Comprehensive Case Study of Melbourne Urban Forest

Name: Panchami Tumkur Narendra

Student Number: 30892554

Tutors: Bruno Mendivez Vasquez, Jeffery Liu, Tutorial 02

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1. Introduction:

Melbourne is a city that harmoniously blends urban development with natural green spaces. It boasts numerous parks and reserves spread throughout its landscape. The iconic Yarra River flows through the city, serving as a vital water source for both the population and the thriving biodiversity. With Melbourne being one of the world's fastest-growing metropolitan areas, accommodating a significant number of immigrants each year, the local government has the responsibility to meet the needs of the population while efficiently maintaining the surrounding flora and fauna.

In this project, we have utilized datasets from the City of Melbourne open data source to delve into the population of various tree species, birds, insects, wildlife, and water bodies within the Urban Forest that encompasses Melbourne. We have also examined data collected from microclimate sensors positioned around the city to understand factors such as temperature, pressure, wind speed, and air particle concentration in these locations. By analysing this data, we aim to uncover the relationship between tree population and its influence on climate factors and greenhouse gas emissions.

Additionally, we have observed the energy consumption patterns of structures situated within the urban forest and investigated how the ecosystem impacts their energy usage. Through this study, we can gain insights into the total population and distribution of different types of trees, animals, insects, and water bodies across the Urban Forest.

Furthermore, we aim to assess the impact of the Urban Forest on temperature, precipitation, humidity, and greenhouse gas emissions in Melbourne. By examining these factors, we can understand how the presence of green spaces influences the local climate and environmental conditions.

Moreover, we will explore how the population of greenery in the Urban Forest has affected the energy consumption in the surrounding neighbourhoods. By analysing energy usage data, we can determine the correlation between the presence of an ecosystem and energy consumption patterns.

Lastly, based on the chosen datasets, we will review future greening projects and identify areas where they should be implemented to establish and maintain an efficient ecosystem in Melbourne. This assessment will focus on improving air quality and reducing energy consumption for a sustainable and environmentally friendly city.

The audience of this project is the local government body members to whom this project can be presented to help plot developmental projects of the city. Also, the residents can view this project to understand what is happening in their environment.

To summarize, the project aims to answer the following questions:

1. What is the total population and distribution of different varieties of trees, animals, insects, and water bodies across the Urban Forest?

2. What is the impact of the Urban Forest on temperature, precipitation, humidity, and greenhouse gas emissions in Melbourne city?

3. How has the population of greenery in the Urban Forest affected the energy consumption in the neighbourhoods?

4. How can future green projects be implemented to help build and maintain an efficient ecosystem in Melbourne city in terms of air quality and energy consumption?

2. Design:

The overall aim of this project is to choose visualisations that can succinctly explain the objectives of the topics and to answer the questions efficiently, with the available data that was collected. This process was methodically put through the Five-design sheets attached to the Appendix of this report. Through the data exploration project, it was found out how data could give answers to questions using the different visualisations. Likewise, for the Five design sheet, the idea is to brainstorm different visualisations which can ultimately be used in combinations to constitute the final visualization which presents the whole project in one place. The following gives justification to the visualisations that have been chosen, the combination of these visualizations across sheets 2 to 4, to give the final sheet which is sheet 5.

Sheet 1 Brainstorm:

In this sheet, about 9 types of visualisation ideas were written. Most of the visualisations jotted here have been inspired by the work done in the Data Exploration Project. Since, the Data contained geographical points and shapes maps were plotted to visualize layout of trees around Melbourne urban forest, stacked bar charts, area charts, bubble charts were used to interpret different varieties of trees, birds, insects and different categories of weather, greening projects, etc. To understand the weather and the electricity consumption heatmaps and line charts were used. Some of the visualizations were repetitive so, the ones not contributing to the ultimate picture were removed and some of the visualisations that could be better explained by combining with another visualization were combined.

Sheet 2 Initial Design:

In this sheet of the FDS, the main visualisations were included that could bring forth the main ideas of the questions that needed to be answered as a part of the project. For the first question, a map with tree population and an area chart to represent different species of plants planted over the years was included. For the second and the third questions, a heatmap to explain the correlation between number of plants across sensor sites alongside a bar chart to show the number of units of electricity consumption by residential and commercial units were shown. For the final question, a map was used to show the laneways with greening potential which was represented through a map colour coded according to the climate and a stacked bar chart to show forest and park potential for the laneways.

