Final Project

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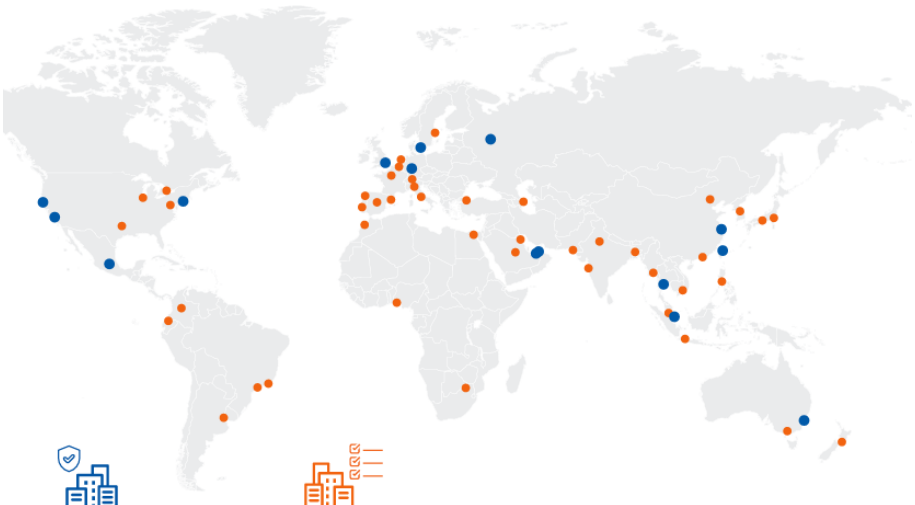
Abstract

This report mainly shows the application of network analysis, heat maps and other spatial data processing tools in evaluating smart cities. The results of the analysis show that Chicago's Central Business District (CBD) is ahead of the rest of Chicago in most areas (except for the Healthcare), which is in line with the assumption that the CBD is smarter than the rest of Chicago in general.

1 Introduction

Figure 6: Cities that have Smart City Plans and Cities that have Secured Smart City Plans



The city has a smart city plan and explicitly focuses on cybersecurity of the smart city infrastructure/ network		The city has a smart city plan or plans to invest in the next five years			
Abu Dhabi	Moscow	Amsterdam	Ho Chi Minh City	Melbourne	Seoul
Bangkok	New York	Baku	Hong Kong	Milan	Stockholm
Copenhagen	San Francisco	Barcelona	Istanbul	Mumbai	Tokyo
Dubai	Shanghai	Beijing	Jakarta	New Delhi	Toronto
Frankfurt	Singapore	Bogota	Johannesburg	Osaka	Washington, DC
London	Sydney	Brussels	Karachi	Paris	Wellington
Los Angeles	Taipei	Buenos Aires	Kuala Lumpur	Quito	Yangon
Mexico City		Cairo	Kuwait City	Rio de Janeiro	Zurich
		Casablanca	Lagos	Riyadh	
		Chicago	Lisbon	Rome	
		Dallas	Madrid	Santiago	
		Dhaka	Manila	Sao Paulo	

As cities around the world increasingly rely on data and technology to improve their services and infrastructure, the concept of the "smart city" has emerged as a popular buzzword. Smart cities use sensors, networks, and data analysis to optimize everything from transportation and energy consumption to public safety and environmental sustainability. The city of Chicago has been a leader in smart city innovation, implementing a number of initiatives aimed at improving the

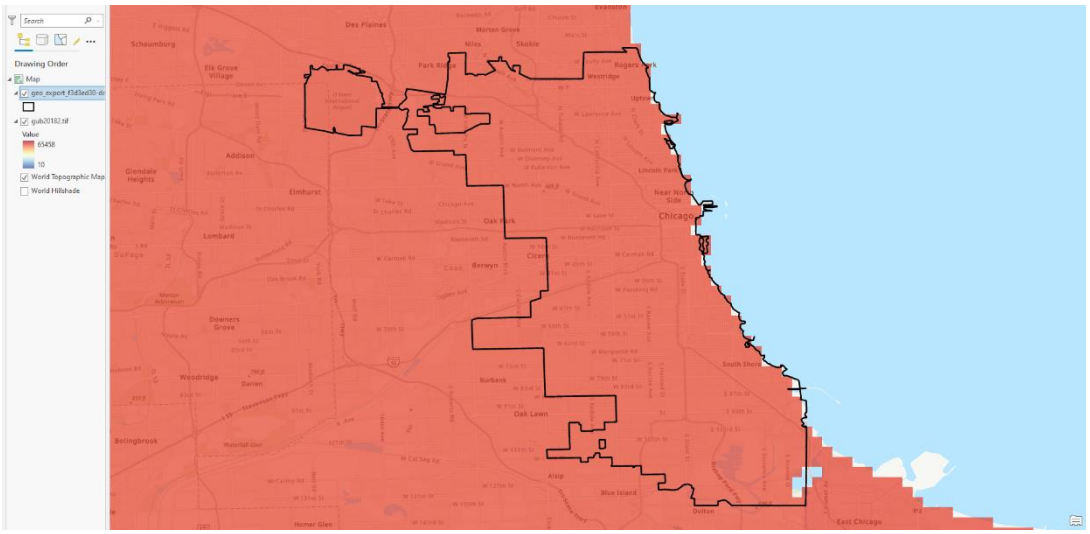
quality of life for its residents and visitors.

