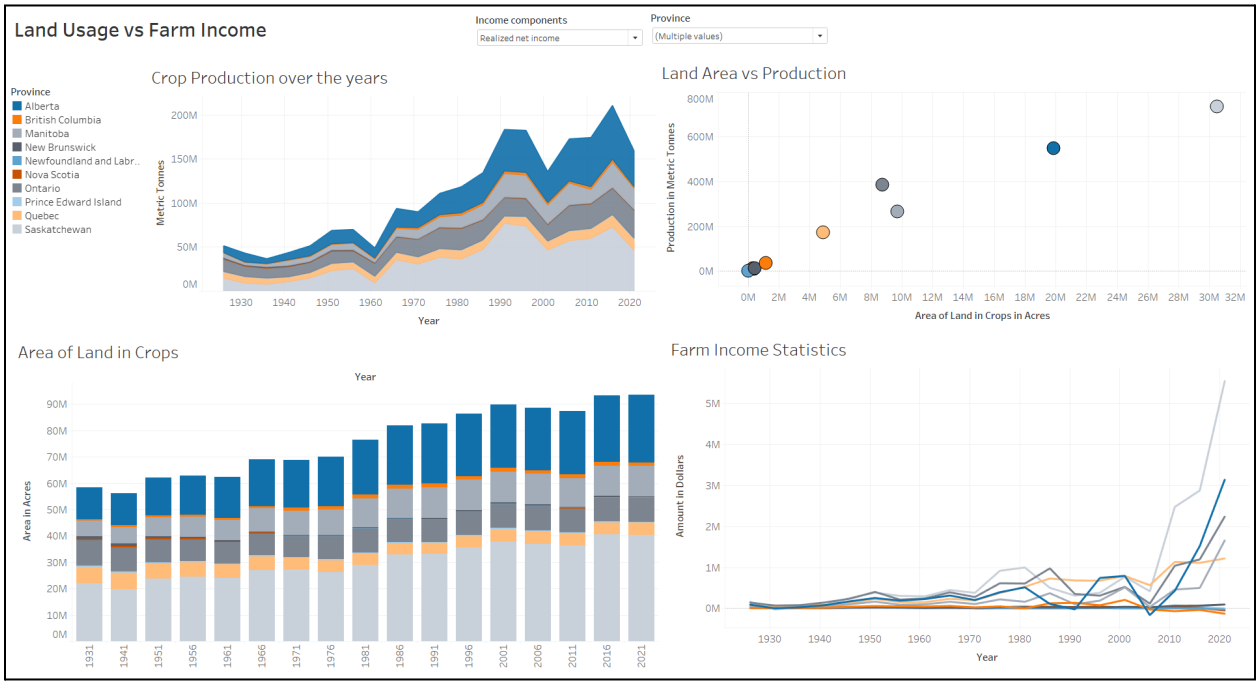
Users will be able to select one or many provinces based on the province filter.



Takeaway:

This dashboard provides insightful visualizations that showcase the usage of commercial fertilizers and pesticides, including fungicides, herbicides, and insecticides, and how their usage impacts the concentration of pesticides in surface water. Notably, the data reveals that Saskatchewan has a significantly higher usage of pesticides and fertilizers, resulting in higher concentrations in surface water runoffs, emphasizing the importance of responsible usage of these chemicals to mitigate the environmental impact on our water resources.

3. Agricultural Revenue by Land Usage



Purpose:

This dashboard provides a comprehensive overview of the agricultural revenue trends in various Canadian provinces, highlighting the correlation between land usage for cultivation and crop production. Its insights can profoundly impact our understanding of the agricultural sector's performance and help us make informed decisions for its future development.

Sections:

With four insightful sections, this dynamic dashboard delves into key aspects of agriculture, including crop production trends over time, the relationship between land

area and production, the area of land dedicated to crops, and farm income fluctuations over the years.

Visualization Design:

- Color hue of identity channel effectively distinguishes various provinces in Canada which is a categorical attribute.

- The area chart visually depicts the crop production levels over a specified time frame for each province by showcasing the amount of crop harvested as the shaded region beneath the curve. This visualization is widely used to analyze trends and patterns.

- The stacked bar chart showcases the total land area devoted to crop production in Canadian provinces for each year, using stacked bars to convey the relative proportion of land usage in each province.

- In the scatter plot, the mark type circle shows the value of cumulative crop production against the average area of land in crops over a time frame for different territories.

- The line marks in the Farm Income statistics section provide a clear and impactful visual representation of the growth in farm income for different regions, showcasing the upward or downward trend in income over the years with great clarity.

