MUSA 6950

Final Project

Asian Elephants Migration Corridor Planner

Yuanhao Zhai

Background & Context

Abnormal Migration Activity

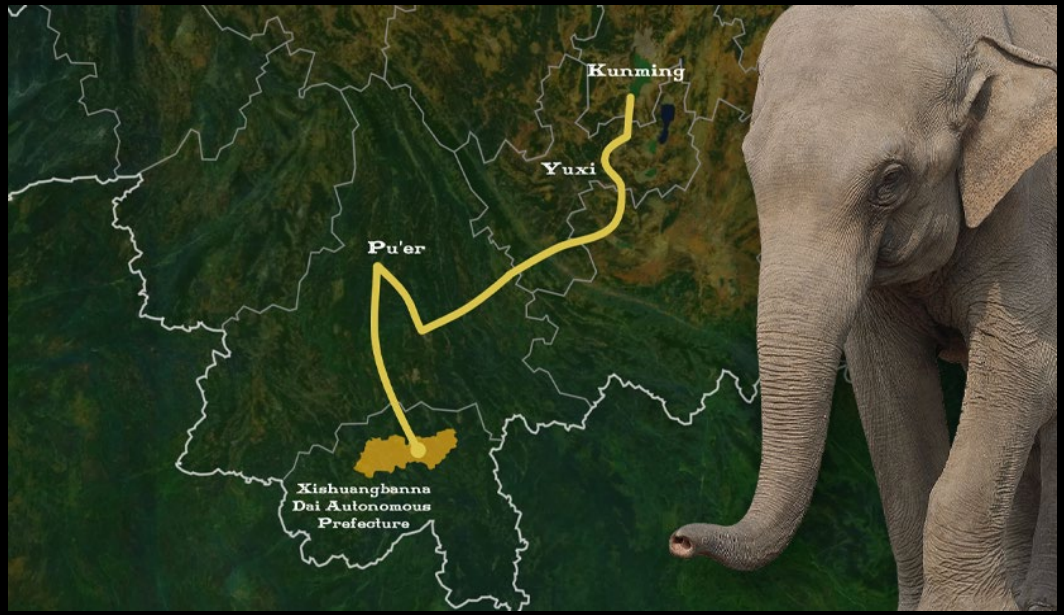
BBC

Home News Sport Business Innovation Culture Travel Earth Video Live

China elephants: 150,000 evacuated from path of trekking herd

One of China's wandering elephants has finally made it home. But problems exposed by the herd's journey aren't going away

Background & Context



Since leaving a nature reserve last year, the herd has trekked more than **500 kilometers (310 miles)** across the Yunnan province, roaming free through fields, villages, and large towns.

The herd traveling from a nature reserve in Xishuangbanna to Yuxi, a city of 2.6 million people.

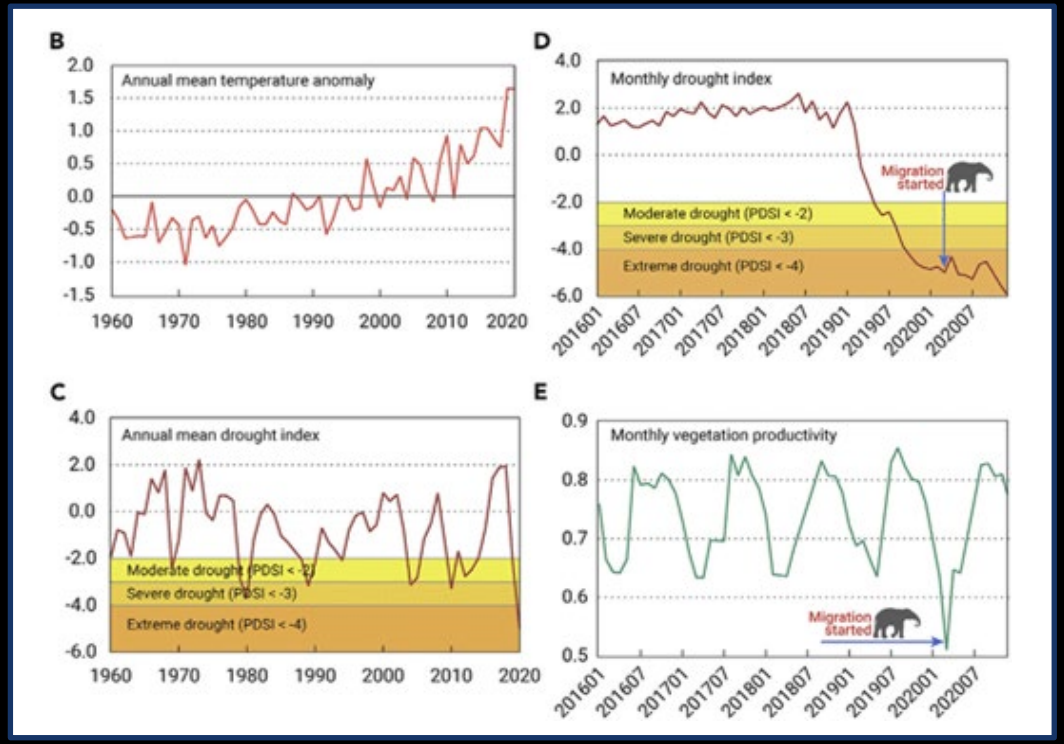
A government official shows the migration route of the elephants in Eshan County on May 28.