In my research on evaluating Chicago's smart city initiatives, I discovered that the City of Chicago has integrated data from various departments and levels of government into its data portal, which includes data not only for the city itself but also for Cook County. Data sources include but are not limited to the Chicago Transit Authority (CTA) and the Illinois Department of Public Health (IDPH). The detailed data available on the portal dates back to at least 2010, indicating that Chicago has been collecting and analyzing data for smart city initiatives for at least 13 years. This extensive and detailed data collection and analysis shows that Chicago has been committed to smart city initiatives for a long time, which can have significant benefits for the city and its residents which can be proved by the handbook I found published by the Economics.

2. Study Area, Data Source and Description

I. Study Area: the City of Chicago

a. Determining the city boundaries of Chicago: The city of Chicago itself has a dense population and the administrative area does not include large areas of undeveloped land, so there is no need to trim it. Therefore, the administrative boundary of Chicago is its city boundary.



II. Data Source: Chicago Data Portal

All the indexes belong to these 5 aspects below which weights 20% for each aspect: Education (Ed), Health Sustainability (HS), Transportation(T), Environment(Eco), Commercial Business(C)

a. Raw Data

Index	Description	Aspect	Pre-Weight in its aspect
Bus Garage		T	2
Bike Routes	Not mentioned in this report	T	1.5
Bus Turnaround	Reduce bus stop spacing and improve transit performance by minimizing access time and line-haul time. Avoid bus contention and data	T	1.5

	corruption when using multiplexed memory devices such as PSRAM.		
Park & Ride Metro Station	Offering low-cost or free parking and avoiding tolls, parking fees, and traffic delays	T	1.5
Pedestrian Only Street	Not mentioned in this report	T	1.2
Boulevard	Not mentioned in this report	T	1
Major Streets	Not mentioned in this report	T	1
Metro Station		T	1
Sidewalk	Not mentioned in this report	T	1
Bus Stop		T	0.8
Hospitals	Providing advanced medical services	HS	2
CDPH Clinic	The Chicago Department of Public Health offers many services through its Neighborhood Health Clinics. Some of these services include HIV primary care, immunizations for children 0 through 18 years of age at no out-of-pocket cost, and mental health services	HS	1
Connect Chicago	Connect Chicago is a network of more than 250 places in the city where you can access internet and computer services, digital skills training, and online learning resources for free	Ed	1
Green Roofs	Provide valuable green space in urban areas where land is scarce.	Eco	2.5
Habitat		Eco	1.5
Campus Park		Eco	1
Parks		Eco	1
Water Body		Eco	1
Building	Base data for all the building calculation	Base	0
CBD	Sub Research Area	Base	0
Chicagoland	Research Area	Base	0
Land Use Type		Base	0
Street Center Lines	Base data for all the road calculation	Base	0

3. Methodology & Hypothesis

I. The purpose of this study is to try to establish an equation that can assess the degree of smartness of a smart city.

II. The study introduces the concept of the Central Business District (CBD), which in general is the most developed area of the whole city and should have the highest corresponding intelligence index. This corresponds to the hypothesis of this study, but also the results and hypothesis of this equation can provide some suggestions for the improvement of this equation, e.g. if it is concluded that most CBDs are less intelligent than other areas of the city, then it is reasonable to question the usability of this equation in calculating the intelligence of smart cities.

III. The source data is of type point/line/face shapefile.

   a. When studying point data (e.g. stations, hospitals), focus on the accessibility and spatial layout of these locations.

   b. When studying line data (e.g.: city avenues, pedestrian streets), the percentage of these high level roads in the total roads, in addition to accessibility and spatial layout, are the indices to be focused on in this study.

   c. When studying surface data (e.g., green space), all aspects should be of interest.

