Information Visualization Redesign Project

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INFOSCI 301

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Theory – Critical Engagement with Visualization Methodologies

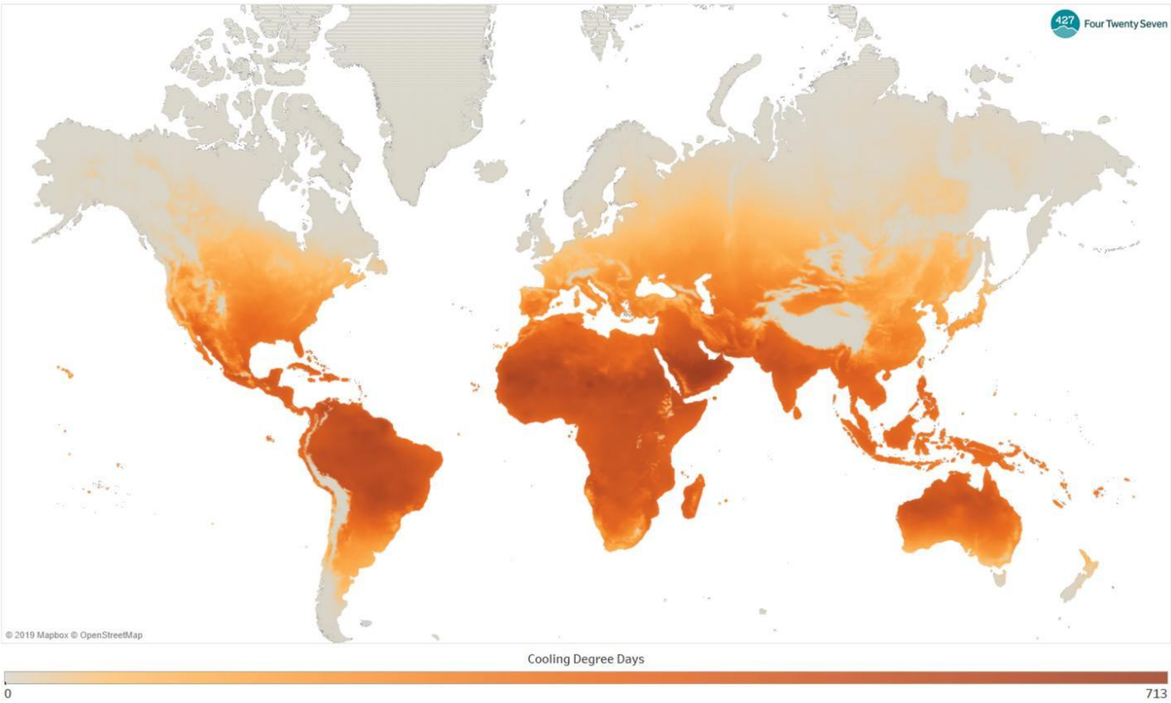

Figure 1: Cooling Degree Days

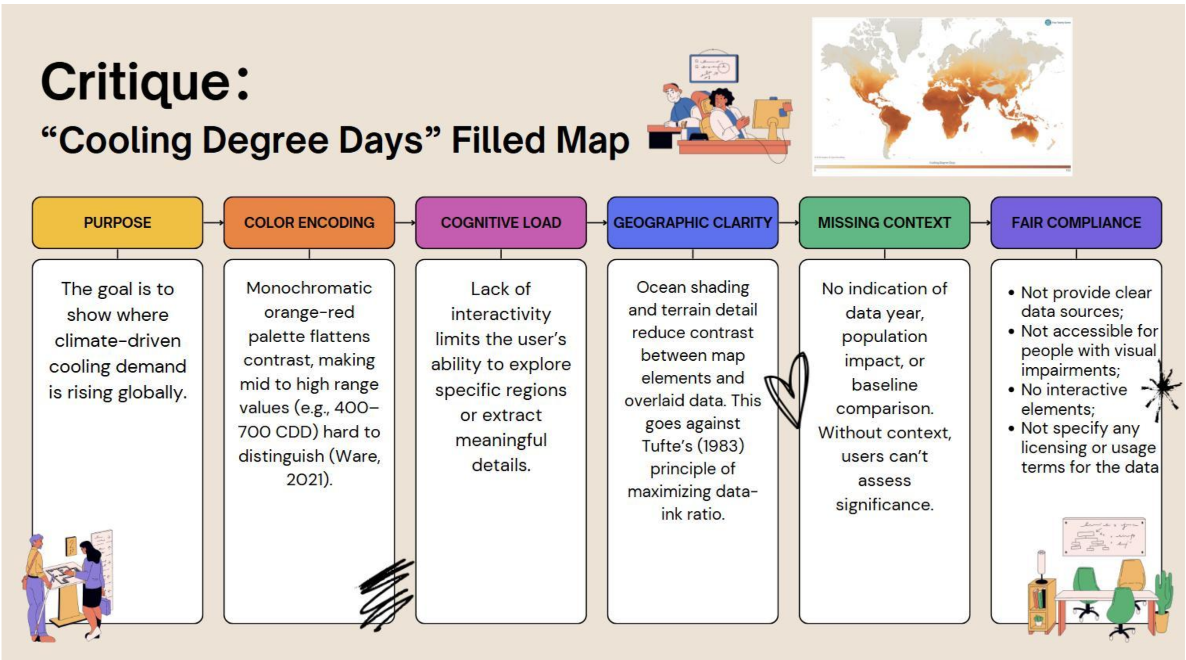

Figure 2: Critique of Cooling Degree Days

Concise explanation

This critique(Figure 2) of the cooling degree visualization(Figure 1) applies a structured method based on visual perception theory and data ethics. The process begins with identifying the infographic's intent—to communicate global cooling energy demand under climate change scenarios. It then analyzes visual encoding strategies (color, layout, resolution), evaluates perceptual clarity and assesses compliance with the FAIR data principles. The critique incorporates theoretical references from Edward Tufte[1], Colin Ware[2], and Wilkinson[3]. Based on these evaluations, specific recommendations are made to enhance interpretability, accessibility, and data transparency.

1 Edward R. Tufte, *The Visual Display of Quantitative Information* (Cheshire, CT: Graphics Press, 1983).