The interactivity used was slide bar to adjust the population of the trees and to change the units of electricity consumed by different grids. Checkbox to filter the species of trees, the climates for the laneways with greening potential.

The layout did not answer all the nuances of the questions, there was no context or explanation given in the page showing the visualisations. The layout seems to busy trying to show too many things at once.

Sheet 3 Initial Design:

In this sheet to answer the first question, the first tile included the map to show the population of the trees, a stacked bar chart to show the birds across different locations, a bubble chart to represent different species of insects found across different sites of survey. In the second tile, a map was used to show locations of different climate sensor sites and a bar chart showing the electricity consumption across different climate sensor sites for commercial and residential areas. The final tile showed a map showing polygons representing different laneways which showed climate type and their potential to be turned into park or forest.

The interactivity tools used in the visualisation were slide bar to change the population of the trees on the map and the amount of electricity consumed by the residential and commercial units. Here, in this sheet tooltips were included to show data of the weather parameters on the map with climate sensor locations and the map showing the laneways to explain the climate type and the park and forest potential. A checkbox was used to filter the schedule types of the laneway's projects.

Although, this provided much more information about the nuances of the questions, very less context was provided to each of the tiles in the visualisations. A lot of information was included together which does not provide a neat layout.

Sheet 4: Initial Design

In this sheet of the FDS, the layout of the visualisation was changed into a dashboard manner with three tabs, each for explaining the different subtopics that are being explained. For the first tab, A title text, introduction to the topic was being provided along with the visualisation that is a map representing the population of trees across Melbourne. The second tab was used to answer the next question and third about the electricity and weather parameters. Here, a stacked bar chart was included to show the energy consumption across different sites. The last and the third tab provided, context about the last question which included a map which showed the polygons representing laneways and giving information about their, schedules, type of climate and the potential.

The interactivity tools used in this were for the first tab a side bar was used to change the population of trees on the map, a tooltip to explain the information, about trees, animals, and birds. The second tab used tooltip to represent show information about weather parameters for different bars which represented the climate sensor sites. The third tab included tooltip to show the park and forest potential and the weather type of the laneways and a checkbox to filter the schedule type associated with each laneway.

Although this provided more context and was structured in a dashboard manner, A map along with the bar chart in the second bar would provide more visual context for audience.

Sheet 5: Final Realisation

This sheet is a combination of the sheets 3 and 4. The layout used for the final sheet is a dashboard type, which will help us explain our context split into three different subtopics in a better fashion. The First tab contains the introduction to the main topic along with headers. This also includes explanations for the type of birds, insects, and the trees. The visualisation used is a map to represent the population of the trees present around Melbourne. To represent the idea of trees, the points that

were plotted on the map were coloured green. The second tab provided a map along with a bar chart. The map here showed site locations of microclimate sensors across Melbourne and the bar chart showed the energy consumptions across these sites. The third tab has a map to show the laneways climate type and the schedules. A stacked bar chart was used to show the Park and forest potential across different climate types. Both the second and the third tabs also included titles and explanations to give a narrative to the questions and the process being answered.

The interactivity used here was a slide bar to change the population of the trees on the map and tooltip to provide information about the tree, birds, and insect species. The second tab included a tooltip to provide information about weather parameters and number of trees present there for different sites. The final tab included a tooltip for the map to show the information about the parking potential and a checkbox to filter climate on the stacked bar chart and the schedules for the map.

In the final visualisations the colours were chosen carefully, so that colour blindness is accounted for in the audience, such that the colours are striking so that they can leave an impression on the users of the dashboard applications.

3. Implementation:

The five-design sheet idea was thought to be best implemented using R shiny. The data was wrangled further after Data Exploration Project to keep attributes that are only required to show the final implantation on the R shiny dashboard. To implement the dashboard design on R a bunch of libraries had to be used. The following shows a list of libraries used and their uses:

Library Names	Uses
tidyverse and dplyr	to read csv files, to include basic manipulations, visualisations, etc.
ggplot2	to visualise data.
leaflet	to build maps using the data.
Shiny	To implement the interactive visualization on the web application.
shinythemes	To style shiny using different pre-built themes.
shinydashboard	To implement dashboard style in shiny app.
sf	To read, manipulate, analyse, and visualize geospatial data.