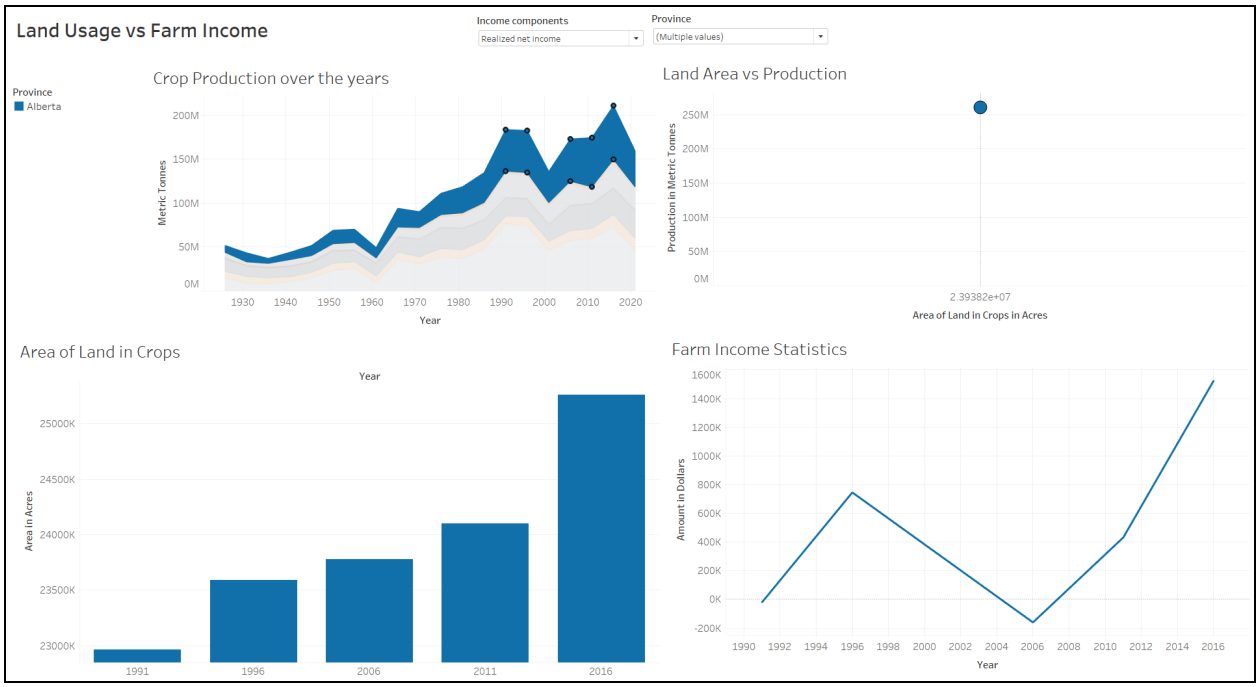
- Line and Area charts help us understand the trends and patterns, scatter plots demonstrate the relationship between two parameters and stacked bar charts show the part-whole quantities.

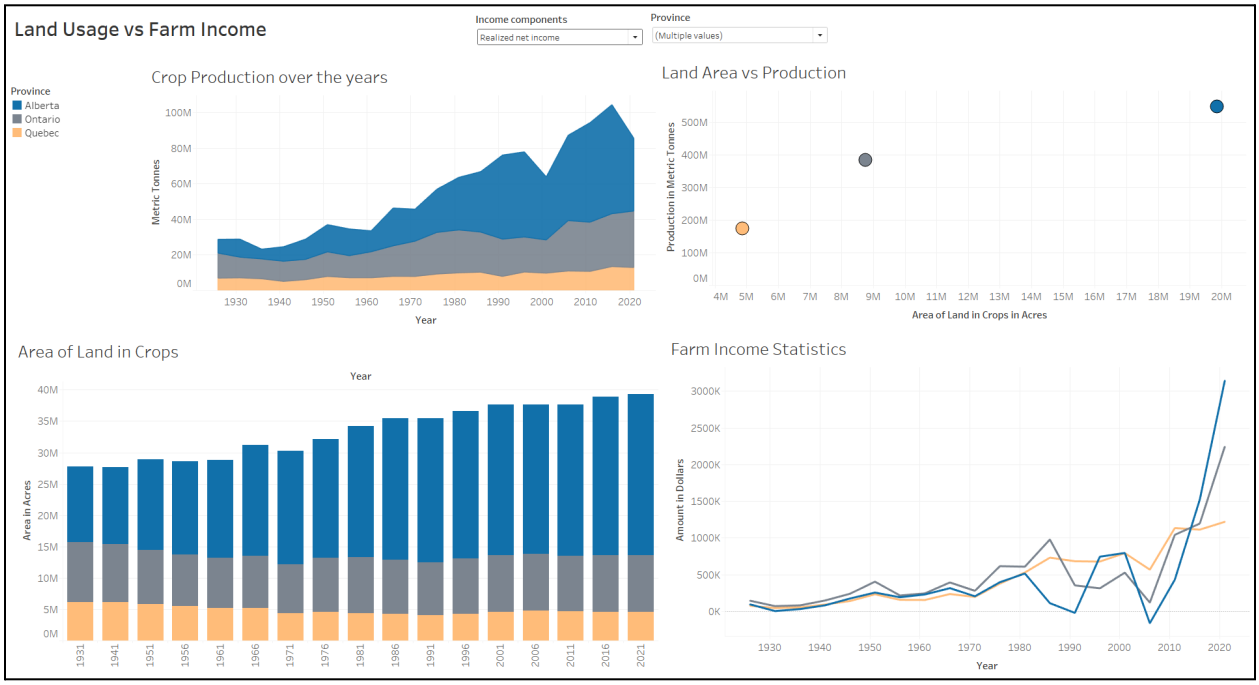
Interactions (Brushing and linking):