2 Colin Ware, *Information Visualization: Perception for Design*, 4th ed. (San Francisco: Morgan Kaufmann, 2021).
3 Sandia National Laboratories, *"FAIRer Data,"* 2022, https://www.sandia.gov/fairer-data.

Research – Literature-Inspired Analysis

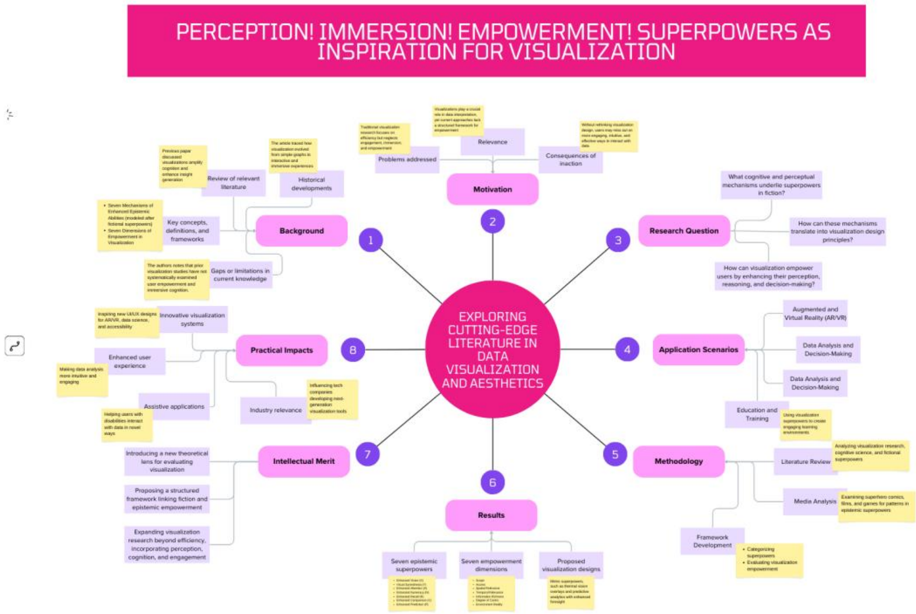

Figure 3: Flowchart of *Perception! Immersion! Empowerment! Superpowers as Inspiration for Visualization*(2022)

The visualization flowchart in Figure 3 systematically explores the research process, illustrating how fictional superpowers can be integrated into data visualization. This study follows the eight structured research facets outlined by Card et al.[4] and Munzner[5], to establish a framework for immersive and empowering visualization techniques. While traditional visualization prioritizes efficiency, and accuracy, it often lacks user engagement and cognitive enhancement. Inspired by sci-fi superpowers, this research investigates how visualization can augment perception, and cognition, thereby making data interaction more intuitive, and impactful[6]. By incorporating elements like enhanced vision, predictive analytics, and attention amplification, visualization has the potential to improve decision-making, and user experience in various fields.