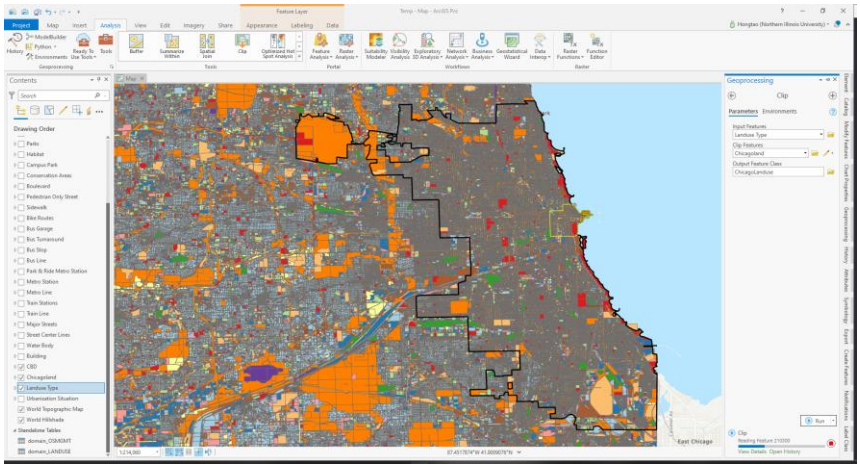
Specific research tools will be shown in the next session when processing the data.

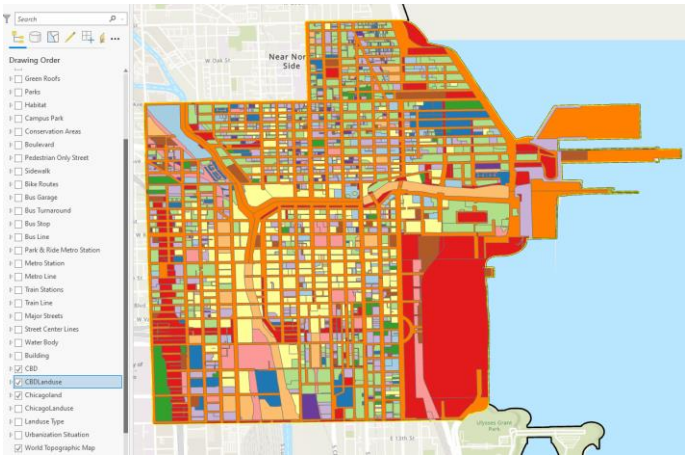
4. Data Processing & Result

I. Commercial Area Density:

   a. Clip

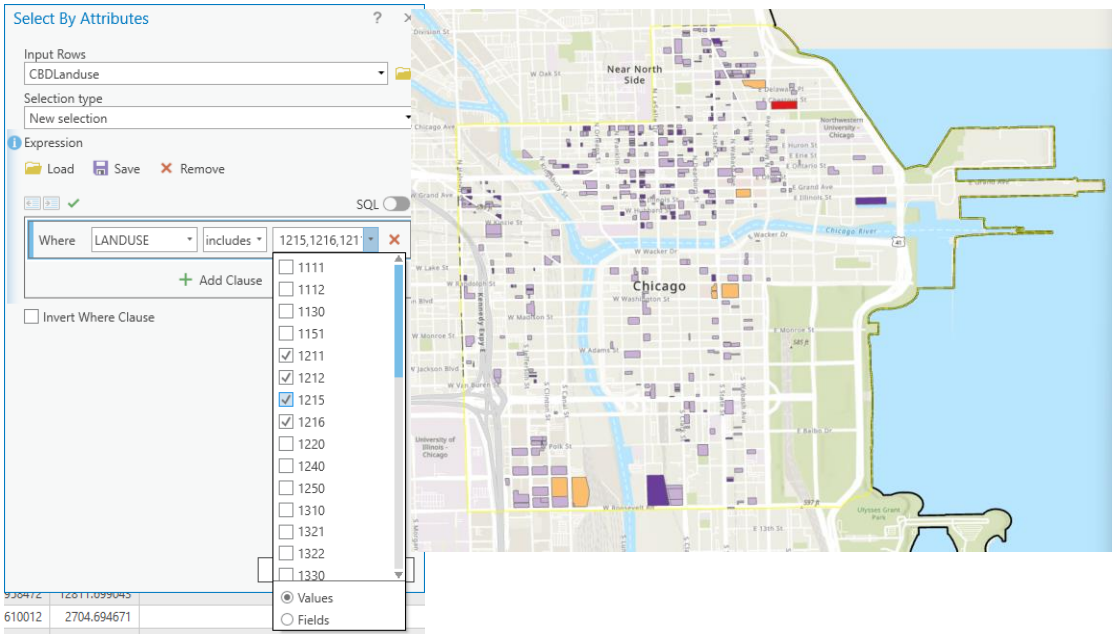
      Crop the land use type file to the boundary of Chicago and its CBD, and the same for other files.