Background & Context

Significant Disruption:

- Residents were told to stay indoors while pedestrians and vehicles were evacuated.
- Between 2014 and 2020, the Yunnan government paid over **$26 million** in compensation for damage caused by elephants.
- From 2013 to 2019, **41 people** were trampled to death and **32 others** were injured by Asian elephants in Yunnan

Background & Context



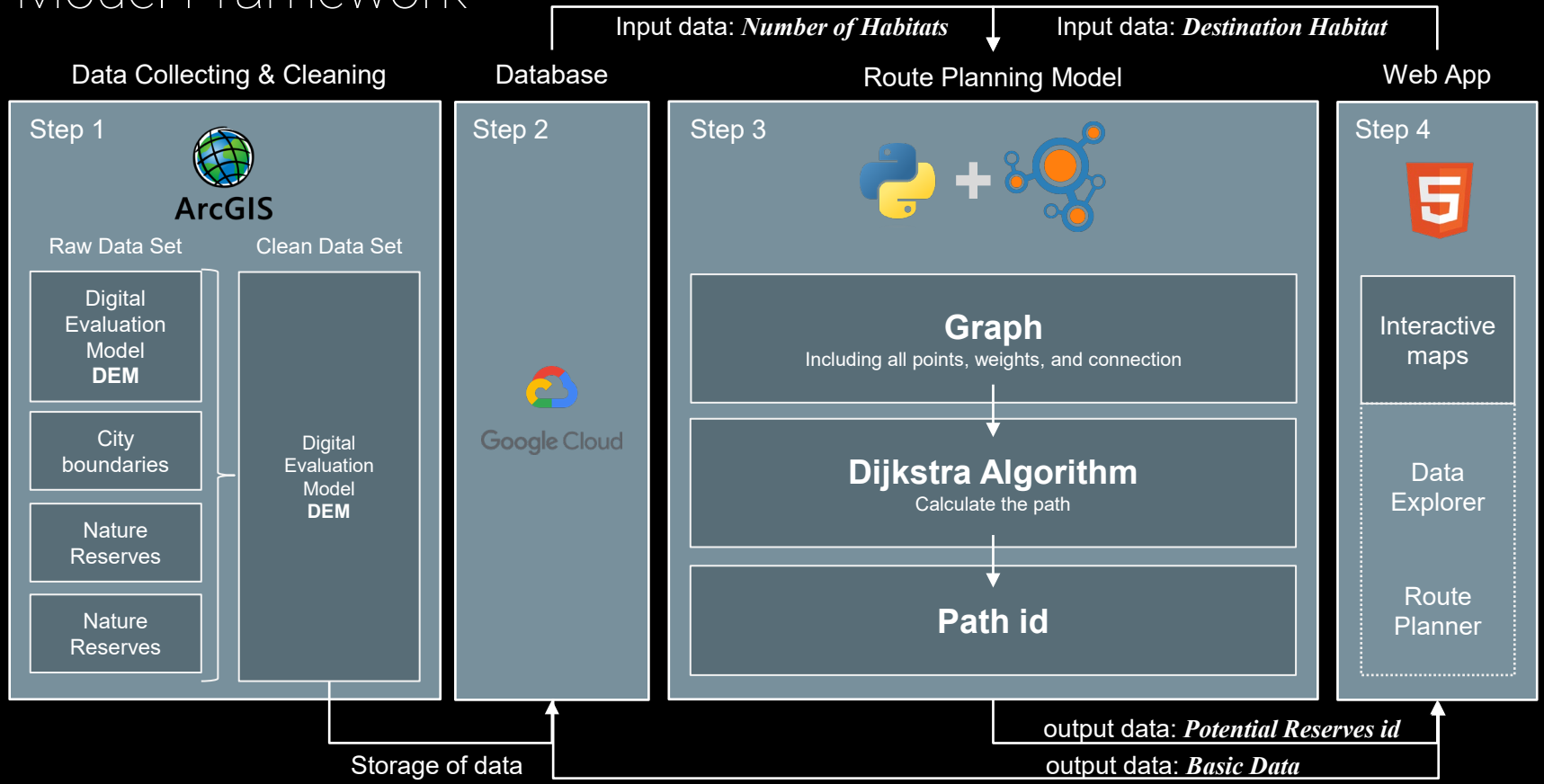
What is the **Reasons** behind it?

Population Growth?
Drought?
Temperature?
Food Resource?
……

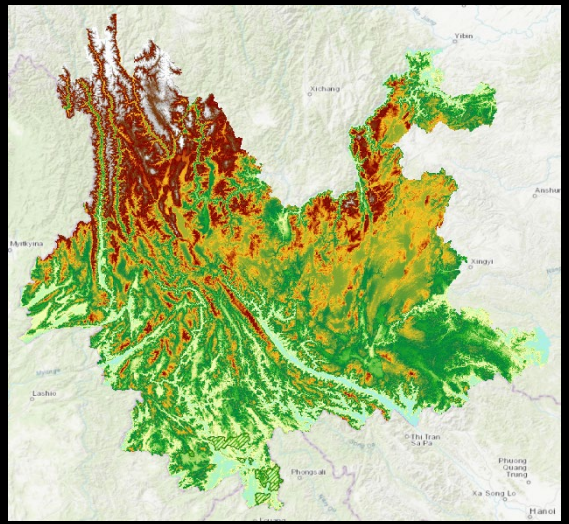
Background & Context

How should we choose the best **elephant migration routes** and set up **migration corridors** to protect both elephants and human property?

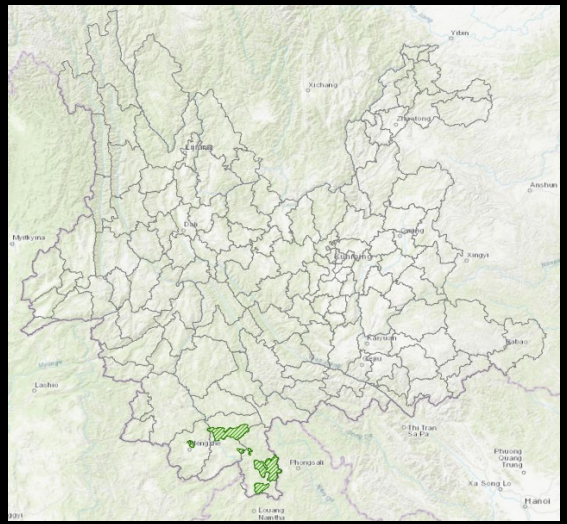
Model Framework



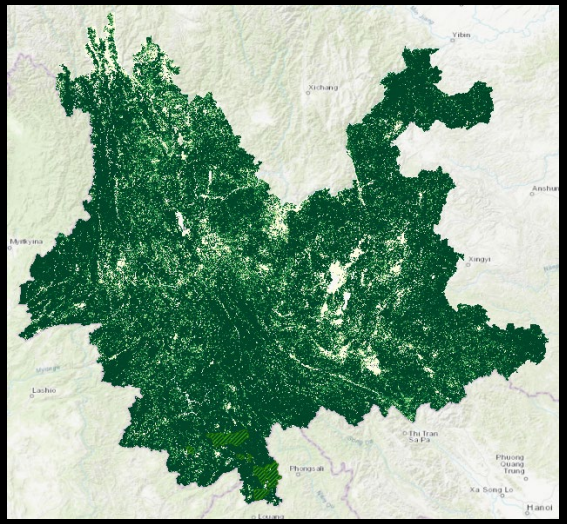
Data Collecting & Cleaning



Digital Elevation Model (DEM)