Table 1: List of libraries used and their context of use in the project.

- *Data Wrangling:*

The data was wrangled further after the data exploration project to make the data more concise to build visualisations for the dashboard in r shiny. Under the first question, the data for the birds and the insects had to be wrangled. During, the data exploration project the data contained a lot of species of birds and insects that were recorded. The species and the count of number of birds and insects recorded under the species were calculated and a new data frame was arranged in descending order with most frequent species of birds and insects on the top and new csv file with the wrangled data was created to be used.

For the second question, the energy and climate data frames that were created by wrangling the data in the data exploration project were combined and a new dataset was created and stored as a csv file.

- *Changes made to the dashboard after FDS:*

As discussed in the sheet 5 of the five-design sheet (FDS), three tabs were implemented to subdivide the four questions being answered in this project to represent three different subtopics. The visualisations and the interactive tools in the final sheets have been altered to account for the better implementations and the limitations of the data being used.

An extra tab has been added in the visualisation, to incorporate the overview, the audience and questions information separately.

In the flora and fauna tab, the slider bar to change the population of the trees according to the year it was planted was tried to be implemented but it was slowing down the change in interaction, so it was removed.

In the Weather and Energy Consumption tab, the tooltips were added to the site locations to include information about the weather parameters and the number of trees and a complementing bar chart to include the number of electricity units consumed across different sites. To view residential and commercial bar charts separately a drop-down menu has been added to select between the two options.

In the Future Greening Projects tab, the map containing geospatial data which included polygons representing the shapes of laneways was visualised. The stacked bar chart representing the park and

forest rank was removed and all the information about the climate, park and forest potential were added to the tool tip on the map. The checkbox for the schedules were removed as it was not adding much context to the question that needed to be answered. A drop-down menu has been added to select different climate types of laneways so that on clicking the options you can choose polygons to appear corresponding to the climate chosen.

All the changes that have been made has been updated in the final sheet of the FDS and has been uploaded in the Appendix of this report.

The following shows how the dashboard looks like:

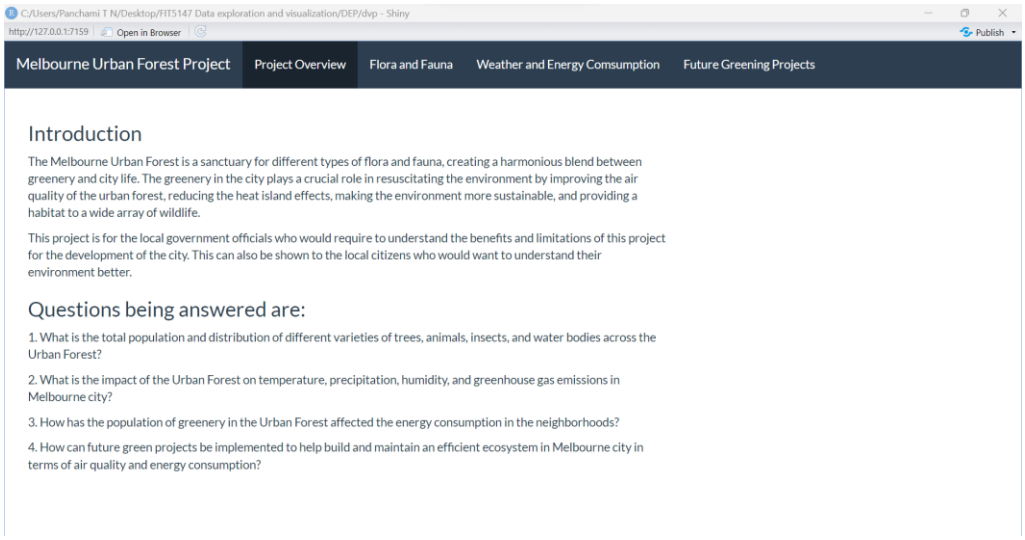

Figure 1: The overview of the dashboard created.