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[4] Stuart K. Card, Jock D. Mackinlay, and Ben Shneiderman, *Readings in Information Visualization: Using Vision to Think* (San Francisco: Morgan Kaufmann, 1999).
[5] Tamara Munzner, *Visualization Analysis and Design* (Boca Raton: CRC Press, 2014).
[6] Wesley Willett, Petra Isenberg, Anastasia Bezerianos, and Pierre Dragicevic, *"Embedded Data Representations,"* IEEE Transactions on Visualization and Computer Graphics 27, no. 2 (2021): 1171–1181.

A central question in this research is how superpower-inspired metaphors can be translated into effective visualization techniques that enhance user perception, and interaction. To address this, the study explores key application scenarios, including AR/VR interfaces, assistive technologies, predictive analytics, and immersive education, demonstrating the practical value of these concepts[7]. The methodology involves analyzing superpower mechanics in fiction, mapping them to cognitive, and perceptual frameworks, designing visualization prototypes, and conducting empirical user testing to measure effectiveness[8].

Findings reveal seven superpower-inspired visualization models, each offering unique improvements in data perception, interactivity, and predictive capabilities. These models bridge the gap between HCI, cognitive science, and visualization research, shifting the focus from efficiency-driven design to experience-driven and cognitively empowering approaches[9]. The study's intellectual merit lies in two key aspects. First, it contributes to the literature by expanding the theoretical foundation of visualization research, referencing both seminal works like Card et al.[10] and recent advancements in immersive visualization frameworks[11]. Second, it identifies key limitations, such as the need for further empirical validation across diverse user groups, and adaptation to real-world datasets, providing a basis for future research on superpower-inspired visualization techniques.

The practical impact of this research extends to AR/VR innovation, accessibility tools, interactive education, and business analytics, where visualization can empower

7 Card, Mackinlay, and Shneiderman, *Readings in Information Visualization.*
8 Munzner, *Visualization Analysis and Design.*
9 Willett et al., *"Embedded Data Representations."*
10 Card, Mackinlay, and Shneiderman, *Readings in Information Visualization.*
11 Munzner, *Visualization Analysis and Design.*

users through enhanced cognitive capabilities. Future studies can refine these techniques, exploring new cognitive frameworks, and evaluating their long-term impact on data interaction and decision-making. By integrating fictional cognition into real-world visualization, this research redefines visualization as an immersive, empowering medium for human-computer interaction.

Practice – Tool-Driven Redesign Preparation

Experiment with Amazon QuickSight (Theory & Practice)