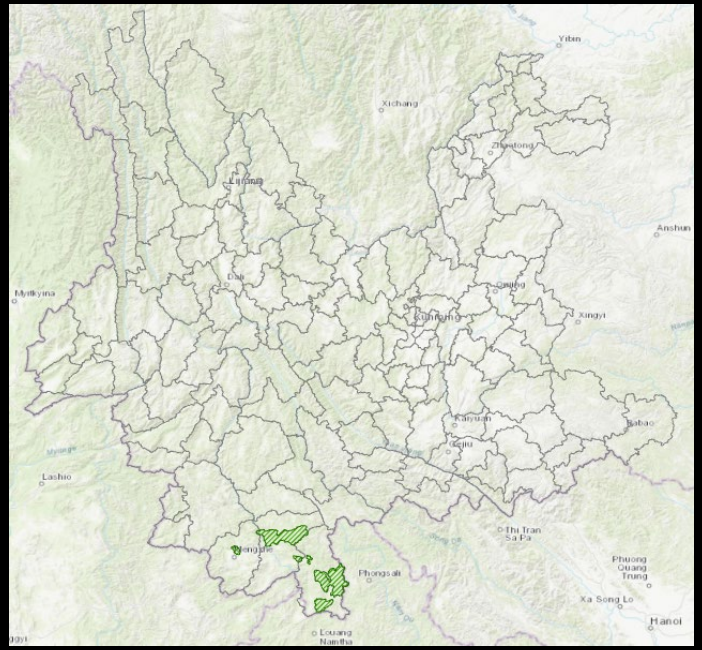


Digital Elevation Model (DEM)

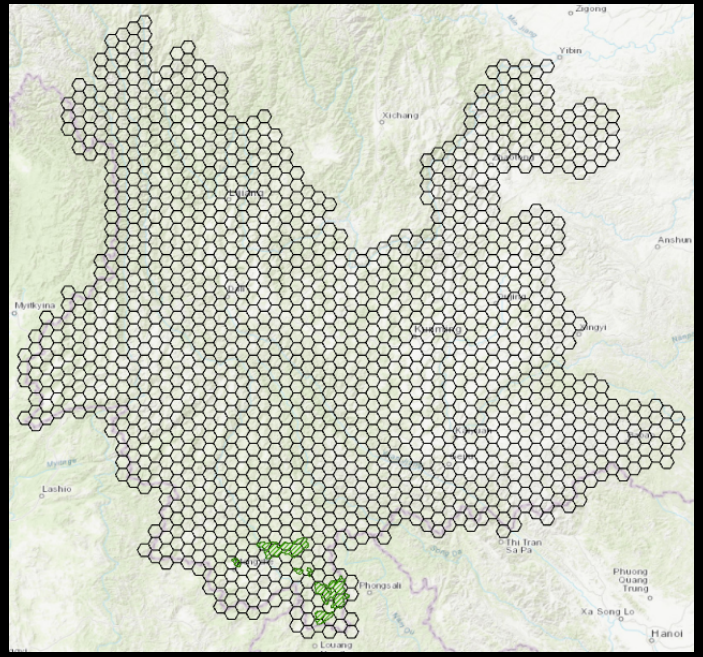


Forest Areas

Data Collecting & Cleaning

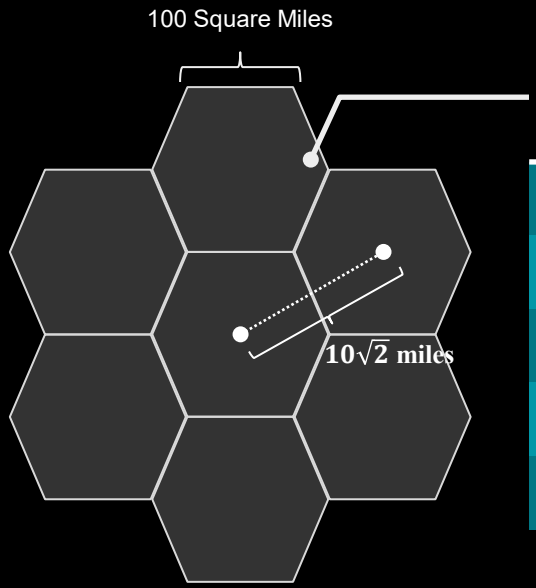


Digital Elevation Model (DEM)



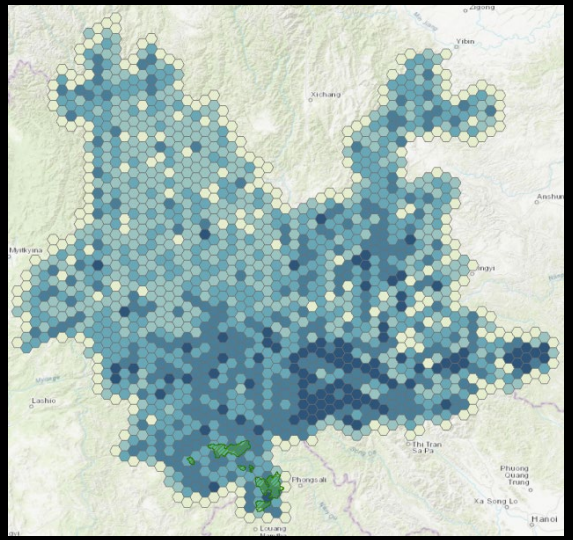
Digital Elevation Model (DEM)

