TIL Programming Project Group

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Research Objective

Main question: "How does the weather influence traffic accidents in urban and rural areas in the Netherlands during the period of 2021-2022?".

Sub questions:

1. Do urban and rural areas have significantly different amount of traffic accidents?
2. Does weather type influence the amount of traffic accidents in urban and rural areas?
3. Does weather type influence the severity of the traffic accidents?

Research Report

1. Introduction

In the intricate tapestry of our daily lives, transport plays an important role. Going from A to B, people use many different modes to travel, whether by car, bus, bike or foot. Yet, while traveling, the potential for accidents lurks, influenced by an array of factors. One of these factors is the weather. To further understand how and why the weather plays a potential pivotal role in the amount of accidents in the Netherlands, a research question has been set:

How does the weather influence traffic accidents in urban and rural areas in the Netherlands during the period of 2021-2022?

To ensure that the research question can be answered, subquestions have also been formulated to support the validity:

1. Are road accidents more common in urban areas compared to rural areas?
2. Does the type of weather influence the amount of accidents?
3. Doest the type of weather influence the severity of accidents?

2. Data Processing

In [1]:

```
import pandas as pd
import requests
from time import sleep
from requests.adapters import HTTPAdapter
from requests.packages.urllib3.util.retry import Retry
import plotly.express as px
import numpy as np
from sklearn.cluster import KMeans
import matplotlib.pyplot as plt
from scipy import stats
from scipy.stats import f_oneway
from scipy.stats import chi2_contingency
```

Dataset 1: Road accidents data in Netherlands

In [ ]:

```
#local absolute file path of large dataset
filename = r"C:\Users\simon\TIL jaar 1\TIL programming\project\traffic data\PGS0112-o-CSV-bestand-J-1-N-N-N\Ongevallengeg
#Loading the dataset
df = pd.read_csv(filename, encoding = 'latin1', low_memory=False)
# alcohol indicator for no was an empty column so that is filled with an n
df["IND_ALC"].fillna("N", inplace = True)
#selecting the necessary columns
data = df[["AP3_CODE", "WGD_CODE_1", "BEBKOM", "MAXSNELHD", "IND_ALC", "GME_NAAM", "PVE_NAAM", "DISTRNAAM"]]
#dropping rows where either 1 of the columns has no value, reduces the amount of rows by approximately half
print(data)
data_cleaned = data.dropna()
print(data_cleaned)
#converting the dataframe to a .pkl file format for easier sharing
data_cleaned.to_pickle("accidents.pkl") #Dataset 1
```

In [7]:
```
df_accidents = pd.read_pickle("accidents.pkl")

df_accidents = df_accidents[['AP3_CODE', 'WGD_CODE_1', 'GME_NAAM', 'PVE_NAAM']]
df_accidents_renamed = df_accidents.rename(columns={'AP3_CODE': 'Severity', 'WGD_CODE_1': 'Weather_Type', 'GME_NAAM': 'Mu

df_accidents_renamed
```

Out[7]:

	Severity	Weather_Type	Municipality	Province_Name
12	DOD	D	Amsterdam	Noord-Holland
15	DOD	D	Tilburg	Noord-Brabant
16	DOD	D	's-Hertogenbosch	Noord-Brabant
30	UMS	D	Súdwest-Fryslân	Friesland
31	UMS	D	Smallingerland	Friesland
...	...	...	...	...
113135	UMS	D	Voorst	Gelderland
113136	UMS	D	Nijkerk	Gelderland
113140	UMS	D	Rotterdam	Zuid-Holland
113149	UMS	D	Haarlemmermeer	Noord-Holland
113154	UMS	D	Hoogeveen	Drenthe

7704 rows × 4 columns

Dataset 2: Municipality's density and road length data

In [2]:
```
# Adding data reference from CBS for clustering analysis
clustering_raw_data = r"C:\Users\LENOVO YOGA\TIL6022 Phython Programming\TIL 6022 TIL Python Programming\00 Final Project
df_cluster_data = pd.read_csv(clustering_raw_data, encoding = 'latin1', low_memory=False)

# Display only the relevant / needed columns
df_cluster_data = df_cluster_data [['Municipality_final','Population','Area','Density','Road_Length']]
df_cluster_data = df_cluster_data.rename(columns={'Municipality_final': 'Municipality_Name'})

df_cluster_data
```

Out[2]:

	Municipality_Name	Population	Area	Density	Road_Length
0	Aa en Hunze	25579	276.66	93	639
1	Almere	32452	20.00	1615	157
2	Alblasserdam	20087	8.87	2290	82
3	Albrandswaard	25934	21.17	1197	151
4	Alkmaar	110783	110.01	1004	594
...	...	...	...	...	...
229	Zoetermeer	125767	34.43	3653	406
230	Zoeterwoude	9302	21.16	440	63
231	Zuidplas	45794	57.76	790	316
232	Zwijndrecht	44789	20.01	2206	209
233	Zwolle	130668	110.07	1181	778

234 rows × 5 columns

3. Analysis

3.1 Traffic Accident Heatmap Visualization

Section 3.1 focuses on the synthesis of accident data with geospatial analysis to create an intuitive heatmap visualization. This method graphically represents the density and distribution of traffic accidents, offering a clear visual summary of areas with higher and lower incident frequencies. Heatmaps are particularly effective in revealing hotspots and patterns that might not be immediately apparent from raw data, thereby providing valuable insights for further investigation and targeted safety measures.

3.1.1 Display Municipality Information

The visualization process begins by identifying and enumerating the unique municipalities involved in the traffic accident dataset. Utilizing the GME_NAAM column, the code snippet isolates each distinct municipality and computes the total count of such unique entities. This preliminary step is instrumental in the preparation for subsequent visual mapping. The output, which includes both a count and a detailed list of these municipalities, serves as a cornerstone for the accurate plotting of incidents in the following stages of analysis. It ensures that the data fed into the heatmap visualization is well-structured and comprehensive, reflecting the true breadth of the dataset's geographic coverage.

In [5]:

```
# Extract unique municipalities from the GME_NAAM column
unique_municipalities = df_accidents['GME_NAAM'].unique()

# Count of unique municipalities
num_unique_municipalities = df_accidents['GME_NAAM'].nunique()

print(f"Number of unique municipalities (GME_NAAM): {num_unique_municipalities}")
print("List of unique municipalities:")
for municipality in unique_municipalities[:5]:
    print(municipality)
```

```
Number of unique municipalities (GME_NAAM): 253
List of unique municipalities:
Amsterdam
Tilburg
's-Hertogenbosch
Súdwest-Fryslân
Smallingerland
```

3.1.2 Coordinates for Municipalities in the Netherlands: Longitude and Latitude Data

Prior to delving into the visualization of accident locations on the map, it is essential to gather accurate geographical coordinates for each municipality in the Netherlands. The dataset provided contains precise longitudinal and latitudinal points, which are crucial for plotting each location on the map. These coordinates serve as the foundational data that will enable the creation of an informative and detailed map, illustrating the spatial distribution of traffic incidents across the municipalities. With these coordinates, each municipality can be accurately represented on the map, providing a clear visual representation of the number of accidents in relation to their geographical context.