With the ability to brush and select areas on either the area graph or stacked bar graph, users can easily explore data for selected province(s) and specific years, creating a dynamic visualization of information.

Filters:

Users will be able to choose a single value for the income component filter and multiple provinces using the multi select filter to help with visualizing data easier.



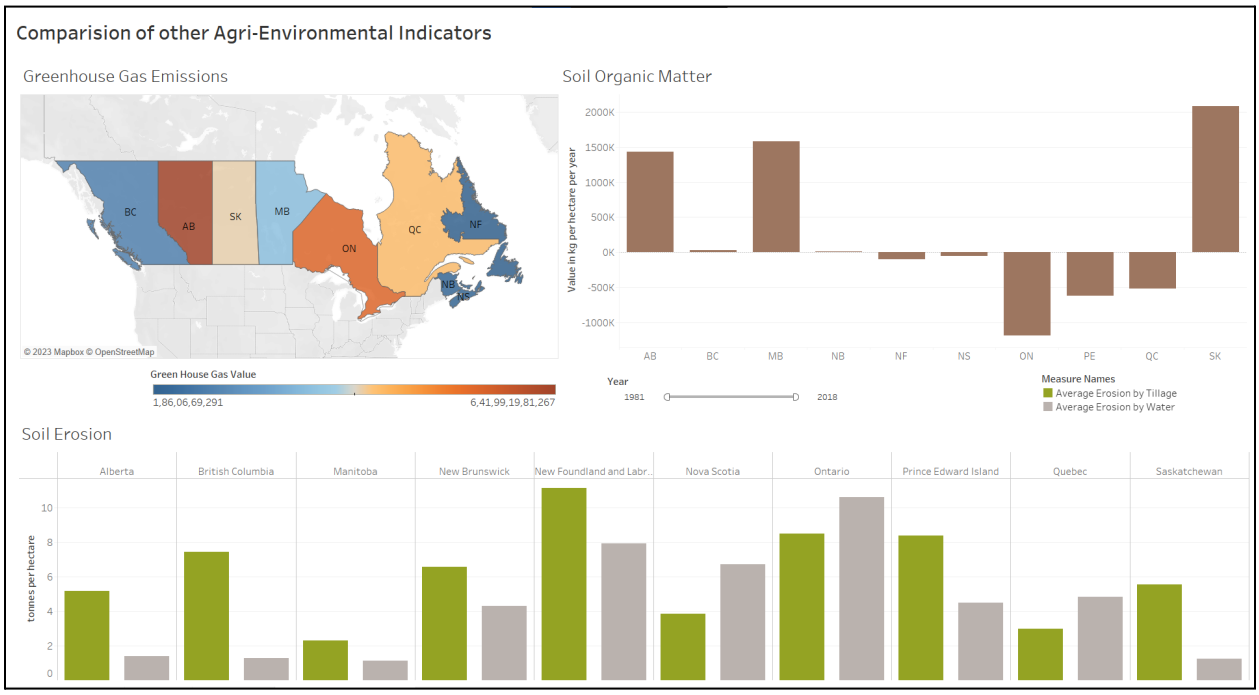


Takeaway

Over the past decade, the agricultural industry has experienced remarkable growth in farm income in select provinces, including Alberta, Ontario, Manitoba, and Saskatchewan. Despite a slight decline in crop production in 2021, farm income

continued to soar. This intriguing phenomenon could be attributed to a surge in the farm product price index, challenging our assumptions and prompting further investigation into the underlying drivers of this trend.

4. Comparison of other important Agri-Environmental Indicators



Purpose:

The above dashboard effectively showcases a comparative visual analysis of other critical agri-environmental indicators among different provinces.

Sections:

The dashboard consists of three panes which describe greenhouse gas emissions, soil organic matter, and soil erosion. The map pane shows estimated net greenhouse gas emissions due to agricultural activities per hectare of Soil Landscapes of Canada agricultural areas. Bar chart in the top right provides a measure of soil health and an estimate of how much carbon dioxide (CO2) has been removed from the atmosphere by plants and sequestered as soil organic carbon (SOC) in agricultural soils. Last pane illustrates the estimated risk of soil loss from the combined effects of water and tillage for Canadian agricultural areas across years.