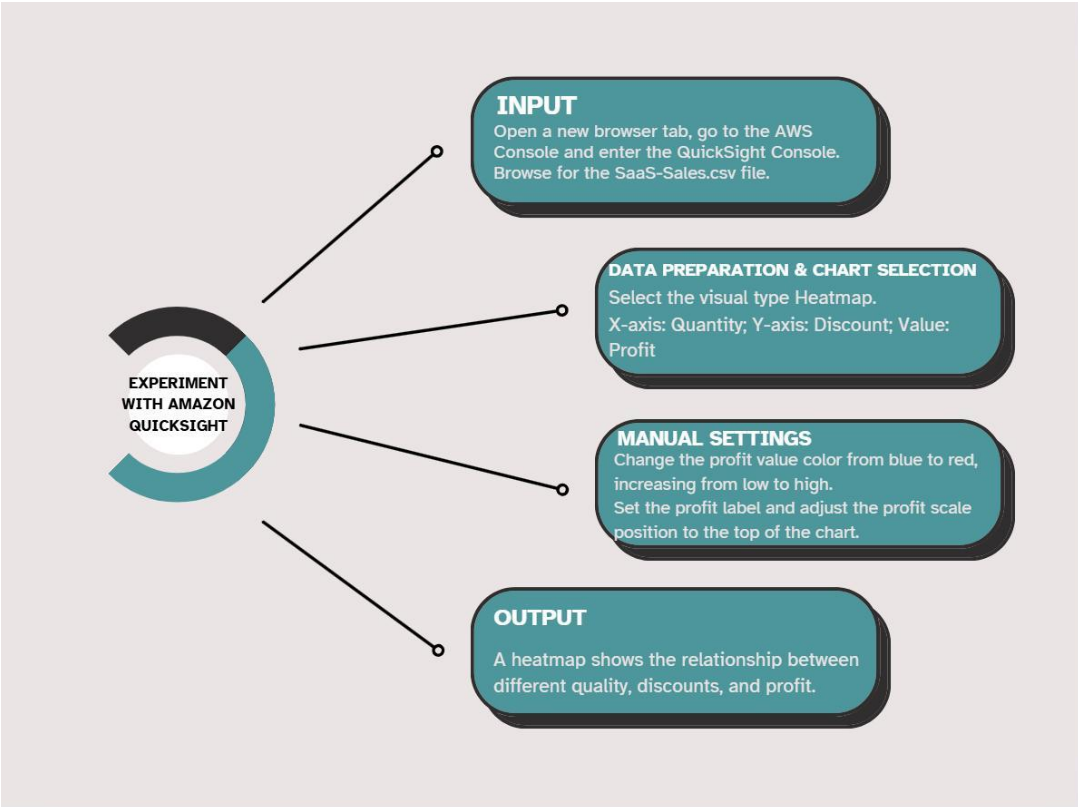

Figure 4: Workflow of the Visualization Process by Amazon QuickSight

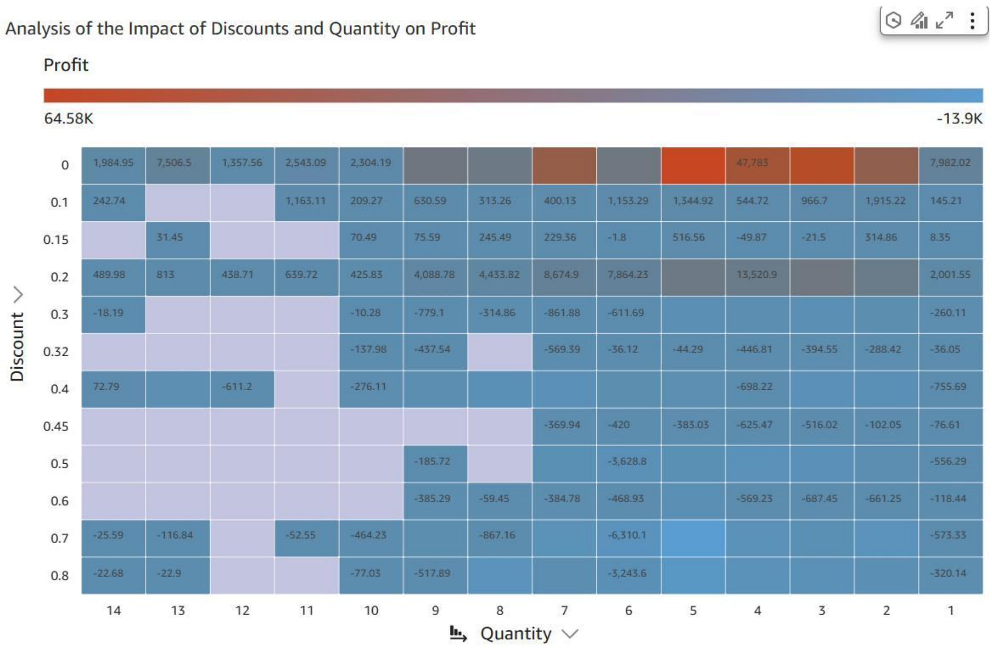

Figure 5: Analysis of the Impact of Discounts and Quantity on Profit

Dataset Description

The dataset used in the heatmap visualization is sourced from SaaS-Sales.csv and analyzes the relationship between Discount, Quantity, and Profit (Amazon Q, n.d.)[12]. It contains 9,994 transaction records from SaaS product sales, covering multiple industries, customer segments, and regions. This dataset helps businesses understand how discounting strategies impact profitability by examining different discount levels and purchase quantities.

Key Variables

- Discount (%) – The percentage reduction applied to sales prices, which directly influences revenue and customer purchase decisions.
- Quantity – The number of units sold per transaction, affecting overall sales volume and revenue generation.
- Profit ($) – The total profit generated after applying discounts, reflecting the financial performance of sales strategies.

Dataset Scope and Structure

Figure 5 (Analysis of the Impact of Discounts and Quantity on Profit) visualizes profitability trends across different discount and quantity combinations. Key insights derived from this visualization include:

1. Trends and Patterns Identified

High-profit regions (red areas) emerge when discounts are low and sales quantities

[12] Amazon Q, "AI Assistant — Amazon Q — AWS," n.d., https://aws.amazon.com/cn/q/.

are high, highlighting the effectiveness of moderate pricing strategies.

Significant losses (blue areas) occur when high discount rates coincide with low sales volumes, emphasizing that excessive discounting without sufficient demand erodes profitability.

Missing data points (purple areas) indicate that certain discount-quantity combinations were either rare or nonexistent in recorded transactions.