In [8]:
```python
# this piece of code takes a while to run, be patient
def get_coordinates(municipality_name, country="Netherlands", max_retries=3, backoff_factor=0.3):
    base_url = "https://nominatim.openstreetmap.org/search"
    params = {
        'q': f'{municipality_name}, {country}',
        'format': 'json',
        'limit': 1
    }

    session = requests.Session()
    retry = Retry(total=max_retries, backoff_factor=backoff_factor)
    adapter = HTTPAdapter(max_retries=retry)
    session.mount('http://', adapter)
    session.mount('https://', adapter)
    session.headers.update({'User-Agent': 'YourAppName/1.0'})  # Add your User-Agent here

    try:
        response = session.get(base_url, params=params, timeout=10)
        response.raise_for_status()
        data = response.json()
        if data:
            lat = float(data[0]['lat'])
            lon = float(data[0]['lon'])
            return lat, lon
    except requests.exceptions.RequestException as e:
        print(f"Error fetching data for {municipality_name}: {e}")
    return None


# Sample municipalities
municipalities = [
    "Amsterdam", "Tilburg", "'s-Hertogenbosch", "Súdwest-Fryslân", "Smallingerland",
    "Westerkwartier", "Oost Gelre", "Roerdalen", "Horst aan de Maas", "Venlo",
    "Breda", "Terneuzen", "Best", "Waddinxveen", "Weststellingwerf",
    "De Fryske Marren", "Leeuwarden", "Apeldoorn", "Barneveld", "Hattem",
    "Gilze en Rijen", "Rotterdam", "Schiedam", "Oosterhout", "Geertruidenberg",
    "Venray", "Neder-Betuwe", "Deventer", "Overbetuwe", "Nijmegen",
    "Purmerend", "Zuidplas", "'s-Gravenhage", "Leidschendam-Voorburg", "Weert",
    "Echt-Susteren", "Haarlemmermeer", "Rijswijk", "Koggenland", "Kaag en Braassem",
    "Moerdijk", "Vlissingen", "Oirschot", "Vught", "Maashorst",
    "Opsterland", "Amersfoort", "Hollands Kroon", "Papendrecht", "Staphorst",
    "Waadhoeke", "Arnhem", "Leiden", "Wierden", "Noordoostpolder",
    "Eindhoven", "Veldhoven", "Beuningen", "West Betuwe", "Land van Cuijk",
    "Heumen", "Utrecht", "Houten", "Utrechtse Heuvelrug", "Oostzaan",
    "Beverwijk", "Zaanstad", "Alkmaar", "Lansingerland", "Vlaardingen",
    "Midden-Delfland", "Heemskerk", "Dordrecht", "Hoeksche Waard", "Zwijndrecht",
    "Zoetermeer", "Heerenveen", "Sittard-Geleen", "Heerlen", "Ouder-Amstel",
    "Peel en Maas", "Almelo", "Lelystad", "Almere", "Tynaarlo",
    "Twenterand", "Wijchen", "Vijfheerenlanden", "Ridderkerk", "Barendrecht",
    "Wormerland", "Alblasserdam", "Etten-Leur", "Harderwijk", "Diemen",
    "Wassenaar", "Albrandswaard", "Maasgouw", "Maastricht", "Beekdaelen",
    "Meerssen", "Leudal", "Raalte", "Eemnes", "De Bilt",
    "Woerden", "Zaltbommel", "Ommen", "Zwolle", "Den Helder",
    "Borne", "Castricum", "Waalwijk", "Son en Breugel", "Sluis",
    "Oss", "Bodegraven-Reeuwijk", "Gouda", "Gooise Meren", "Amstelveen",
    "Hellevoetsluis", "Velsen", "Kampen", "Steenwijkerland", "Rucphen",
    "Bergen op Zoom", "Enschede", "Oude IJsselstreek", "Alphen aan den Rijn", "Meierijstad",
    "Geldrop-Mierlo", "Uitgeest", "Cranendonck", "De Ronde Venen", "Sliedrecht",
    "Tiel", "Culemborg", "Losser", "Veenendaal", "Waalre",
    "Stichtse Vecht", "Beek", "Bernheze", "Groningen", "Goeree-Overflakkee",
    "Heusden", "Gennep", "Laren", "Zeist", "Leiderdorp",
    "Maasdriel", "Valkenburg aan de Geul", "Reimerswaal", "Boxtel", "Westland",
    "Delft", "Emmen", "Leusden", "Soest", "Gorinchem",
    "Midden-Groningen", "Hoogeveen", "Kapelle", "Altena", "Halderberge",
    "Roosendaal", "Woensdrecht", "Eersel", "Aa en Hunze", "Meppel",
    "Schouwen-Duiveland", "Hardinxveld-Giessendam", "Ede", "Putten", "Hengelo",
    "Bergen (NH.)", "Zoeterwoude", "Beesel", "Oldambt", "Nunspeet",
    "Veendam", "Lingewaard", "Blaricum", "Medemblik", "Assen",
    "Middelburg", "Haaksbergen", "Haarlem", "De Wolden", "Goes",
    "Someren", "Roermond", "Westerveld", "Stein", "Voerendaal",
    "Nieuwegein", "Hilvarenbeek", "Schagen", "Epe", "Doetinchem",
    "Hendrik-Ido-Ambacht", "Duiven", "Alphen-Chaam", "Heeze-Leende", "Nijkerk",
    "Renkum", "Hellendoorn", "Rijssen-Holten", "Buren", "Oldebroek",
    "Eemsdelta", "Steenbergen", "Midden-Drenthe", "Zevenaar", "Heerde",
    "Hilversum", "Berkelland", "Bladel", "Harlingen", "Baarn",
    "Montferland", "Teylingen", "Dinkelland", "Deurne", "Oldenzaal",
    "Voorst", "Capelle aan den IJssel", "Coevorden", "Heiloo", "Bunnik",
    "Veere", "Rheden", "Ermelo", "Lisse", "Bunschoten",
    "Oegstgeest", "Zeewolde", "Brielle", "Elburg", "Edam-Volendam",
    "Drimmelen", "Dronten", "Huizen", "Tytsjerksteradiel", "Valkenswaard",
    "Oisterwijk", "Hardenberg", "Noord-Beveland", "Woudenberg", "Molenlanden",
    "Dalfsen", "Hulst", "Zandvoort", "Tholen", "IJsselstein",
    "Katwijk", "Voorburg", "Mook en Middelaar", "Scherpenzeel", "Brunssum",
    "Weesp", "Borger-Odoorn", "Goirle", "Grave", "Reusel-De Mierden",
    "Noordenveld", "Vaals", "Achtkarspelen", "Loppersum", "Gulpen-Wittem",
    "Bronckhorst", "Hoorn", "Eijsden-Margraten"
]

# Replace this list with all 253 municipalities
municipality_coords = {}

for municipality in municipalities:
```

```
    sleep(1)  # To comply with rate limiting
    coords = get_coordinates(municipality)
    if coords:
        municipality_coords[municipality] = coords

print(municipality_coords)
```

{'Amsterdam': (52.3730796, 4.8924534), 'Tilburg': (51.58561845, 5.0660616131367675), "'s-Hertogenbosch": (51.6889387,
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3.1.3 Visual (Graphical) Representation of Traffic Incidents by Municipality in the Netherlands

This analysis explores the distribution and frequency of accidents within The Netherland's municipalities. Data visualization techniques are employed to offer a lucid and informative perspective on traffic safety. The ensuing charts and heatmaps provide insight into the areas with the most reported accidents, pinpointing regions that might require enhanced traffic safety interventions. Such visual data representation not only clarifies the present road safety conditions in the Netherlands but also acts as a valuable resource for policymakers and public safety officials striving to address and reduce traffic-related issues.

In [9]:

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# Load accident data from the .pkl file
df_accidents = pd.read_pickle("accidents.pkl")