Visualization Design:

- Choropleth map with luminance of magnitude channel represents geographical data about the amount of greenhouse gas emissions across provinces over the period.

- Colour hue of identity channel encodes the categorical column measure names.

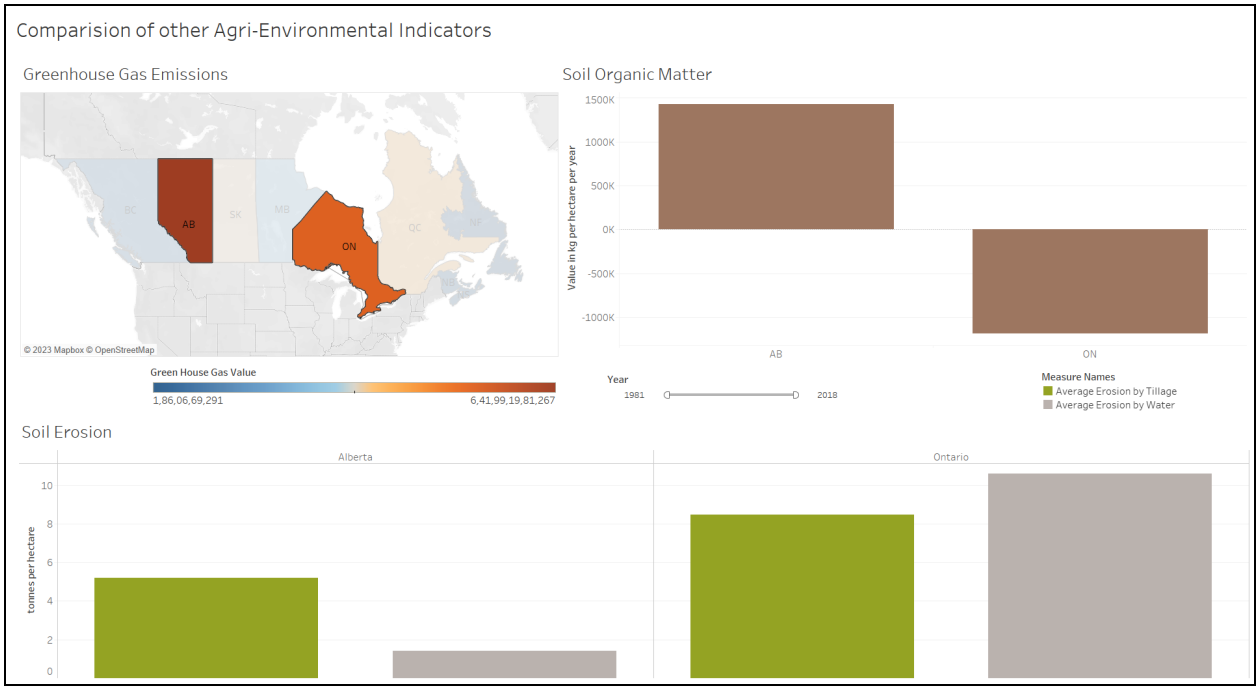
- Dual bar charts help to compare values between two different measures in each province.

Interactions (Brushing and linking):

The choropleth map allows users to brush and select specific areas of interest, enabling them to view corresponding soil organic matter and soil erosion data for the chosen province in the remaining bar charts.

Filters:

With the year filter feature, users can easily slide through different time periods and access the corresponding aggregated data, providing a dynamic and impactful way to view information



Takeaway:

Manitoba stands out with its impressive environmental record, boasting low greenhouse gas emissions, the second-highest level of soil organic matter, and minimal soil erosion caused by both water and tillage practices.

Conclusion

Our dashboards were designed based on the principles of expressiveness and effectiveness by implementing best practices in visualization techniques learned through the IAT 814 coursework. With our dashboards, government officials can identify areas that require attention and take necessary actions to improve agricultural practices that will increase productivity and profitability.

Future Work

- Explore other factors involved in Canadian agriculture such as employment, natural disasters, etc which can be used for better analysis.
- Considering the data of imports/exports to find better ways in achieving a sustained economy.
- Examine the relationship between pesticide usage and greenhouse gasses in different provinces across Canada.

Acknowledgements

We express our heartfelt gratitude to Dr. Lyn Bartram for her invaluable mentorship and expert guidance throughout the course, which enabled us to comprehend and master the intricate workings of cutting-edge visualization techniques

Dashboard Link

https://drive.google.com/drive/folders/1pyNZKGb6fRXwR22lElswDC1td5H3YQjV?usp=sharing

Project Demo Video

https://youtu.be/cqa7H2U0Zfc

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