2. Decision-Making and Understanding the Data

The insights from this dataset assist businesses in refining their discount strategies by:

- Identifying the optimal discount levels that maximize revenue while maintaining profitability.
- Avoiding discounts that lead to negative profits, ensuring sustainable business performance.
- Using data-driven pricing models to balance competitive pricing with financial health.

By leveraging these insights, businesses can develop strategic pricing policies that drive long-term revenue growth while minimizing financial risks[13].

Critical Evaluation of Amazon QuickSight

Amazon QuickSight is an effective data visualization tool that efficiently extracts

[13] Gartner, *Magic Quadrant for Analytics and Business Intelligence Platforms,* 2023, https://www.gartner.com.

insights from datasets and provides interactive visualizations without coding. The tool provides customization options for legends and labels, allowing users to adjust visual elements to some extent. Additionally, Amazon Q helps users generate relevant tables for exploring specific analytical questions and enables modifications based on requirements. Furthermore, QuickSight includes predictive modeling capabilities, allowing users to identify trends and forecast future outcomes, making data-driven decision-making more effective.

However, QuickSight has several limitations. For instance, the heatmap visualization does not allow setting a middle reference value, such as zero for Profit, which makes it harder to differentiate between positive and negative values effectively. Amazon Q struggles with handling complex modifications, making it difficult to refine charts beyond basic settings. Additionally, the interface lacks flexibility for advanced users who require detailed adjustments to elements like axis scaling and conditional formatting, making it not versatile enough to use.

Improvements & Recommendations

To improve the user experience, QuickSight should introduce more customization options, such as allowing manual adjustments to color scales and axis references.

Enhancing Amazon Q's AI capabilities to interpret and execute complex modifications would also make the tool more adaptable to user needs. Gartner's 2023 BI report highlights QuickSight's strong cloud-based analytics but acknowledges its UI limitations. Addressing these areas would help QuickSight compete more effectively with industry leaders.

A Summary of Tool Exploration and Redesign Strategy

As part of my visualization critique and redesign process, I initially explored Amazon QuickSight as the primary tool for reworking the filled map visualization. However, due to QuickSight's limitation in exporting complete interactive visualization data, I decided to generate reference images using QuickSight and then use Google Colab to edit Python code and recreate the visualization manually. This approach allowed me to retain QuickSight's visual style while overcoming its data export constraints.

In this process, QuickSight was used to experiment with dynamic filtering, tooltip customization, and enhanced legends. The generated images served as prototypes and the final visualization was recreated in Colab through customized coding, enabling precise control over visual elements and interactivity that were otherwise limited in QuickSight.

This hybrid approach of combining QuickSight's visual capabilities with the flexibility of Colab coding ensures that the redesigned visualization not only maintains aesthetic consistency but also provides greater control over data representation and interaction.

Innovation – Final Redesign and Integration

Redesign Summary

Title

Enhancing Climate Risk Communication

Inspiration and Theoretical Foundations

This redesign is inspired by a combination of theoretical and practical sources:

Tufte[14] – For minimizing chartjunk and maximizing data-to-ink ratio.

Ware[15] – For applying perceptually effective color schemes and reducing cognitive load.

FAIR Data Principles[16] – To ensure data transparency and reuse.

Tools

Amazon QuickSight[17] (for generating reference images)

Google Colab[18] (for code-based visualization recreation)

Source

Climate Risk and Economic Losses

https://www.kaggle.com/datasets/thedevastator/global-climate-risk-index-and-related-economic-l?resource=download

Redesign Improvements Over Original

The redesign introduces several key improvements over the original filled map.

[14] Edward R. Tufte, *The Visual Display of Quantitative Information* (Cheshire, CT: Graphics Press, 1983).
[15] Colin Ware, Information Visualization: Perception for Design, 4th ed. (San Francisco: Morgan Kaufmann, 2021).
[16] Sandia National Laboratories, "FAIRer Data," 2022, https://www.sandia.gov/fairer-data.
[17] Amazon Q, "AI Assistant — Amazon Q — AWS," n.d., https://aws.amazon.com/cn/q/.
[18] Google Colab is a hosted Jupyter notebook environment by Google used here for customized visualization development.

While QuickSight was used to prototype the visualization and generate reference images, the final version was recreated using Google Colab to enable more detailed customization and flexibility.

A color gradient from red to yellow to blue was applied, clearly distinguishing the Climate Risk Rank across regions while also improving accessibility for visually impaired users. Additionally, the dark mode of the QuickSight map was utilized in the reference images, reducing background clutter and enhancing data contrast.