4. User Manual:

The dashboard consists of three tabs that can be clicked on to navigate around the subtopics. The following explains each of the interactions that are present in each of the tabs.

Flora and Fauna tab:

1. Tree population Map:

❖ Each of the green dots present on the map represents a tree. On hovering the cursor on a green dot, a tool tip pops up which gives information about the tree species, the year it was planted etc.

Weather and Energy Consumption tab:

1. Map to show site ids:

❖ The site ids are represented by purple dots on the map. The cursor can be hovered on top of the purple dot to get information about each of the weather parameters (temperature, pressure, windspeed and air particle concentration) and, also the number of trees.

2. Bar chart:

❖ A drop-down menu is clicked to choose the residential or commercial building to view bar charts for each of these by clicking the options available.

Future Greening Projects tab:

1. Map to represent laneways:

- The blue colour shapes represent laneways that have been identified to have greening potentials. To get information about each of the laneways, the blue coloured shapes need to be clicked on which will pop a tooltip up. The tool tip will contain information about address of the laneway, the climate type, forest, and park potential for the laneway.

- A drop-down menu is added representing laneway with different climate types. The dropped menu can be clicked to choose climate options. The choice would display only the laneway polygons corresponding to climate.

5. Conclusion:

The visualisation has been built to answer the questions asked as a part of the project concisely. For user convenience the visualisation has been converted into a dashboard with three tabs representing the subtopics.

The first tab answers the first question in the project about population of the trees, birds, and insects. The trees have been shown as green dots plotted across Melbourne city to aid the visual appeasement of the users to support the theme of greenery. The stacked bar chart and the scatter plot has been successful in representing the top species of birds and insects that are present across different locations of the Urban Forest.

The second tab displayed sites across different locations of urban forest on a map and gave the information about number of trees and the weather parameters present in a 1 km radius of the climate sensor sites. The bar plot present explains the number of electricity units consumed across residential and commercial units present across the sites.

The third tab again is visualised on a map given the geospatial polygon data that has been a part of the data collected. These polygons are provided with a tool tip which would give its address, whether if it can be turned into a park or forest and the climate type of the laneway.

These visualisations are based on data which mostly contains geospatial and categorical data and very limited numerical data. Due to the limitations in the availability of the data types in the columns that were necessary to draw answers, a lot of complex derivations could not be conducted.

6. References:

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7. *Appendix:*

Title: Comprehensive Case Study of Melbourne Urban Forest
Author: Panchami Tumkur Narendra
Date: 16/05/2023
Sheet 1: Brainstorm

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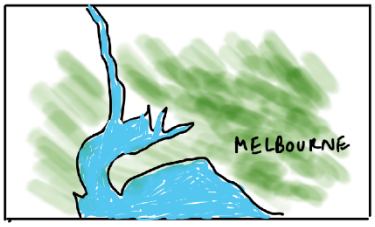
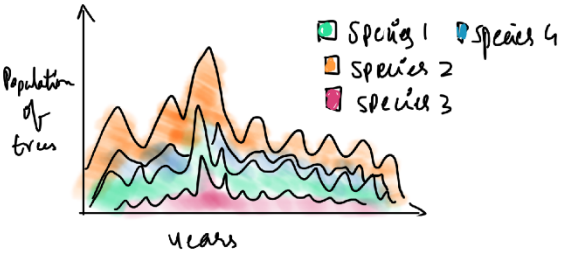
1. Ideas:

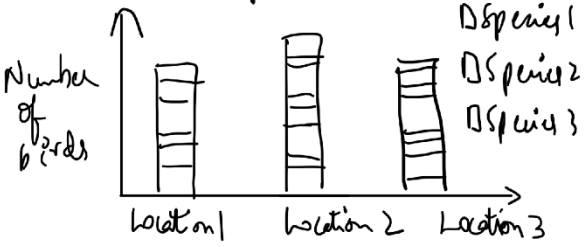
① Map to represent the population density of trees across Melbourne city. The gradation of colour to represent the population density.