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'Steenbergen': (51.603292100000004, 4.309251716161476),
'Midden-Drenthe': (52.87061935, 6.568055858657804),
'Zevenaar': (51.927908099999996, 6.077526279085048),
'Heerde': (52.4056303, 6.0413984003658525),
'Hilversum': (52.2241375, 5.1719396),
'Berkelland': (52.10152, 6.618404626883939),
'Bladel': (51.37121075, 5.234630644566941),
'Harlingen': (53.1752103, 5.4141998),
'Baarn': (52.2002549, 5.269143393313942),
'Montferland': (51.92400575, 6.205514601615217),
'Teylingen': (52.21739375, 4.511393222538171),
'Dinkelland': (52.371448799999996, 6.915066619316923),
'Deurne': (51.4281834, 5.828106871124028),
'Oldenzaal': (52.30853685, 6.914603743122237),
'Voorst': (52.2374112, 6.086274393475191),
'Capelle aan den IJssel': (51.9312552, 4.5883596),
'Coevorden': (52.6612281, 6.7407359),
'Heiloo': (52.60192475, 4.70503175175436),
'Bunnik': (52.039151849999996, 5.220319799249577),
'Veere': (51.55640385, 3.577269355747127),
'Rheden': (52.03136695, 6.060504296329905),
'Ermelo': (52.2858356, 5.654938589920705),
'Lisse': (52.2540183, 4.541928029675811),
'Bunschoten': (52.2391743, 5.3734101),
'Oegstgeest': (52.1833669, 4.472129402976295),
'Zeewolde': (52.3451194, 5.4580775473608565),
'Brielle': (51.901662, 4.1626292),
'Elburg': (52.415659149999996, 5.841321708557087),
'Edam-Volendam': (52.54861165, 5.0266156034337826),
'Drimmelen': (51.69768865, 4.743934177567655),
'Dronten': (52.531389649999994, 5.750631211201343),
'Huizen': (52.296484449999994, 5.240582040690262),
'Tytsjerksteradiel': (53.20512135, 5.973447146507526),
'Valkenswaard': (51.3202409, 5.458181897733282),
'Oisterwijk': (51.56610775, 5.198644959051684),
'Hardenberg': (52.56982145, 6.633166913313982),
'Noord-Beveland': (51.56520675, 3.8009095733783114),
'Woudenberg': (52.08025955, 5.4122265761644925),
'Molenlanden': (51.891504350000005, 4.836502624912571),
'Dalfsen': (52.51178365, 6.256636721854065),
'Hulst': (51.33154005, 4.087702848747496),
'Zandvoort': (52.3713394, 4.5307624),
'Tholen': (51.57085015, 4.076142821673509),
'IJsselstein': (52.026205250000004, 5.028685923229064),
'Katwijk': (52.2005078, 4.4146372),
'Voorburg': (52.0703201, 4.3558561),
'Mook en Middelaar': (51.74830635, 5.906406373368311),
'Scherpenzeel': (52.0795901, 5.4904134),
'Brunssum': (50.9431108, 5.9705675),
'Weesp': (52.3072593, 5.0420822),
'Borger-Odoorn': (52.9000925, 6.8821614819282875),
'Goirle': (51.5056266, 5.033774070783131),
'Grave': (51.7596504, 5.7411125),
'Reusel-De Mierden': (51.37099705, 5.1468666691668705),
'Noordenveld': (53.0945705, 6.4209724500257455),
'Vaals': (50.7781016, 5.981067967268041),
'Achtkarspelen': (53.207516749999996, 6.150763705175438),
'Loppersum': (53.3320144, 6.7469502),
'Gulpen-Wittem': (50.79962605, 5.890529675273097),
'Bronckhorst': (52.0529087, 6.269274781349422),
'Hoorn': (52.653272, 5.0735802),
```

```
    'Eijsden-Margraten': (50.80499415, 5.768281669696572)
}

# Group by GME_NAAM and count the number of accidents
df_grouped = df_accidents.groupby('GME_NAAM').size().reset_index(name='num_accidents')

# Merge with coordinates
df_grouped['latitude'] = df_grouped['GME_NAAM'].map(lambda x: municipality_coords.get(x, (np.nan, np.nan))[0])
df_grouped['longitude'] = df_grouped['GME_NAAM'].map(lambda x: municipality_coords.get(x, (np.nan, np.nan))[1])

# Remove rows with NaN coordinates (municipalities not in the dictionary)
df_grouped.dropna(subset=['latitude', 'longitude'], inplace=True)

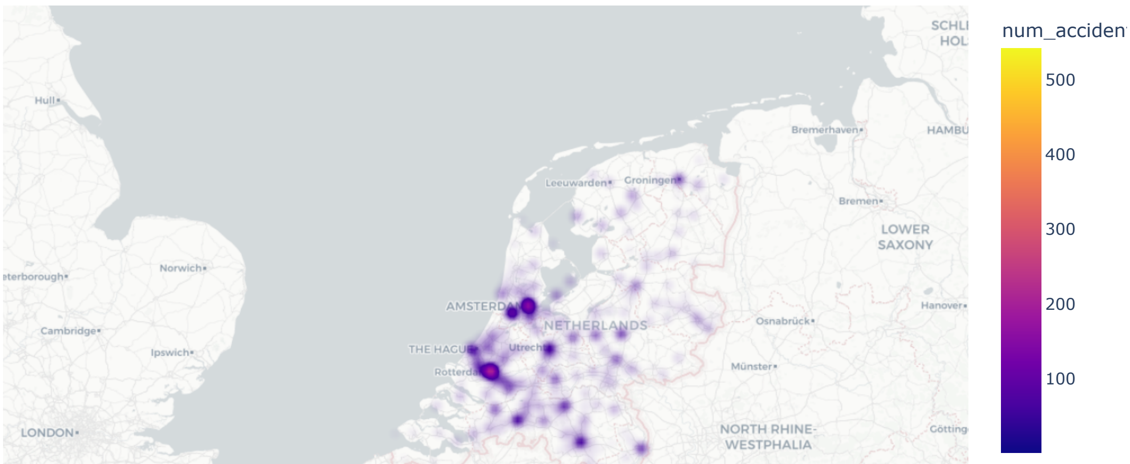
# Define a threshold for displaying municipality names
threshold = 100

fig = px.density_mapbox(df_grouped,
                        lat='latitude',
                        lon='longitude',
                        z='num_accidents',
                        radius=10,  # Reduced radius for less blurriness
                        center=dict(lat=52.3, lon=5.5),  # Centering on Netherlands
                        zoom=6,
                        hover_name='GME_NAAM',
                        title="Number of Accidents by Municipality",
                        color_continuous_scale=px.colors.sequential.Plasma,
                        template="plotly")

fig.update_layout(mapbox_style="carto-positron")

fig.show()
```

Number of Accidents by Municipality



The image depicts a heatmap of the number of accidents by municipality in the Netherlands. The heatmap is color-coded based on the number of accidents, with the color scale shown on the right side indicating that darker shades of purple represent areas with more accidents, scaling from 1 to over 500.

The map allows for the visual identification of these municipalities through prominent purple spots. Large cities in the Netherlands, such as Rotterdam and Amsterdam, are depicted with large, dark purple bubbles, signifying a high concentration of accidents. Other municipalities are also represented with bubbles, which may appear slightly smaller or lighter in color, corresponding to a fewer number of accidents.

Moving from the visual cues on the heatmap to the empirical data, this table presents a quantitative snapshot of traffic accidents across various municipalities in the Netherlands, offering a focused look at the locations with the highest incidence rates. The data is organized to highlight the number of accidents in descending order, starting with Rotterdam at the forefront, followed by Amsterdam, and trailing down to Apeldoorn. Each entry correlates to a unique municipality, represented by its respective name under the column 'GME_NAAM', alongside the total count of recorded accidents in the 'num_accidents' column. The figures reflect a range of accident frequencies, providing a basis for understanding the distribution of traffic-related incidents in these urban areas.

In [10]:
```
# Sort the grouped DataFrame by 'num_accidents' in descending order
df_sorted = df_grouped.sort_values('num_accidents', ascending=False)

# Take the top 5 rows
top_5_municipalities = df_sorted.head(10)

# Print out the top 5 municipalities
print(top_5_municipalities[['GME_NAAM', 'num_accidents']])
```

```
              GME_NAAM  num_accidents
182          Rotterdam            543
13           Amsterdam            419
87      Haarlemmermeer            246
208            Utrecht            157
36               Breda            149
68           Eindhoven            146
0         's-Gravenhage           127
1      's-Hertogenbosch           117
217              Venlo            108
14           Apeldoorn            104
```

The table lists the number of traffic accidents in various Dutch municipalities, providing a snapshot of areas with the highest incidence of events. Rotterdam tops the table with 543 reported incidents, marking it as the municipality with the most accidents. Amsterdam is next with 419 accidents, underscoring its status as another focal point for traffic incidents. Further down, Haarlemmermeer, Utrecht, and Breda also report significant numbers, though not as high as the leading cities. Additional municipalities like Eindhoven, 's-Gravenhage, and 's-Hertogenbosch are noted, each with accidents totaling over a hundred, ending with Venlo and Apeldoorn. This information is key to identifying and understanding the patterns of traffic-related incidents in these populated areas.

3.1.4 Visual (Graphical) Representation of Traffic Incidents by Province in the Netherlands

Building on the analysis of traffic incidents at the municipal level, the scope now extends to the examination of accident patterns across the provinces of the Netherlands. The data aggregated at this higher administrative level reveals regional trends and identifies provinces with higher frequencies of traffic-related events. This comparative view highlights the volume of accidents within each province and offers insights into potential underlying factors contributing to regional differences. The ensuing discussion aims to deliver a comprehensive understanding of the distribution of traffic accidents across the Dutch provinces.

In [11]:

```
import pandas as pd
import plotly.express as px

provinces = {
    'North Holland': ['Amsterdam', 'Haarlem', 'Hilversum', 'Purmerend', 'Zandvoort'],
    'South Holland': ['Rotterdam', 's-Gravenhage', 'Leiden', 'Delft', 'Schiedam', 's-Gravenzande', 'Zoetermeer', 'Rijswi
    'Zeeland': ['Vlissingen', 'Kapelle', 'Schouwen-Duiveland', 'Borsele', 'Noord-Beveland', 'Tholen', 'Veere'],
    'Drenthe': [
        'Aa en Hunze', 'Assen', 'Borger-Odoorn', 'Coevorden', 'De Wolden',
        'Emmen', 'Hoogeveen', 'Meppel', 'Midden-Drenthe', 'Noordenveld',
        'Tynaarlo', 'Westerveld'
    ],
    'Flevoland': [
        'Almere', 'Dronten', 'Lelystad', 'Noordoostpolder', 'Urk', 'Zeewolde'
    ],
    'Friesland': [
        'De Fryske Marren', 'Heerenveen', 'Leeuwarden', 'Opsterland',
        'Smallingerland', 'Súdwest-Fryslân', 'Tytsjerksteradiel', 'Waadhoeke'
    ],
    'Gelderland': [
        'Aalten', 'Apeldoorn', 'Arnhem', 'Beuningen', 'Berg en Dal', 'Berkelland',
        'Beuningen', 'Buren', 'Culemborg', 'Doesburg', 'Doetinchem', 'Druten',
        'Duiven', 'Ede', 'Elburg', 'Epe', 'Ermelo', 'Geldrop-Mierlo', 'Harderwijk',
        'Hattem', 'Heerde', 'Heumen', 'Lingewaard', 'Lochem', 'Maasdriel', 'Montferland',
        'Nijkerk', 'Nijmegen', 'Nunspeet', 'Oldebroek', 'Oost Gelre', 'Ooststellingwerf',
        'Oude IJsselstreek', 'Overbetuwe', 'Putten', 'Renkum', 'Rheden', 'Rijssen-Holten',
        'Rozendaal', 'Scherpenzeel', 'Tiel', 'Voorst', 'Wageningen', 'West Betuwe',
        'West Maas en Waal', 'Westervoort', 'Wijchen', 'Winterswijk', 'Zaltbommel',
        'Zevenaar', 'Gennep', 'Buren', 'Lingewaard', 'Overbetuwe', 'West Betuwe',
        'Montferland', 'Oude IJsselstreek', 'Winterswijk', 'Voorst', 'Doetinchem',
        'West Maas en Waal', 'Nijkerk', 'Heerde', 'Epe', 'Berkelland', 'Bronckhorst',
        'Lochem', 'Oost Gelre', 'Aalten', 'Zutphen'
    ],
    'Groningen': [
        'Eemsdelta', 'Groningen', 'Het Hogeland', 'Midden-Groningen', 'Oldambt',
        'Pekela', 'Stadskanaal', 'Veendam', 'Westerkwartier', 'Westerwolde'
    ],
    'Limburg': [
        'Beek', 'Beekdaelen', 'Beesel', 'Bergen', 'Brunssum', 'Echt-Susteren',
        'Gulpen-Wittem', 'Heerlen', 'Horst aan de Maas', 'Kerkrade', 'Landgraaf',
        'Leudal', 'Maastricht', 'Maasgouw', 'Meerssen', 'Mook en Middelaar',
        'Nederweert', 'Peel en Maas', 'Roermond', 'Simpelveld', 'Sittard-Geleen',
        'Stein', 'Vaals', 'Valkenburg aan de Geul', 'Venlo', 'Venray', 'Voerendaal',
        'Weert'
    ],
    'Noord-Brabant': [
        'Alphen-Chaam', 'Altena', 'Baarle-Nassau', 'Hilvarenbeek', 'Goirle',
        'Reusel-De Mierden', 'Eersel', 'Bladel', 'Oirschot', 'Best', 'Veldhoven',
        'Eindhoven', 'Oisterwijk', 'Haaren', 'Tilburg', "'s-Hertogenbosch",
        'Meierijstad', 'Sint-Michielsgestel', 'Boxtel', 'Haaren', 'Vught', 'Dongen',
        'Loon op Zand', 'Gilze en Rijen', 'Tilburg', 'Gilze en Rijen',
        'Geertruidenberg', 'Oosterhout', 'Waalwijk', 'Heusden', 'Altena'
    ],
    'Utrecht': [
        'Eemnes', 'De Bilt', 'Stichtse Vecht', 'Baarn', 'Nieuwegein', 'Woudenberg',
        'Utrecht', 'Houten', 'Lopik', 'Vijfheerenlanden', 'Woerden', 'Zeist'
    ]
}


# Data
data = {
    'Province': ['North Holland', 'South Holland', 'Zeeland', 'Drenthe', 'Flevoland',
                 'Friesland', 'Gelderland', 'Groningen', 'Limburg', 'Noord-Brabant', 'Utrecht'],
    'Total accidents': [465, 1198, 40, 171, 133, 259, 823, 198, 478, 757, 386]
}

coordinates = {
    'North Holland': (52.6323814, 4.7533755),
    'South Holland': (51.9225, 4.47917),
    'Zeeland': (51.4991747, 3.6151451),
    'Drenthe': (52.8775717, 6.6178052),
    'Flevoland': (52.5246256, 5.7400598),
    'Friesland': (53.1641641, 5.7763946),
    'Gelderland': (52.0583672, 5.5363016),
    'Groningen': (53.2190652, 6.5680077),
    'Limburg': (51.2091958, 5.9925004),
    'Noord-Brabant': (51.5287863, 5.5592763),
    'Utrecht': (52.0809856, 5.1276839)
}

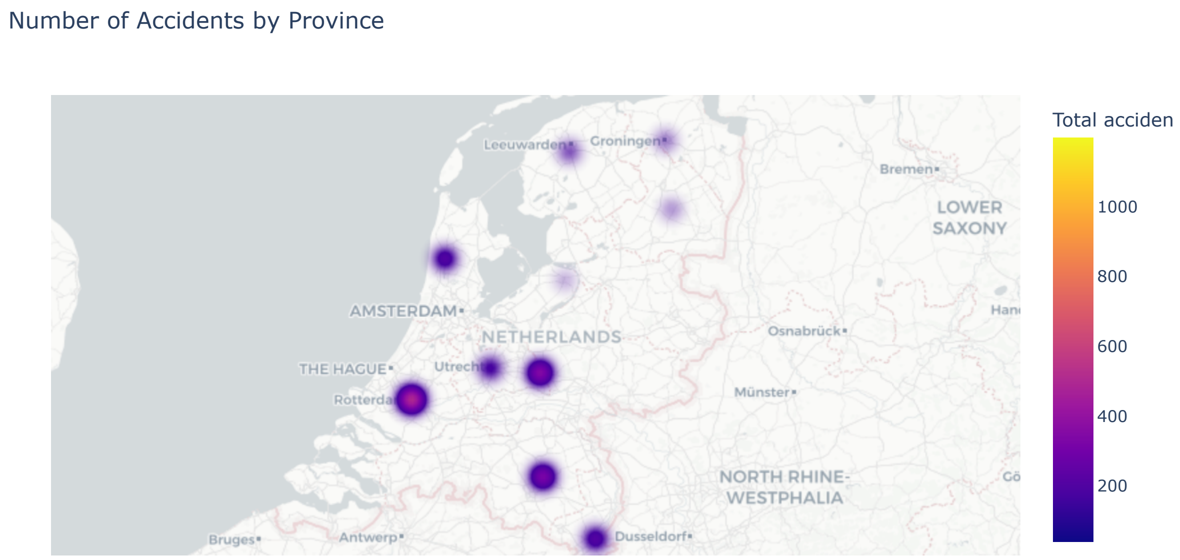
df = pd.DataFrame(data)
df['Latitude'] = df['Province'].apply(lambda x: coordinates[x][0])
df['Longitude'] = df['Province'].apply(lambda x: coordinates[x][1])

# Create a density_mapbox figure
fig = px.density_mapbox(df,
                        lat='Latitude',
                        lon='Longitude',
                        z='Total accidents',
                        radius=20,  # Adjust radius as needed
                        center=dict(lat=52.3, lon=5.5),  # Centering on Netherlands
```

```
                        zoom=6,
                        hover_name='Province',
                        title="Number of Accidents by Province",
                        color_continuous_scale=px.colors.sequential.Plasma,
                        template="plotly")