The background source data was provided, allowing users to accurately pinpoint the location of the visualized data in the source tables. To further enhance interactivity, hover functions were implemented in the Colab-recreated version, allowing users to view the Climate Risk Rank and Climate Risk Score for each region when hovering over different areas.

Furthermore, the redesign includes metadata links and relevant licenses, ensuring that the data is open and compliant with the FAIR principles — Findable, Accessible, Interoperable, and Reusable. These improvements not only make the heatmap more visually intuitive and accessible but also significantly enhance the user interaction experience, while ensuring the data meets high standards for transparency and usability.

Implementation

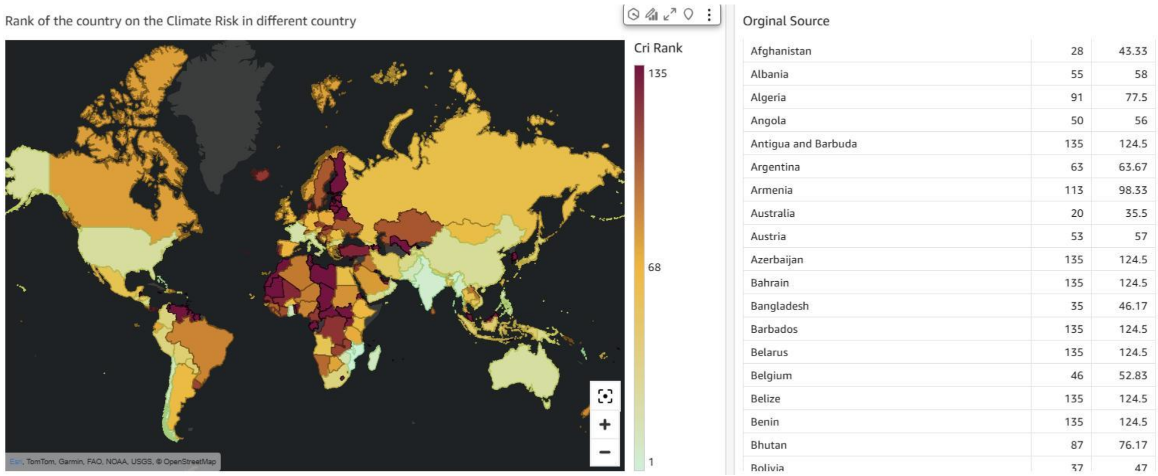

Figure 6: AWS - Enhancing Climate Risk Communication

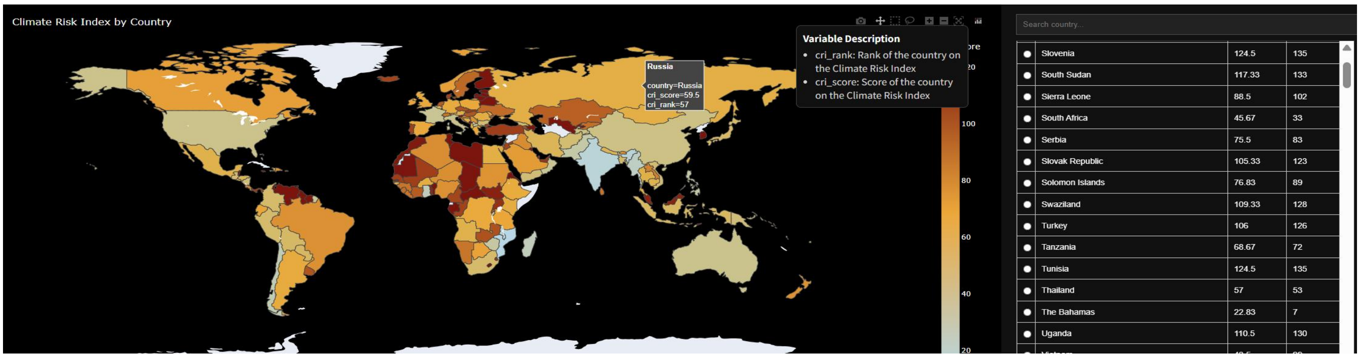

Figure 7: Colab - Enhancing Climate Risk Communication

Statement of Contribution to Sustainable Development Goals (SDGs)

This Information Visualization Redesign Project actively supports several United Nations Sustainable Development Goals (SDGs) by advancing data accessibility, promoting environmental awareness, and fostering innovative visualization practices grounded in critical theory and practical application.