Data Source

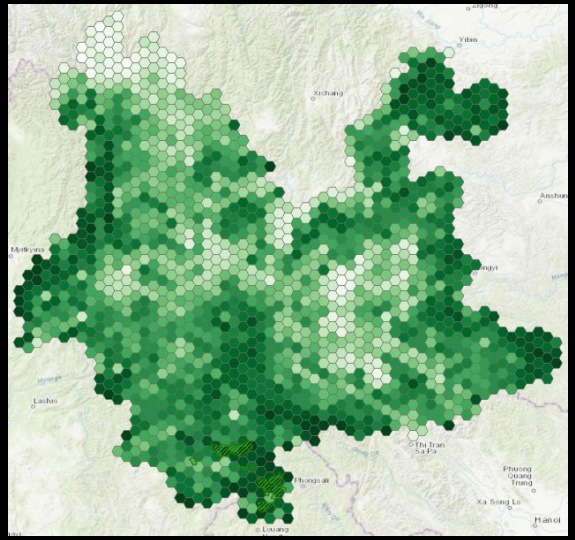


id	Forest_Area	Altitude	Water_Area	Population	Is_City	Is_Habitat
001	9000	2471	300	500	1	0
002	8000	2300	140	0	0	0
003	7560	2201	540	2000	1	0
004	6770	3210	270	2888	0	0
005	9290	2200	261	1000	0	1

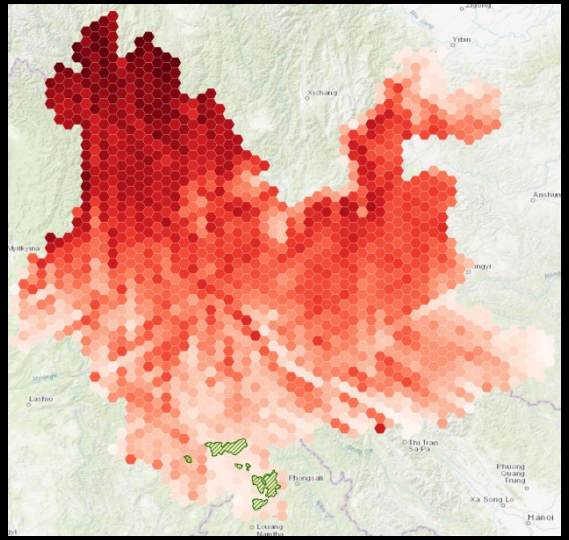
Data Collecting & Cleaning



Water Source

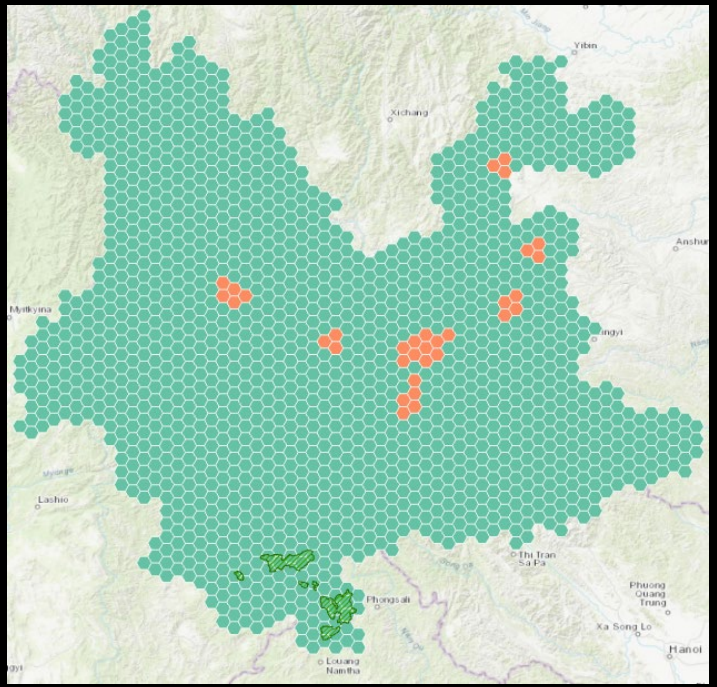


Forest & Food Source

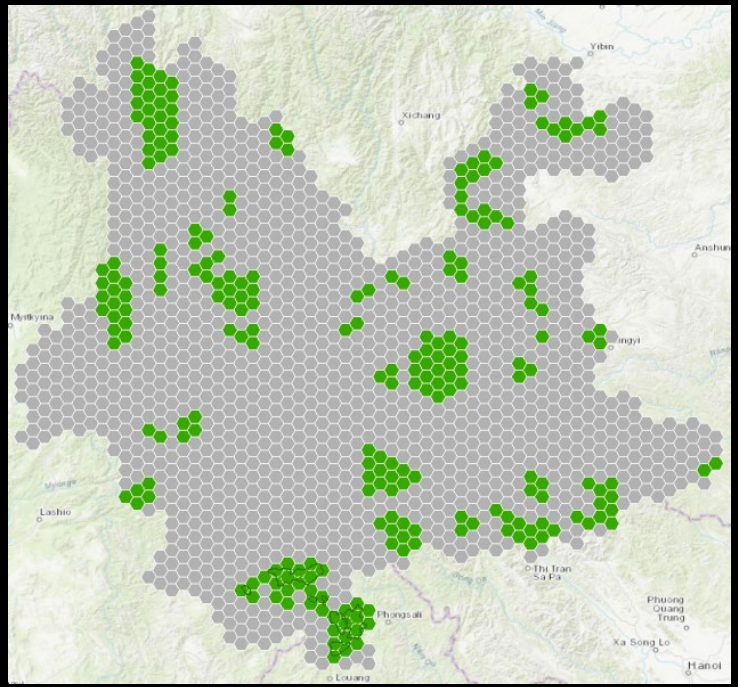


Altitude

Data Collecting & Cleaning



Is it a city?