# Update the layout to use a mapbox style
fig.update_layout(mapbox_style="carto-positron")

# Display the figure
fig.show()
```



The image displays a heatmap on a map of the Netherlands, showing the distribution of traffic accidents by province. The intensity of the accidents is visualized by color-coded circles, with the color scale on the right indicating the number of accidents. Darker shades of purple signify a higher number of accidents, scaling from 200 to over 1000, as indicated by the color legend labeled "Total accidents."

The largest and darkest bubble is centered over South Holland, reflecting its status as the province with the highest number of accidents. Other provinces with notable accident counts, like North Holland and Gelderland, are marked by slightly smaller, yet still intensely colored bubbles. Provinces with fewer accidents are represented by even smaller and lighter-colored circles. The map provides a clear visual representation of how traffic accidents are distributed across the provinces, highlighting areas with higher and lower frequencies of traffic incidents.

In [12]:

```
# Load accident data from the .pkl file
df_accidents = pd.read_pickle("accidents.pkl")

# Define the provinces and their municipalities
provinces = {
    'North Holland': ['Amsterdam', 'Haarlem', 'Hilversum', 'Purmerend', 'Zandvoort'],
    'South Holland': ['Rotterdam', 's-Gravenhage', 'Leiden', 'Delft', 'Schiedam', 's-Gravenzande', 'Zoetermeer', 'Rijswij
    'Zeeland': ['Vlissingen', 'Kapelle', 'Schouwen-Duiveland', 'Borsele', 'Noord-Beveland', 'Tholen', 'Veere'],
    'Drenthe': [
        'Aa en Hunze', 'Assen', 'Borger-Odoorn', 'Coevorden', 'De Wolden',
        'Emmen', 'Hoogeveen', 'Meppel', 'Midden-Drenthe', 'Noordenveld',
        'Tynaarlo', 'Westerveld'
    ],
    'Flevoland': [
        'Almere', 'Dronten', 'Lelystad', 'Noordoostpolder', 'Urk', 'Zeewolde'
    ],
    'Friesland': [
        'De Fryske Marren', 'Heerenveen', 'Leeuwarden', 'Opsterland',
        'Smallingerland', 'Súdwest-Fryslân', 'Tytsjerksteradiel', 'Waadhoeke'
    ],
    'Gelderland': [
        'Aalten', 'Apeldoorn', 'Arnhem', 'Beuningen', 'Berg en Dal', 'Berkelland',
        'Beuningen', 'Buren', 'Culemborg', 'Doesburg', 'Doetinchem', 'Druten',
        'Duiven', 'Ede', 'Elburg', 'Epe', 'Ermelo', 'Geldrop-Mierlo', 'Harderwijk',
        'Hattem', 'Heerde', 'Heumen', 'Lingewaard', 'Lochem', 'Maasdriel', 'Montferland',
        'Nijkerk', 'Nijmegen', 'Nunspeet', 'Oldebroek', 'Oost Gelre', 'Ooststellingwerf',
        'Oude IJsselstreek', 'Overbetuwe', 'Putten', 'Renkum', 'Rheden', 'Rijssen-Holten',
        'Rozendaal', 'Scherpenzeel', 'Tiel', 'Voorst', 'Wageningen', 'West Betuwe',
        'West Maas en Waal', 'Westervoort', 'Wijchen', 'Winterswijk', 'Zaltbommel',
        'Zevenaar', 'Gennep', 'Buren', 'Lingewaard', 'Overbetuwe', 'West Betuwe',
        'Montferland', 'Oude IJsselstreek', 'Winterswijk', 'Voorst', 'Doetinchem',
        'West Maas en Waal', 'Nijkerk', 'Heerde', 'Epe', 'Berkelland', 'Bronckhorst',
        'Lochem', 'Oost Gelre', 'Aalten', 'Zutphen'
    ],
    'Groningen': [
        'Eemsdelta', 'Groningen', 'Het Hogeland', 'Midden-Groningen', 'Oldambt',
        'Pekela', 'Stadskanaal', 'Veendam', 'Westerkwartier', 'Westerwolde'
    ],
    'Limburg': [
        'Beek', 'Beekdaelen', 'Beesel', 'Bergen', 'Brunssum', 'Echt-Susteren',
        'Gulpen-Wittem', 'Heerlen', 'Horst aan de Maas', 'Kerkrade', 'Landgraaf',
        'Leudal', 'Maastricht', 'Maasgouw', 'Meerssen', 'Mook en Middelaar',
        'Nederweert', 'Peel en Maas', 'Roermond', 'Simpelveld', 'Sittard-Geleen',
        'Stein', 'Vaals', 'Valkenburg aan de Geul', 'Venlo', 'Venray', 'Voerendaal',
        'Weert'
    ],
    'Noord-Brabant': [
        'Alphen-Chaam', 'Altena', 'Baarle-Nassau', 'Hilvarenbeek', 'Goirle',
        'Reusel-De Mierden', 'Eersel', 'Bladel', 'Oirschot', 'Best', 'Veldhoven',
        'Eindhoven', 'Oisterwijk', 'Haaren', 'Tilburg', "'s-Hertogenbosch",
        'Meierijstad', 'Sint-Michielsgestel', 'Boxtel', 'Haaren', 'Vught', 'Dongen',
        'Loon op Zand', 'Gilze en Rijen', 'Tilburg', 'Gilze en Rijen',
        'Geertruidenberg', 'Oosterhout', 'Waalwijk', 'Heusden', 'Altena'
    ],
    'Utrecht': [
        'Eemnes', 'De Bilt', 'Stichtse Vecht', 'Baarn', 'Nieuwegein', 'Woudenberg',
        'Utrecht', 'Houten', 'Lopik', 'Vijfheerenlanden', 'Woerden', 'Zeist'
    ]
}


# Create a dictionary to store the total accidents per province
total_accidents_by_province = {}

# Iterate over provinces and calculate the total accidents
for province_name, municipalities in provinces.items():
    filtered_data = df_accidents[df_accidents['GME_NAAM'].isin(municipalities)]
    total_accidents = filtered_data.shape[0]
    total_accidents_by_province[province_name] = total_accidents

# Sort the total accidents by province in descending order
sorted_accidents_by_province = sorted(total_accidents_by_province.items(), key=lambda item: item[1], reverse=True)

# Print the sorted total accidents for each province
for province, accidents in sorted_accidents_by_province:
    print(f"Total accidents in {province}: {accidents}")
```

```
Total accidents in South Holland: 1198
Total accidents in Gelderland: 823
Total accidents in Noord-Brabant: 757
Total accidents in Limburg: 478
Total accidents in North Holland: 465
Total accidents in Utrecht: 386
Total accidents in Friesland: 259
Total accidents in Groningen: 198
Total accidents in Drenthe: 171
Total accidents in Flevoland: 133
Total accidents in Zeeland: 40
```

The data provided lists the number of traffic accidents recorded across various provinces in the Netherlands, ordered from the highest to the lowest number of incidents. South Holland tops the list with 1198 accidents, indicating it has the highest occurrence of traffic incidents among the provinces. Gelderland follows with 823 accidents, and Noord-Brabant is close behind with 757, suggesting these are also high-incident areas.

Limburg and North Holland are in the middle range, with 478 and 465 accidents respectively, while Utrecht, Friesland, and Groningen show fewer incidents, ranging from 386 to 198. Drenthe and Flevoland have even lower numbers, with 171 and 133 accidents, suggesting a lower rate of traffic-related issues. Zeeland has the fewest reported accidents, with only 40, which could indicate it is the safest among the listed provinces in terms of traffic incidents or it has lower traffic density.

3.2 Analysis for Subquestion 1: Comparison of Traffic Accidents in Rural and Urban Area

3.2.1 Clustering Analysis

Clustering analysis is performed to classify the cities / municipality into two groups, urban and rural area. We use two variables as the clustering factors, they are population density and road length, because urban area is usually identified with higher population density and better infrastructure development (represented by the road length variable) compared to rural area. This analysis is needed because higher density area with better infrastructure will have more traffic movements, and eventually resulted in higher number of accidents.

In [13]:

```python
# Rename several columns for easier usability
df_accidents = df_accidents[['AP3_CODE', 'WGD_CODE_1', 'GME_NAAM', 'PVE_NAAM']]
df_accidents = df_accidents.rename(columns={'AP3_CODE': 'Severity', 'WGD_CODE_1': 'Weather_Type', 'GME_NAAM': 'Municipali

# Creating a new dataset that aggregating accidents by municipality
df_accident_agg = df_accidents.groupby(['Municipality']).size().reset_index(name='Accident_Count')