Specifically, the project contributes to:

Goal 4: Quality Education

Through a structured critique of existing visualization methodologies, integration of perception and cognition theories, and tool-driven experimentation, the project promotes higher standards of data literacy. By enhancing the interpretability and transparency of climate-related data, it empowers diverse audiences to engage with complex information more effectively.

Goal 9: Industry, Innovation, and Infrastructure

The project embodies innovation by bridging traditional visualization practices with emerging technologies. By combining Amazon QuickSight's visual capabilities with customized Python-based development, it demonstrates a flexible, hybrid approach to building more accessible, interactive, and FAIR-compliant visualizations. This contributes to strengthening data infrastructure and advancing sustainable innovation.

Goal 13: Climate Action

Focusing on the communication of climate risk and economic impacts, the redesigned visualization raises public awareness of climate change challenges. By improving data clarity and user engagement, the project facilitates more informed, responsible decision-making aligned with global climate action initiatives.

In addition, by adhering to the FAIR (Findable, Accessible, Interoperable, and Reusable) data principles throughout the redesign process, the project reinforces open science practices and fosters equitable access to critical environmental information. This commitment enhances the global efforts toward building inclusive, transparent, and sustainable knowledge infrastructures.

Future Research Direction on Digital Humanities

Building on insights from the field trip to the Zhouzhuang Mystery of Life Museum, this project identifies several future research directions at the intersection of information visualization, digital humanities, and scientific storytelling.

The museum's exhibits, featuring real human, terrestrial, and marine biological specimens, highlighted the power of tangible artifacts in communicating complex biological and ecological knowledge. Inspired by this, future visualization projects can explore how digital platforms — including augmented reality (AR), virtual reality (VR), and interactive web environments — can replicate and enhance the educational impact of physical specimens.

Potential research directions include:

1. Digital Preservation and Visualization of Biological Specimens: Creating high-fidelity 3D models of real-world specimens to expand access to rare biological resources and support global scientific literacy.

2. Immersive Storytelling for Biodiversity Education: Developing AR/VR experiences that allow users to interact with biological data and narratives, bridging gaps between scientific information, aesthetic engagement, and ethical considerations.

3. Ethical Visualization in Digital Humanities: Investigating best practices for digitally representing real biological entities, ensuring respect for life, scientific accuracy, and ethical storytelling in digital environments.

The museum effectively merged aesthetics with scientific precision, presenting biological specimens in a way that was both visually captivating and informative. This integration has directly inspired how I approach my future data visualization projects. The importance of balancing factual, scientific presentation with an ethical approach is something I aim to incorporate in all my future work.

The museum's use of real-world specimens to tell a story about biodiversity and the ethics of conservation has inspired me to think about how digital platforms can be used to tell similar stories. I plan to create interactive visualizations that not only communicate complex data but also evoke an emotional connection with the audience, emphasizing the need for ethical responsibility in scientific representation.

In future data visualization projects, I'll focus on the intersection of art, science, and ethics, ensuring that all projects respect the integrity of the subjects they depict while encouraging users to reflect on broader societal and environmental issues.

For each deliverable, I will include photographs from the museum visit to document how its exhibits and aesthetics have shaped my thinking on these topics.

Bibliography

Amazon Q. AI Assistant — Amazon Q — AWS. n.d. https://aws.amazon.com/cn/q/.