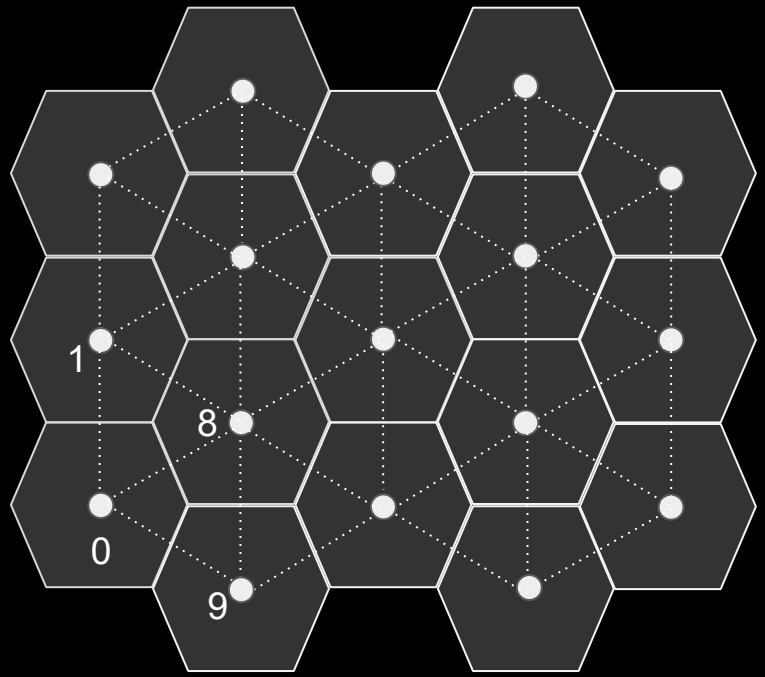
Is it a habitat?

Algorithm design

Graph build

```python
def dijkstra_shortest_path(gdf, start_id, end_id):
    # Build a graph from GeoDataFrame
    graph = {}
    for index, row in gdf.iterrows():
        graph[row['id']] = {}
        for neighbor_index, neighbor_row in gdf.iterrows():
            if index != neighbor_index:
                distance = row['geometry'].distance(neighbor_row['geometry'])
                if distance <= 2000:  # 只连接距离小于等于 2000 米的邻居点
                    graph[row['id']][neighbor_row['id']] = distance
```


{0: {1: 18907.67976640627, 8: 19924.581230591983, 9: 18910.64278611532},
 1: {0: 18907.67976640627, 2: 18907.67976641894, 9: 19913.299319651444},
 2: {1: 18907.67976641894, 3: 18907.67976641602, 9: 18910.642786131157, 10: 19924.581230591983, 11: 18910.642786129818},
 3: {2: 18907.67976641602, 4: 18907.679766407855, 11: 19913.299319652375},
 4: {3: 18907.679766407855, 5: 18907.679766413698, 11: 18910.64278611581, 12: 19924.58123059245, 13: 18910.642786125314},
 5: {4: 18907.679766413698, 13: 19913.299319651444},
 6: {14: 18916.615944290752, 15: 19947.310281448066, 16: 18916.61594429733},
 7: {16: 18916.615944297082, 17: 19947.310281447135, 18: 18916.61594428551},
 8: {0: 19924.581230591983, 9: 18913.621493892995, 20: 19947.3102814476, 21: 18916.615944288922},
 9: {0: 18910.64278611532, 1: 19913.299319651444, 2: 18910.642786131157, 8: 18913.621493892995, 10: 18913.621493902494, 21: 19935.91817050893},……

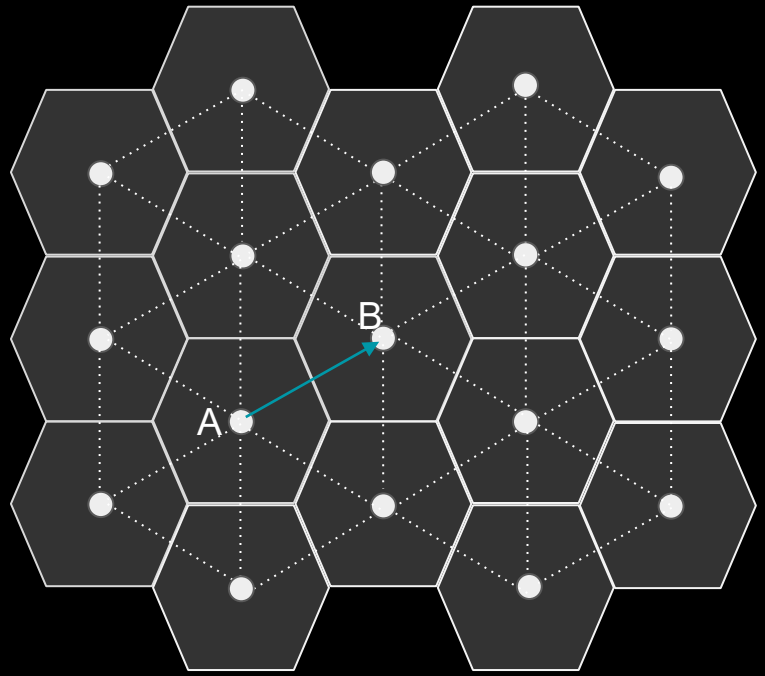


Algorithm design

So, when we do the simulation, how do we consider the **‘altitude’, ’river source’, and ‘forest source’?**
To move from Point A to Point B, the cost is:

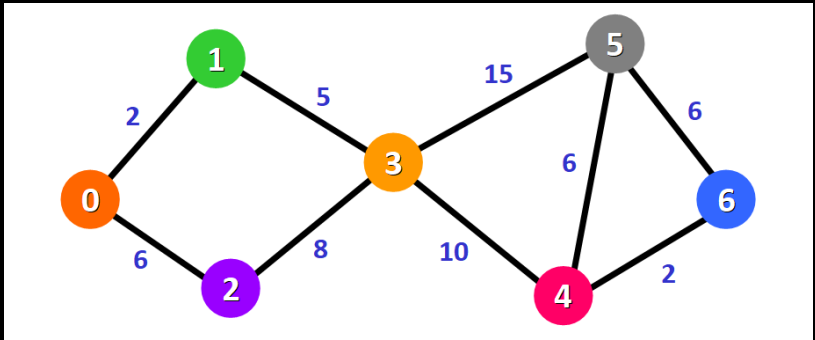
$$Cost = \alpha \cdot Distance - \beta \cdot Forest\ Source - \gamma \cdot River\ Length + \delta \cdot Average\ Altitude$$