# Merge the DataFrames of accidents and clustering data using municipality name as reference key
merged_data = df_cluster_data.merge(df_accident_agg, left_on='Municipality_Name', right_on='Municipality', how='left')

# Drop the redundant 'Municipality' column
df_merged_data = merged_data.drop(columns='Municipality')

df_merged_data
```

Out[13]:

	Municipality_Name	Population	Area	Density	Road_Length	Accident_Count
0	Aa en Hunze	25579	276.66	93	639	21
1	Almere	32452	20.00	1615	157	63
2	Alblasserdam	20087	8.87	2290	82	20
3	Albrandswaard	25934	21.17	1197	151	3
4	Alkmaar	110783	110.01	1004	594	28
...	...	...	...	...	...	...
229	Zoetermeer	125767	34.43	3653	406	36
230	Zoeterwoude	9302	21.16	440	63	8
231	Zuidplas	45794	57.76	790	316	59
232	Zwijndrecht	44789	20.01	2206	209	13
233	Zwolle	130668	110.07	1181	778	54

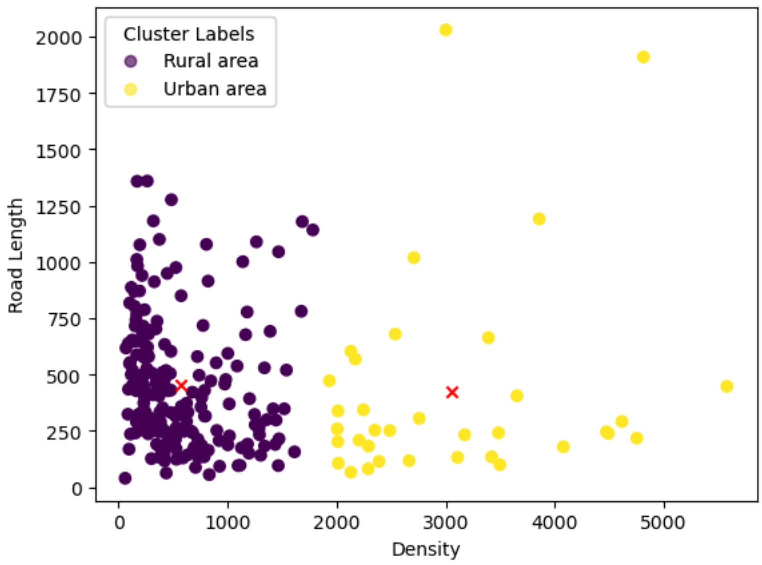
234 rows × 6 columns

The clustering process is conducted by plotting all cities in two axis chart, with Density as X-axis and Road Length as Y-axis. Two groups of city were formed, the purple ones with lower population density is named **Rural area** and the yellow ones with higher density is labeled as **Urban area**. Meanwhile, there is no remarkable difference in the number of road length between the two groups. Then, the cluster name is added to the existing dataframe.

In [14]:

```
k = 2  # The number of clusters
kmeans = KMeans(n_clusters=k)

# Select numeric columns for clustering
numeric_data = df_merged_data[['Density', 'Road_Length']].values
kmeans.fit(numeric_data)
labels = kmeans.labels_  # This assigns each data point to a cluster
centers = kmeans.cluster_centers_  # These are the cluster centroids

# Map cluster labels to desired names
label_names = {0: 'Rural area', 1: 'Urban area'}
label_names_list = [label_names[label] for label in labels]
cluster_names = [label_names[label] for label in labels]

# Plotting
scatter = plt.scatter(numeric_data[:, 0], numeric_data[:, 1], c=labels, cmap='viridis', label=label_names_list)
plt.scatter(centers[:, 0], centers[:, 1], c='red', marker='x', label='Cluster Centers')

# Add labels to the clusters in the legend
handles, labels = scatter.legend_elements(prop="colors", alpha=0.6)
legend1 = plt.legend(handles, [label_names[0], label_names[1]], title='Cluster Labels')
plt.gca().add_artist(legend1)  # Add the legend to the existing plot

plt.xlabel('Density')
plt.ylabel('Road Length')
plt.show()

# Add the 'Cluster_Name' column to the DataFrame
df_merged_data['Cluster_Name'] = cluster_names
df_merged_data
```

```
C:\Users\LENOVO YOGA\anaconda3\Lib\site-packages\sklearn\cluster\_kmeans.py:1412: FutureWarning:

The default value of `n_init` will change from 10 to 'auto' in 1.4. Set the value of `n_init` explicitly to suppress th
e warning

C:\Users\LENOVO YOGA\anaconda3\Lib\site-packages\sklearn\cluster\_kmeans.py:1436: UserWarning:

KMeans is known to have a memory leak on Windows with MKL, when there are less chunks than available threads. You can a
void it by setting the environment variable OMP_NUM_THREADS=1.
```



Out[14]:

	Municipality_Name	Population	Area	Density	Road_Length	Accident_Count	Cluster_Name
0	Aa en Hunze	25579	276.66	93	639	21	Rural area
1	Almere	32452	20.00	1615	157	63	Rural area
2	Alblasserdam	20087	8.87	2290	82	20	Urban area
3	Albrandswaard	25934	21.17	1197	151	3	Rural area
4	Alkmaar	110783	110.01	1004	594	28	Rural area
...	...	...	...	...	...	...	...
229	Zoetermeer	125767	34.43	3653	406	36	Urban area
230	Zoeterwoude	9302	21.16	440	63	8	Rural area
231	Zuidplas	45794	57.76	790	316	59	Rural area
232	Zwijndrecht	44789	20.01	2206	209	13	Urban area
233	Zwolle	130668	110.07	1181	778	54	Rural area

234 rows × 7 columns

3.2.2 T-test analysis

Rural area consists of 199 out of 234 cities in the data, while the rest is classified as urban area. The descriptive statistics data shows that urban area has higher average number of accidents compared to the rural area. To test whether this difference is statistically significant or not, we will perform a T-test analysis. T-test method is commonly used to check the significance of difference between the average of two populations. In this case, the two populations are urban and rural area.

The T-test results show that the higher number of accidents owned by urban area is statistically significant in comparison to rural area. Hence, in order to answer the research question, the identification of weather's impact to the number of accidents have to be performed separately for each city group.

In [15]:

```
# Give the name for the table
print('\033[1mDescriptive Statistics Data for each City Group created\033[0m')

# Descriptive Data: ACCIDENT COUNT
accident_descriptive = df_merged_data.groupby('Cluster_Name')['Accident_Count'].describe()
accident_descriptive = accident_descriptive.rename(columns={'count': 'Count', 'mean': 'Mean', 'std': 'Std', 'min': 'Min',

# Descriptive Data: POPULATION DENSITY
density_descriptive = df_merged_data.groupby('Cluster_Name')['Density'].describe()
density_descriptive = density_descriptive.rename(columns={'count': 'Count', 'mean': 'Mean', 'std': 'Std', 'min': 'Min', '

# Descriptive Data: ROAD LENGTH
roadlength_descriptive = df_merged_data.groupby('Cluster_Name')['Road_Length'].describe()
roadlength_descriptive = roadlength_descriptive.rename(columns={'count': 'Count', 'mean': 'Mean', 'std': 'Std', 'min': 'M

# Concatenate the DataFrames
combined_descriptive = pd.concat([accident_descriptive, density_descriptive, roadlength_descriptive], keys=['ACCIDENT COU

# Format 'Mean' and 'Std' columns to display one digit after the decimal point
combined_descriptive['Mean'] = combined_descriptive['Mean'].round(1)
combined_descriptive['Std'] = combined_descriptive['Std'].round(1)

# Display the combined DataFrame
combined_descriptive
```

Descriptive Statistics Data for each City Group created

Out[15]:

	Cluster_Name	Count	Mean	Std	Min	25%	50% (Med)	75%	Max
ACCIDENT COUNT	**Rural area**	199.0	25.3	28.1	1.0	9.0	18.0	32.0	246.0
	Urban area	35.0	62.3	111.7	1.0	13.5	31.0	55.5	543.0
POPULATION DENSITY	**Rural area**	199.0	575.4	417.3	63.0	244.0	432.0	790.5	1783.0
	Urban area	35.0	3049.3	1000.6	1934.0	2226.0	2708.0	3574.5	5576.0
ROAD LENGTH	**Rural area**	199.0	451.2	283.8	40.0	245.0	374.0	589.0	1359.0
	Urban area	35.0	424.3	461.4	67.0	181.5	252.0	460.5	2030.0

In [16]:
```
from scipy import stats