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Additional Flowcharts

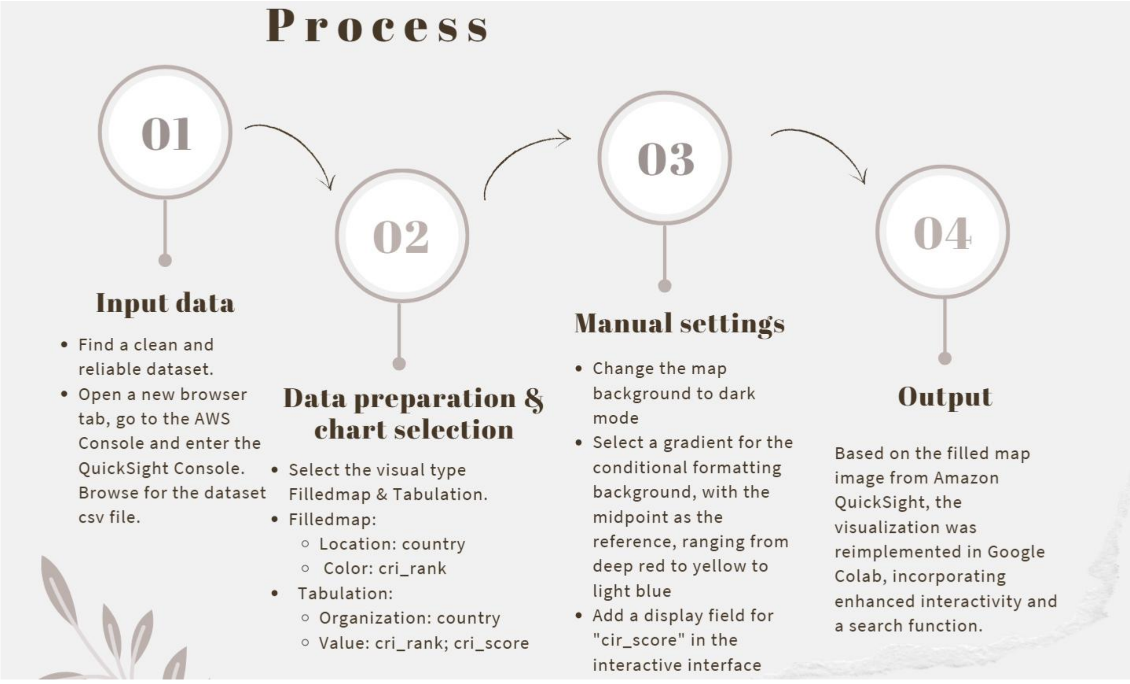

Figure 6: Final project implementation process

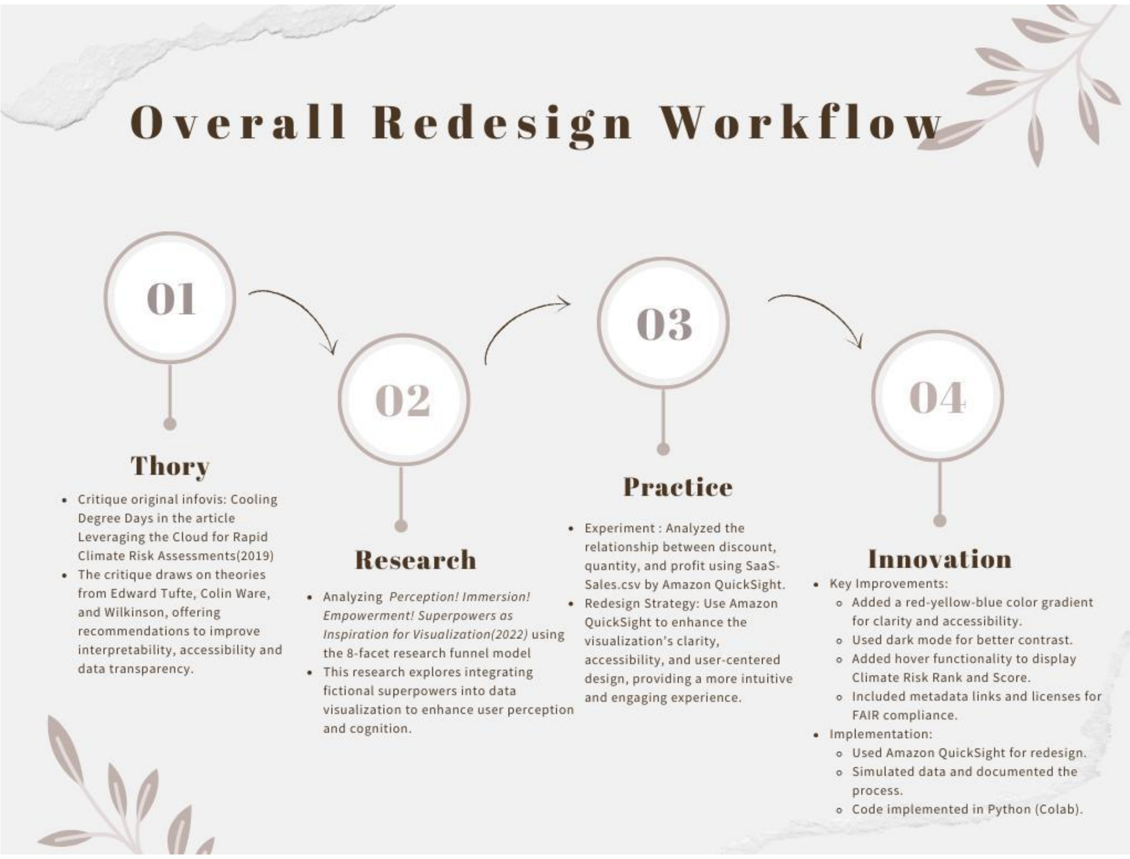

Figure 7: Overall Redesign Workflow

Github URL: https://github.com/Cattum/Infovis-Redesign.git