$\alpha, \beta, \gamma, \delta$ are the weight we add to the attribute



Algorithm design

Dijkstra Algorithm

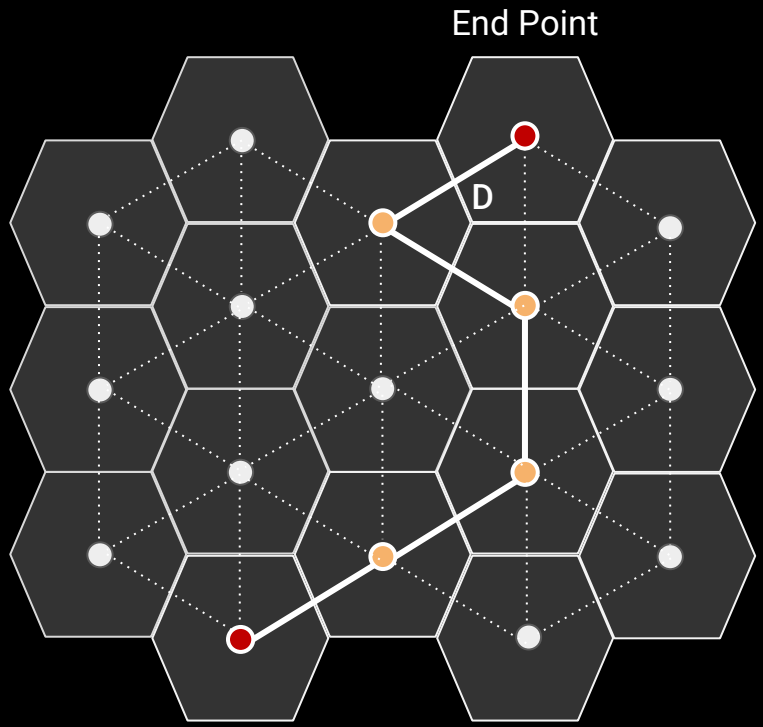


The algorithm will generate the shortest path from node 0 to all the other nodes in the graph.

Distance:

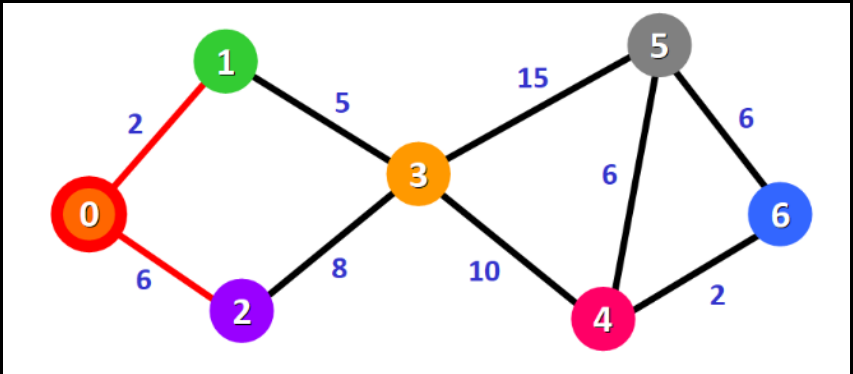
0: 0
1: ∞
2: ∞
3: ∞
4: ∞
5: ∞
6: ∞

Unvisited Nodes: {0, 1, 2, 3, 4, 5, 6}



Algorithm design

Dijkstra Algorithm

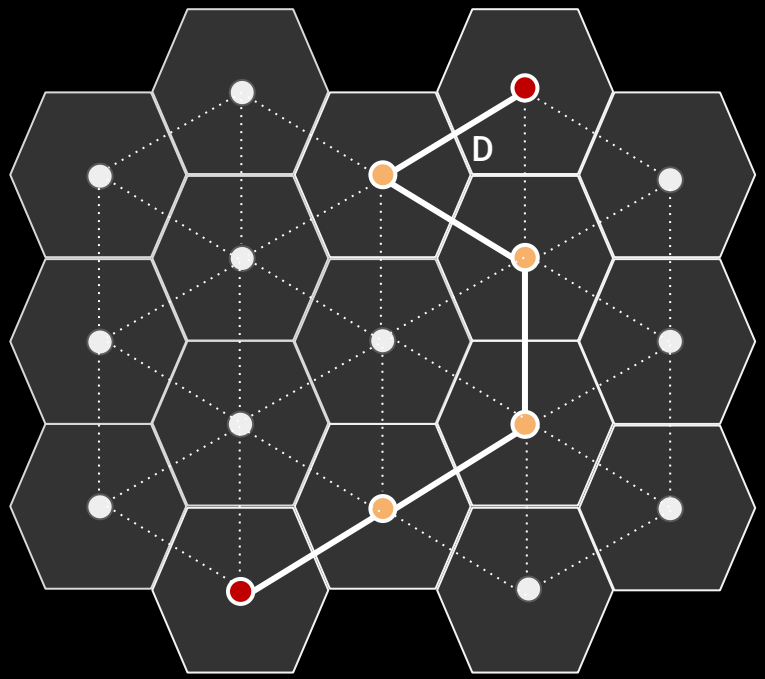


update the distances from node 0 to node 1 and node 2 with the weights of the edges that connect them to node 0 (the source node).