# Print hypothesis to test and confidence level used
print('\033[1mHYPOTHESIS\033[0m')
print('HO: Average road accident in Urban area = Average road accident in Rural area')
print('H1: Average road accident in Urban area ≠ Average road accident in Rural area')
print('\n')

print('\033[1mCONFIDENCE LEVEL\033[0m')
print('Alpha = 5%')
print('\n')

# Creating two population of data: Urban and Rural area
urban_data = merged_data[df_merged_data['Cluster_Name'] == 'Urban area']
rural_data = merged_data[df_merged_data['Cluster_Name'] == 'Rural area']

# Extract the 'Accident Count' data for each group
urban_accident_count = urban_data['Accident_Count']
rural_accident_count = rural_data['Accident_Count']

# Calculate average and standard deviation for each group
urban_avg = urban_accident_count.mean()
rural_avg = rural_accident_count.mean()

# Perform an independent two-sample t-test
t_stat, p_value = stats.ttest_ind(urban_accident_count, rural_accident_count)

# Print results
print('\033[1mT-TEST RESULTS\033[0m')
print(f"T-statistic: {t_stat:.2f}")
print(f"P-value: {p_value:.5f}")
print('\n')

# Determine whether the difference is statistically significant (using confidence level = 0.05)
print('\033[1mCONCLUSION\033[0m')
if p_value < 0.05:
    print("P_value < alpha, then H0 is rejected.")
else:
    print("P_value > alpha, then H0 is accepted.")

if p_value < 0.05:
    print("This hypothesis: 'Average road accident in Urban area ≠ Average road accident in Rural area' is accepted.")
else:
    print("This hypothesis: 'Average road accident in Urban area = Average road accident in Rural area' is accepted.")

if urban_avg > rural_avg:
    print("Then, it's concluded that \033[1mUrban area has statistically higher average of road accident than Rural area.
else:
    print("Then, it's concluded that \033[1mRural area has statistically higher average of road accident than Urban area.
```

```
HYPOTHESIS
HO: Average road accident in Urban area = Average road accident in Rural area
H1: Average road accident in Urban area ≠ Average road accident in Rural area


CONFIDENCE LEVEL
Alpha = 5%


T-TEST RESULTS
T-statistic: 4.04
P-value: 0.00007


CONCLUSION
P_value < alpha, then H0 is rejected.
This hypothesis: 'Average road accident in Urban area ≠ Average road accident in Rural area' is accepted.
Then, it's concluded that Urban area has statistically higher average of road accident than Rural area.
```

3.3 Analysis for Subquestion 2: Influence of Weather Type to the Amount of Accidents

The impact of weather type to the amount of accidents is identified by comparing the number of accidents for each weather type. If one or more weather type have different number of accidents (either lower or higher) compared to other weather type, then it's statistically safe to say that the weather type does have impact to the accidents.

The analysis is performed by using ANOVA method. This statistical test is commonly used to identify is there any significant difference between the average of more than two populations. And in this case, we have five populations that represent all types of weather listed in the data (Dry, Rain, Snow, Wind, Fog and Unknown). The ANOVA test is done twice, for urban and rural area, because they have significantly different average number of accidents (based on the result of T-test analysis).

For the analysis, we need a new dataset that contains municipality, weather type, accident count and cluster name. So, we have to create an aggregated accident dataset per municipality per weather type, and then merge it with the area clustering dataset (output of clustering analysis).

The ANOVA test will compare the average of **accident percentage** between each weather type instead of the average of **absolute accident number**. Hence, we need to form an additional column named *Accident_Percentage* for the analysis.

In [17]:

```
# Creating new dataset from df_accidents which aggregating tne number of accident by weather_type
df_accident_weather_agg = df_accidents.groupby(['Municipality','Weather_Type']).size().reset_index(name='Accident_Count')
df_accident_weather_agg = df_accident_weather_agg.sort_values(by=['Municipality','Weather_Type'])

# Get the filtered cluster name data per municipality
df_clustered_area = df_merged_data[['Municipality_Name','Cluster_Name']]

# Merge the two DataFrames on the 'Municipality' and 'Municipality_Name' columns
merged_data_2 = df_accident_weather_agg.merge(df_clustered_area, left_on='Municipality', right_on='Municipality_Name', ho

# Drop the redundant 'Municipality_Name' column
df_cluster_weather_data = merged_data_2.drop(columns='Municipality_Name')
df_cluster_weather_data = df_cluster_weather_data.sort_values(by=['Municipality', 'Weather_Type'])

df_cluster_weather_cleaned = df_cluster_weather_data.dropna()

# Create new column for accident_percentage
total_accident_counts = df_cluster_weather_cleaned.groupby('Municipality')['Accident_Count'].transform('sum')

# Calculate the accident percentage and add it to the dataframe
df_cluster_weather_cleaned['Accident_Percentage'] = (df_cluster_weather_cleaned['Accident_Count'] / total_accident_counts
df_cluster_weather_cleaned
```

```
C:\Users\LENOVO YOGA\AppData\Local\Temp\ipykernel_4256\2197853070.py:21: SettingWithCopyWarning:


A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a
-view-versus-a-copy (https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus-a-co
py)
```

Out[17]:

	Municipality	Weather_Type	Accident_Count	Cluster_Name	Accident_Percentage
6	Aa en Hunze	D	18	Rural area	85.714286
7	Aa en Hunze	R	3	Rural area	14.285714
8	Alblasserdam	D	20	Urban area	100.000000
9	Albrandswaard	D	2	Rural area	66.666667
10	Albrandswaard	R	1	Rural area	33.333333
...	...	...	...	...	...
576	Zuidplas	M	1	Rural area	1.694915
577	Zuidplas	R	4	Rural area	6.779661
578	Zwijndrecht	D	13	Urban area	100.000000
579	Zwolle	D	46	Rural area	85.185185
580	Zwolle	R	8	Rural area	14.814815

525 rows × 5 columns

The ANOVA results show that there are significant difference of accident percentage between weather type groups, both in urban area as well as rural area. Dry weather has highest accident percentage, followed by Fog, Rain, Wind and Snow in Rural area. Meanwhile, in Urban area, Dry weather also has the highest accident percentage, but then followed by Rain, Snow, Wind and Fog in the last.

In [18]:
```
# Print hypothesis to test and confidence level used
print('\033[1mHYPOTHESIS\033[0m')
print('HO: There is no difference of the average of accident percentage among weather type.')
print('H1: There is significant difference of the average of accident percentage among weather type.')
print('\n')

print('\033[1mCONFIDENCE LEVEL\033[0m')
print('Alpha = 5%')
print('\n')

# Define the dictionary to map old values to new values
weather_name = {'D': 'Dry', 'R': 'Rain', 'M': 'Fog', 'S': 'Snow', 'H': 'Wind', 'O': 'Unknown'}

# Apply the mapping to the 'Weather_Type' column
df_cluster_weather_cleaned['Weather_Type'] = df_cluster_weather_cleaned['Weather_Type'].replace(weather_name)

# Create subsets of the data for each cluster
cluster_names = df_cluster_weather_cleaned['Cluster_Name'].unique()

print('\033[1mANOVA TEST RESULTS AND CONCLUSION\033[0m')

for cluster_name in cluster_names:
    subset = df_cluster_weather_cleaned[df_cluster_weather_cleaned['Cluster_Name'] == cluster_name]

   # Perform one-way ANOVA for each cluster
    unique_weather_types = sorted(subset['Weather_Type'].unique())  # Sort weather types alphabetically
    weather_groups = [subset[subset['Weather_Type'] == weather]['Accident_Percentage'] for weather in subset['Weather_Typ

    # Perform the ANOVA test
    f_statistic, p_value = f_oneway(*weather_groups)

    # Calculate and display the average for each weather type
    averages = [f'{group.mean():.2f}' for group in weather_groups]

    # Determine whether the difference is statistically significant (using confidence level = 0.05)
    print(f"\033[1mCluster Name: {cluster_name.upper()}\033[0m")
    print("Average number of accident percentage per weather type:")

    sorted_weather_averages = sorted(zip(unique_weather_types, averages), key=lambda x: x[0])
    for weather_type, avg in sorted_weather_averages:
        print(f"    {weather_type} = {avg}")

    print(f"P-value: {p_value:.5f}")
    # print t-value as well

    print(f"\033[1mConclusion:\033[0m")
    if p_value < 0.05:
        print("P_value < alpha, then H0 is rejected.")
    else:
        print("P_value > alpha, then H0 is accepted.")

    if p_value < 0.05:
        print(f"Then, it's concluded that there is \033[1msignificant difference of the average of accident percentage am
    else:
        print(f"Then, it's concluded that there is \033[1mno significant difference of the average of accident percentage
    print()
```

```
HYPOTHESIS
HO: There is no difference of the average of accident percentage among weather type.
H1: There is significant difference of the average of accident percentage among weather type.