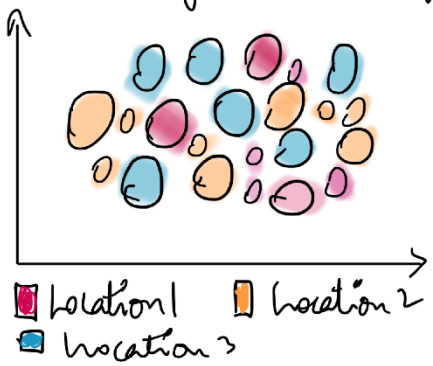
② An area chart to represent the population of different species of trees planted over the years



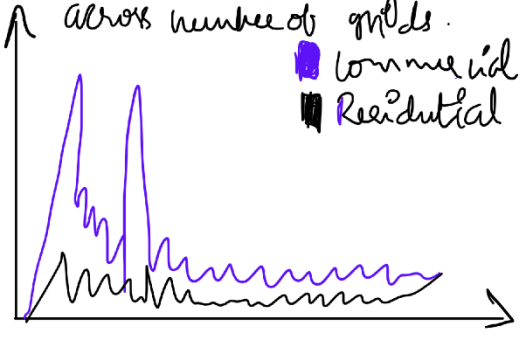
③ The population of birds can be represented using stacked bar chart as per their location



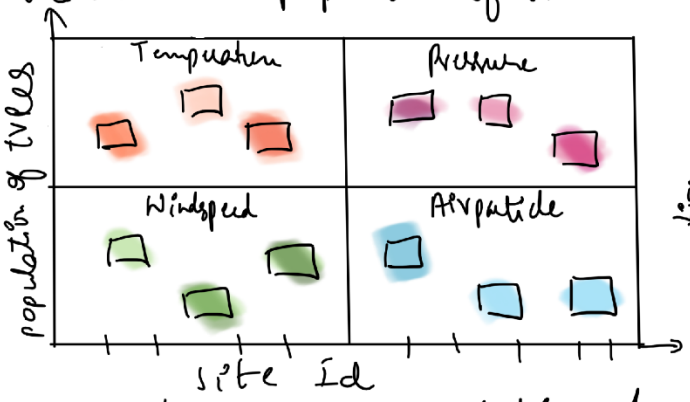
④ A bubble chart to show the population of insects. The colour coding is done based on location and number & size of bubbles depends on species and population of insects respectively



⑤ Line plot to show variation of energy consumption for residential and commercial grids across number of grids.

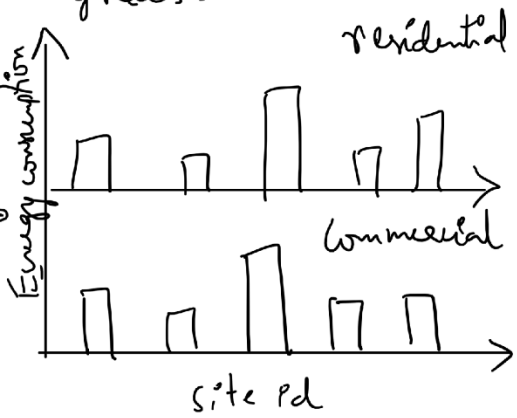


⑥ Heatmap to show variations of weather parameters over different locations and population of trees.



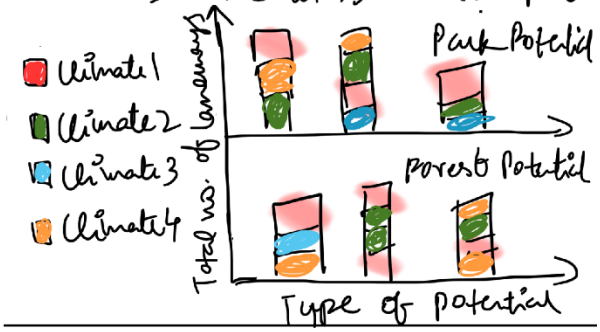
The above shows gradation of colour depending on values of weather parameters.

⑦ A bar chart to show energy consumption across different locations and residential and commercial grids.