Distance:

0: 0
1: ~~∞~~ 2
2: ~~∞~~ 6
3: ∞
4: ∞
5: ∞
6: ∞

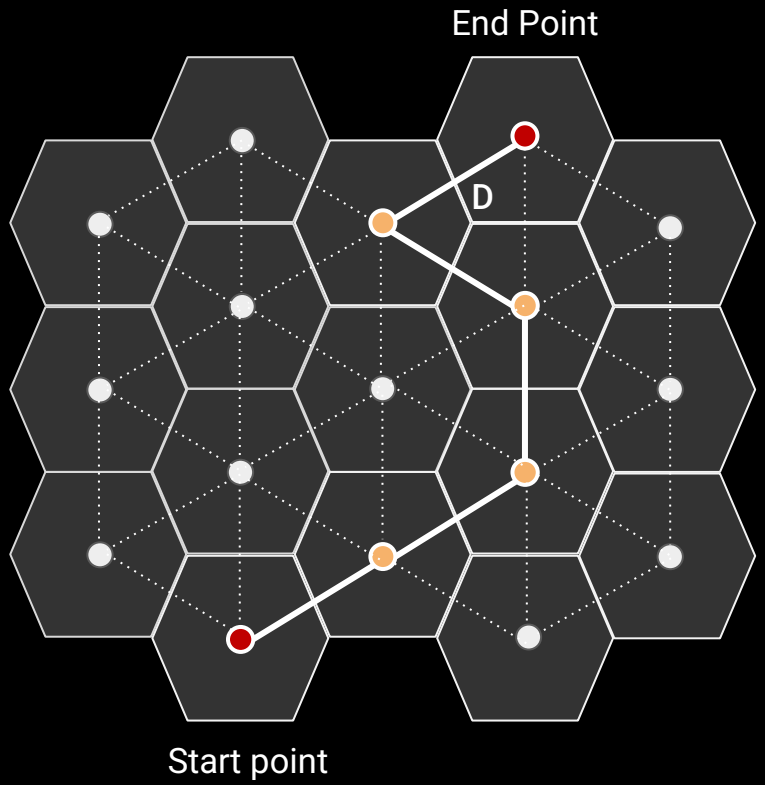
Unvisited Nodes: {~~0~~, ~~1~~, 2, 3, 4, 5, 6}



Algorithm design

As there are 1600 points in the geodata frame
Avg Calculation Time: **10min +**…

How to cut down the average calculation time?

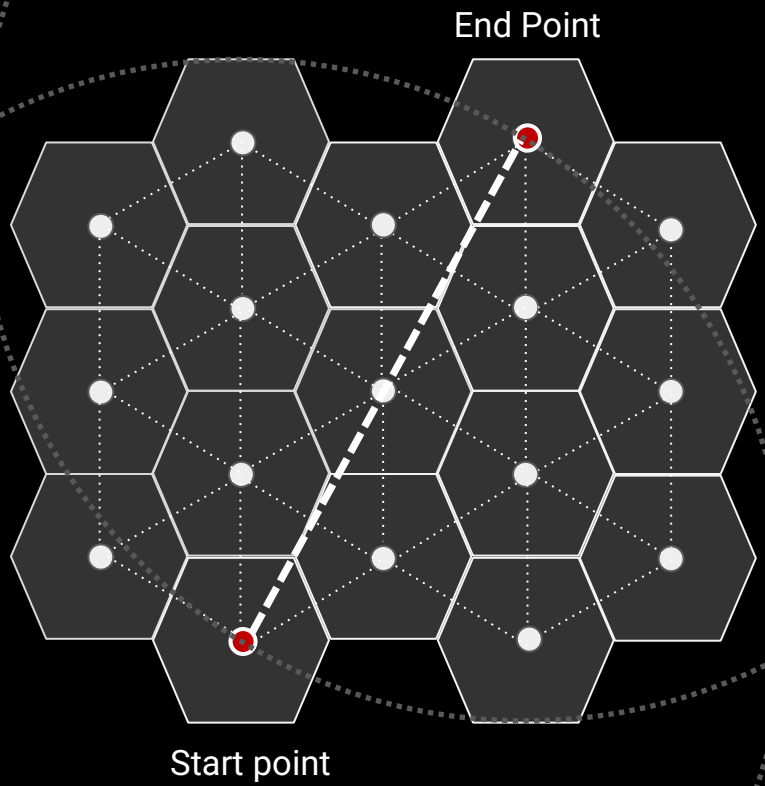


Algorithm design

Here, I will use pruning to enhance efficiency by eliminating unnecessary computations.

In this model, I will calculate the straight-line distance from the startpoint to the endpoint, and then consider only the points within this distance, slightly expanding the range (e.g., by an additional 10%) to ensure that potential optimal paths are not overlooked.

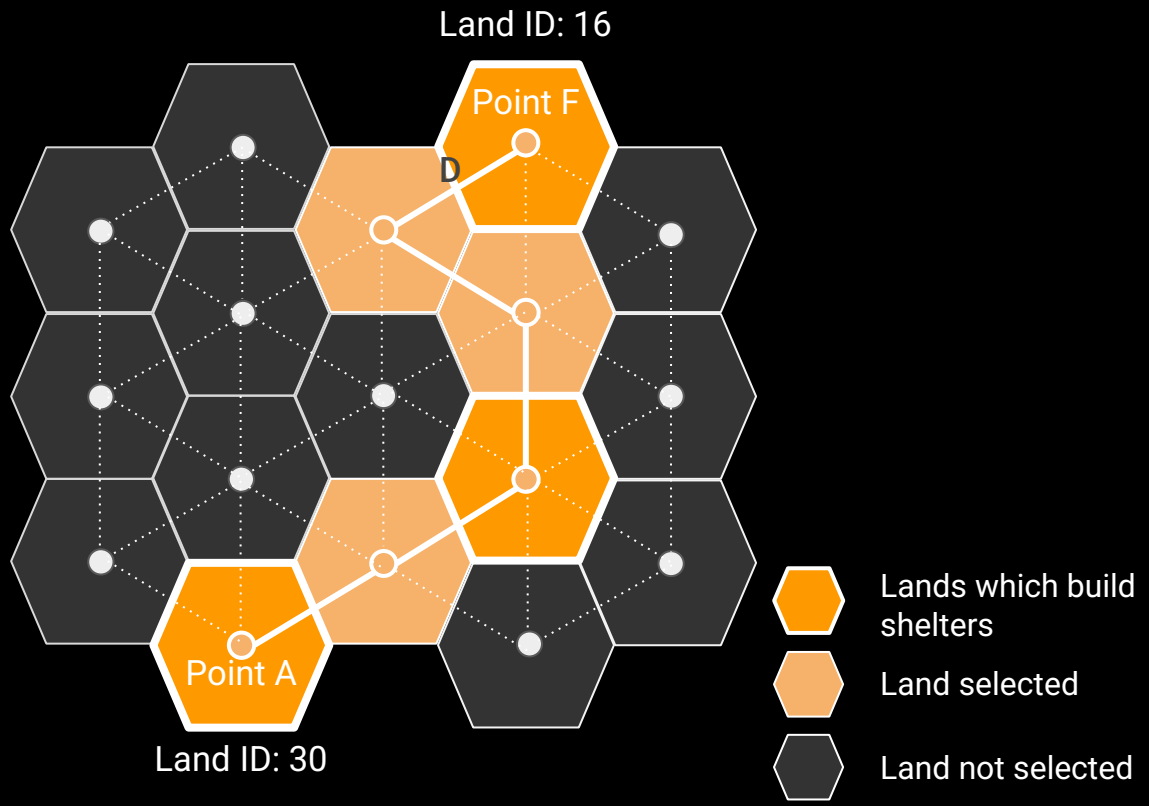
```
# caculate the distance of two points
line_distance = start_point.distance(end_point)

# search radius = 1.1* distance
search_radius = line_distance * 1.10

# filter the points within radius
mask = gdf['geometry'].apply(lambda x: x.distance(start_point) <= search_radius or
pruned_gdf = gdf[mask]
```