CONFIDENCE LEVEL
Alpha = 5%


ANOVA TEST RESULTS AND CONCLUSION
Cluster Name: RURAL AREA
Average number of accident percentage per weather type:
   Dry = 84.91
   Fog = 13.75
   Rain = 6.54
   Snow = 3.18
   Wind = 5.78
P-value: 0.00000
Conclusion:
P_value < alpha, then H0 is rejected.
Then, it's concluded that there is significant difference of the average of accident percentage among weather type.

Cluster Name: URBAN AREA
Average number of accident percentage per weather type:
   Dry = 89.49
   Fog = 0.75
   Rain = 11.98
   Snow = 2.69
   Wind = 1.30
P-value: 0.00000
Conclusion:
P_value < alpha, then H0 is rejected.
Then, it's concluded that there is significant difference of the average of accident percentage among weather type.


C:\Users\LENOVO YOGA\AppData\Local\Temp\ipykernel_4256\2599872427.py:15: SettingWithCopyWarning:


A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a
-view-versus-a-copy (https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus-a-co
py)
```

3.4 Analysis for Subquestion 3: Influence of Weather Type to the Severity of Accidents

We will use chi-square test to examine the impact weather to accident severity. This method is chosen because it allows us to identify the correlation between two categorical groups of data. In this case, both weather type and accident severity data are categorical.

The results show that there is no significant association / correlation between weather type and accident severity. It means the number of accidents is equally spread across all severity level regardless the weather type.

In [19]:

```python
# Creating new dataset that aggregating accidents by Weather_Type and Severity
df_weather_severity_agg = df_accidents.groupby(['Weather_Type','Severity']).size().reset_index(name='Accident_Count')
df_weather_severity_agg = df_weather_severity_agg.sort_values(by=['Weather_Type','Severity'])

# Create a dictionary for abbreviation contained in the data
weather_name = {'D': 'Dry', 'R': 'Rain', 'M': 'Fog', 'S': 'Snow', 'H': 'Wind', 'O': 'Unknown'}
severity = {'DOD': 'Deadly', 'LET': 'Injury', 'UMS': 'Material damage'}

# Apply the mapping to the 'Weather_Type' column
df_weather_severity_agg['Weather_Type'] = df_weather_severity_agg['Weather_Type'].replace(weather_name)
df_weather_severity_agg['Severity'] = df_weather_severity_agg['Severity'].replace(severity)

# Use pivot to create the matrix with 'Weather_Type' as rows and 'Severity' as columns
matrix = df_weather_severity_agg.pivot(index='Weather_Type', columns='Severity', values='Accident_Count').fillna(0)

matrix
```

Out[19]:

Severity	Deadly	Injury	Material damage
Weather_Type			
Dry	44.0	870.0	5771.0
Fog	0.0	3.0	35.0
Rain	0.0	85.0	766.0
Snow	0.0	11.0	100.0
Wind	0.0	1.0	18.0

In [20]:

```
# Print hypothesis to test and confidence level used
print('\033[1mHYPOTHESIS\033[0m')
print('HO: Accident severity and Weather type have no association.')
print('H1: Accident severity and Weather type have significant association.')
print('\n')

print('\033[1mCONFIDENCE LEVEL\033[0m')
print('Alpha = 5%')
print('\n')

# Creating new dataset that aggregating accidents by Weather_Type and Severity
df_weather_severity_agg = df_accidents.groupby(['Weather_Type','Severity']).size().reset_index(name='Accident_Count')
df_weather_severity_agg = df_weather_severity_agg.sort_values(by=['Weather_Type','Severity'])

# Create a dictionary for abbreviation contained in the data
weather_name = {'D': 'Dry', 'R': 'Rain', 'M': 'Fog', 'S': 'Snow', 'H': 'Wind', 'O': 'Unknown'}
severity = {'DOD': 'Deadly', 'LET': 'Injury', 'UMS': 'Material damage'}

# Apply the mapping to the 'Weather_Type' column
df_weather_severity_agg['Weather_Type'] = df_weather_severity_agg['Weather_Type'].replace(weather_name)
df_weather_severity_agg['Severity'] = df_weather_severity_agg['Severity'].replace(severity)

# Create a contingency table for 'Weather_Type' and 'Severity'
contingency_table = pd.crosstab(df_weather_severity_agg['Weather_Type'], df_weather_severity_agg['Severity'])

# Perform the chi-square test of independence
chi2, p_value, _, _ = chi2_contingency(contingency_table)

# Determine whether the difference is statistically significant (using confidence level = 0.05)
print('\033[1mCHI-SQUARE TEST RESULTS\033[0m')
print(f"Chi-square statistic: {chi2:.2f}")
print(f"P-value: {p_value:.4f}")
print('\n')

print('\033[1mCONCLUSION\033[0m')
if p_value < 0.05:
    print("P_value < alpha, then H0 is rejected.")
else:
    print("P_value > alpha, then H0 is accepted.")

if p_value < 0.05:
    print("Then, it's concluded that there is \033[1msignificant association between Weather Type and Accident Severity.\
else:
    print("Then, it's concluded that there is \033[1mno significant association between Weather Type and Accident Severit
```

```
HYPOTHESIS
HO: Accident severity and Weather type have no association.
H1: Accident severity and Weather type have significant association.


CONFIDENCE LEVEL
Alpha = 5%


CHI-SQUARE TEST RESULTS
Chi-square statistic: 2.93
P-value: 0.9385


CONCLUSION
P_value > alpha, then H0 is accepted.
Then, it's concluded that there is no significant association between Weather Type and Accident Severity.
```

5. Conclusion

The subquestions have all been answered through different analyses. First, a T-test was performed to provide an answer for subquestion 1. From this, it was concluded that on average more accidents happen in rural areas compared to urban areas. After this, a One-way ANOVA test was conducted to provide an answer for subquestion 2. The conclusion from this test was that there is a significant difference between different weather types influencing the amount of accidents. Finally, subquestion 3 was answered by performing a Chi-Square Analysis. The result from this analysis is that there is no significant association between the weather type and the accident severity. By answering all subquestions, **we can conclude that weather does have impact on the amount of traffic accidents, but not on the severity in both type of areas (urban and rural) in Netherlands during the period of 2021-2022.**

6. Contribution Statement

Alex van Wijngaarden:

- Writing narrative for introduction part
- Writing narrative for conclusion part

Eka Devi Wulandari:

- Data searching and processing for dataset 2 (density and road length data)

- Performing Clustering analysis, T-test, ANOVA and Chi-square test
- Writing narrative for the statistical analysis part

Nadhira Zahrani Widiafina:

- Municipality longtitude ana latitude data
- Municipality Heatmap Visualization
- Province Heatmap Visualization
- Writing narrative for heatmap visualization (municipality and province)

Simon, van der Horst:

- Data searching and processing for dataset 1 (traffic accident data)
- Compiling all reports into 1 file

Wiet Kalf:

- Province and municipality's accident heatmap
- Report finalization

Everyone:

- Background research
- Research conceptualization

7. Data Source

Dataset 1: Verkeersongevallen - Bestand geRegistreerde Ongevallen Nederland https://data.overheid.nl/dataset/9841-verkeersongevallen---bestand-geregistreerde-ongevallen-nederland (https://data.overheid.nl/dataset/9841-verkeersongevallen---bestand-geregistreerde-ongevallen-nederland)

Dataset 2: Additional data (population, area, density and road length) needed for the clustering analysis from CBS and wikipedia. Here are the links:

- density and area data: https://en.wikipedia.org/wiki/Municipalities_of_the_Netherlands (https://en.wikipedia.org/wiki/Municipalities_of_the_Netherlands)
- length of road data: https://opendata.cbs.nl/statline/#/CBS/nl/dataset/70806ned/table?ts=1699173969758 (https://opendata.cbs.nl/statline/#/CBS/nl/dataset/70806ned/table?ts=1699173969758)