⑧ Tree planting zones are plotted on the a map and are colour coded according to their schedule

⑨ Potential of turning laneway into parks and forests based on climate can be as stacked barplot



Filter

After applying filtering among the graphs I can go ahead with the idea: ①, ②, ③, ④, ⑥, ⑦, ⑧, ⑨

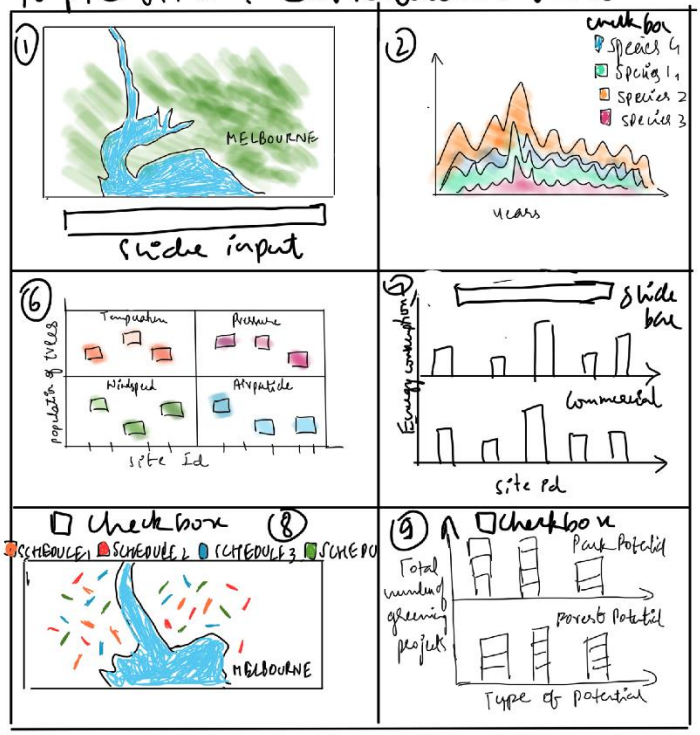
Combine and Refine

①, ② & ③ can be combined into a map

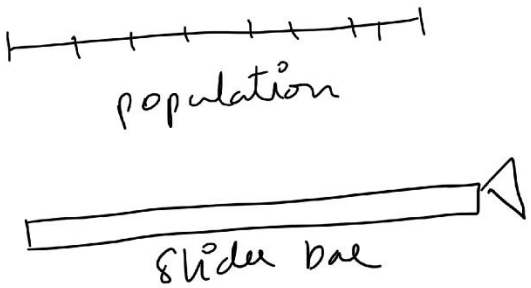
⑥ & ⑦ can be combined & shown on a map

Sheet 2 : Initial Design Layout :

Topic title : Introduction text



Focus :



Title : Comprehensive Case Study of Melbourne Urban Forest

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Operations

* Changing population of trees using slider and change energy consumption.
* Check box to filter schedules, tree species, etc.

Discussion :

* The layout is showing a lot of features together
* Not showing able to show number of insects & birds
* Not enough content is being given about graphs.

Sheet 3: Initial Design Layout :

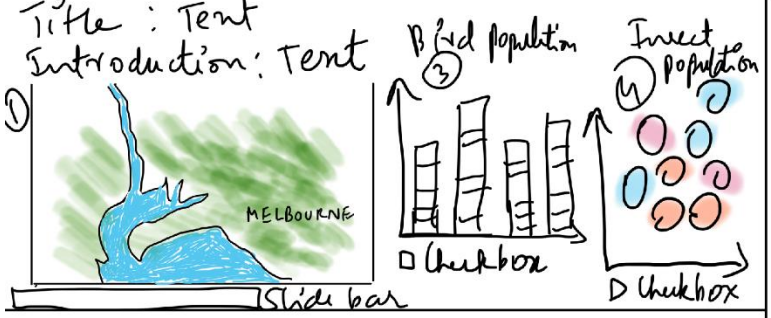
Title : Comprehensive Case Study of Melbourne Urban Forest