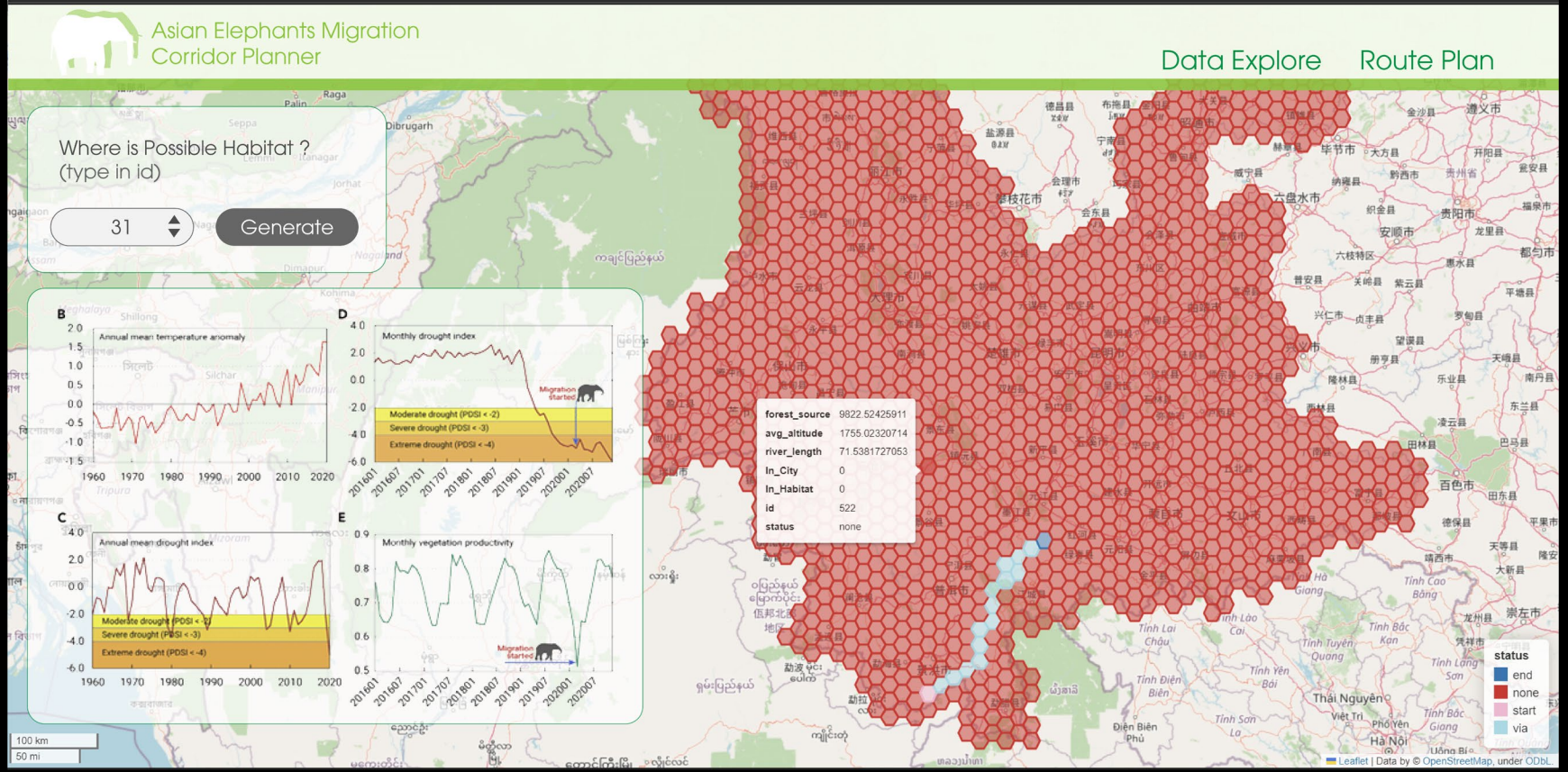


Algorithm design

Path IDs: [30, 44, 61, 79, 96, 95, 116, 143, 179, 180, 221, 222, 266, 267, 314, 315, 366, 367, 419, 420, 475, 476, 536, 537, 598, 599, 656]

Total Forest Area
Total River Area
Total Distance
Financial cost




Asian Elephants Migration Corridor Planner
Data Explore
Route Plan
Where is Possible Habitat ? (type in id)
31
Generate
B
Annual mean temperature anomaly
D
Monthly drought index
Moderate drought (PDSI < -2)
Severe drought (PDSI < -3)
Extreme drought (PDSI < -4)
Migration started
C
Annual mean drought index
E
Monthly vegetation productivity
forest_source 9822.52425911
avg_altitude 1755.02320714
river_length 71.5381727053
In_City 0
In_Habitat 0
id 522
status none
status
end
none
start
via
100 km
50 mi
Leaflet | Data by © OpenStreetMap, under ODbL

Reference

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