Author : Panchami Tumkur Narendra

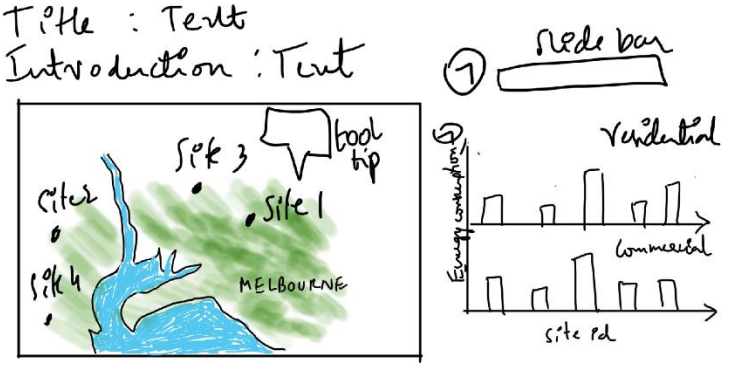
Date : 16/05/2023

Topic : Introduction text

Title : Text
Introduction : Text



Title : Text
Introduction : Text



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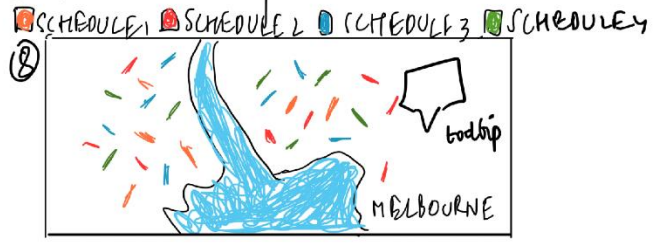
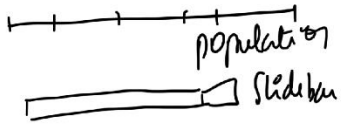
Introduction : Text



Focus :



Operations

* Slide bar to change the population density of trees, energy consumption
* Filters to show population of insects and birds
* Tool tip shows graph (6) data for weather parameters and t

Discussion :

* In the first part it is trying to show a lot of features
* The Energy consumption bar plot can be added as tool tip as well.
* The slide bar to change energy consumption is not giving significant information

Sheet 4: Initial Design

Layout:

Main Page | Subtopic 1 | Sub topic 2

Title: text
Introduction: text

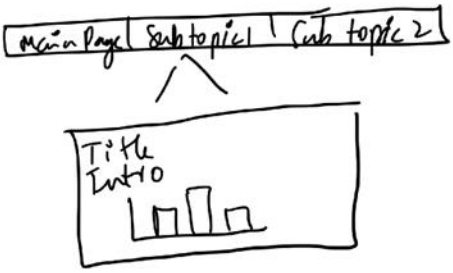
①

Subtopic 1

Subtopic 2

Title: Text
Introductions: Text

Focus:



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Operations

* Showing slide bar for population
* tool tip show weather parameters.
* Check box to filter schedules
* tooltip to show information about greening projects

Discussion:

* The Segmentation into 3 page will help split the
* The bar chart for energy consumption along with weather parameter will be better on a map.

Sheet 5: Final Realization

Layout :

Project Overview | Flora & Fauna | Weather and Energy consumption | Future Greening Projects

Introduction
- - -
- - - .

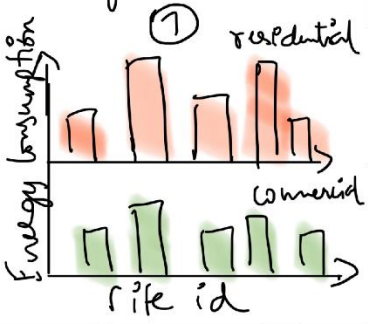
Questions to be answered are :
1. - .
2. - . .
3. . . .
4. - . -

Flora and Fauna — Life in Urban Forest
Trees, insects and birds : Text

Weather and Energy Consumption

Energy consumption : Information — Drop down menu

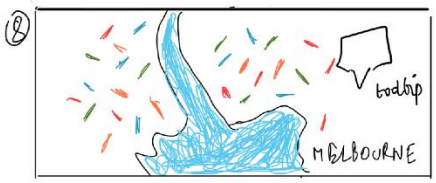
Weather across diffent microclimate zones : Text



Future Greening Projects

Hanaway with greening potential : Text

Drop down menu
Select Climate



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Operations

* Slide bar is used to change the population
* tool tip is used to display information about temperature and weather parameters, Number of potential greening projects and bird & insect information
* Check box to filter out schedules.

Detail :

* Clear titles and explanations
* The outline is clean
* Slider shows population density.

Focus :-

Main Page | Subtopic1 | Subtopic2