b. Data Extraction

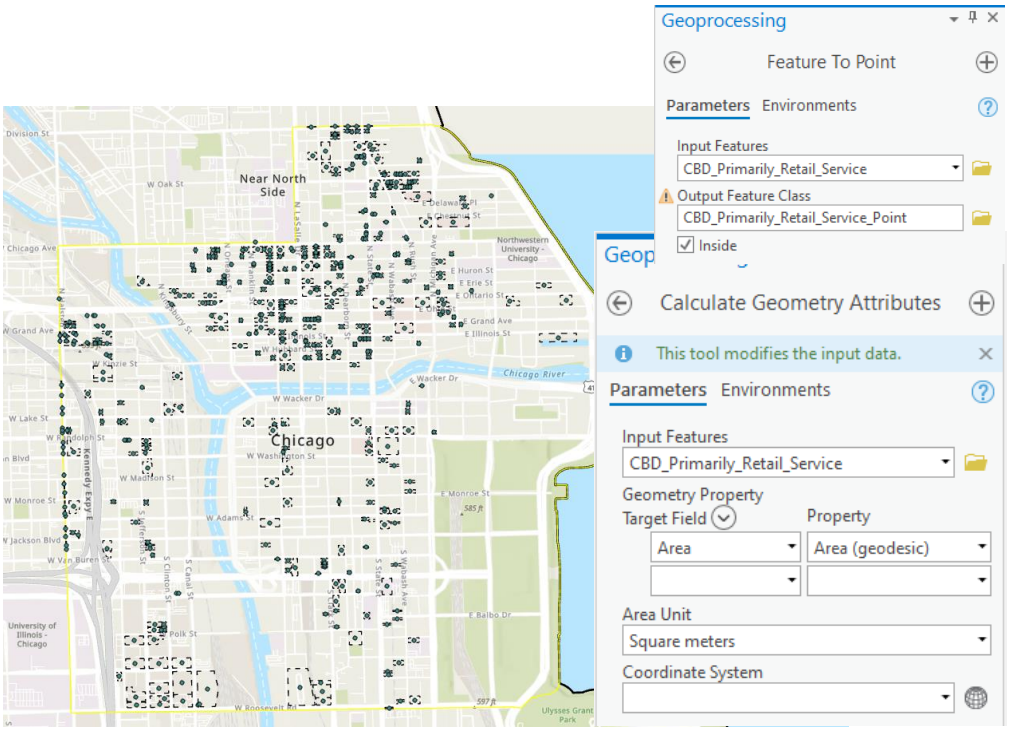
According to Parcel-Based Land Use Inventory categories, released by the Chicago Metropolitan Agency for Planning December 2020, under the 1200 COMMERCIAL category, 1211 Shopping Malls [COM_MALL], 1212 Regional & Community Retail Centers [COM_REGIONAL], 1214 Single Large- Site Retail [COM_BIGBOX], 1215 Urban Mix [COM_URBMIX] and 1216 Urban Mix w/Residential Component [COM_URBMIXwRES] are the target extracts for this step. Then export.

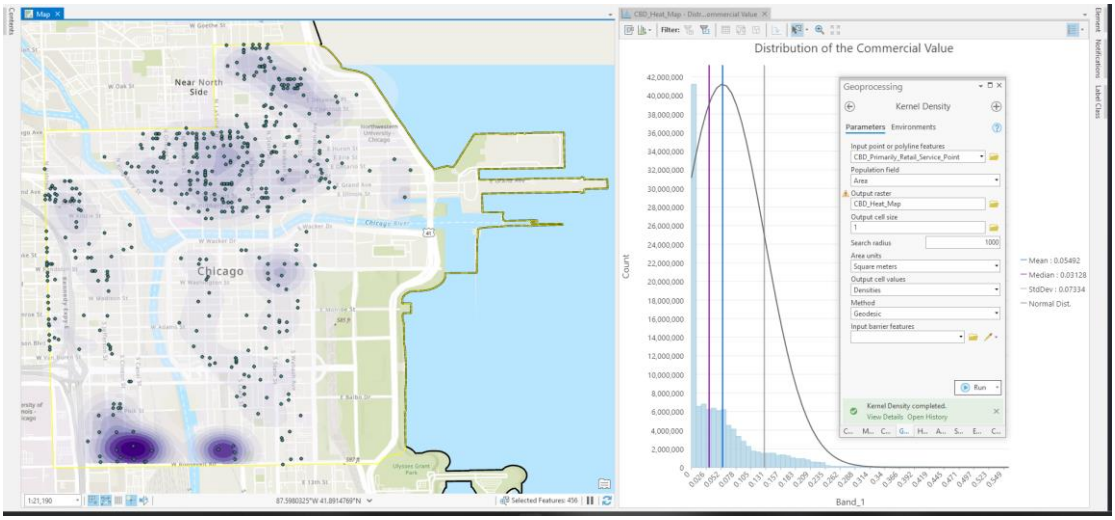


c. Heat Map Creation

Generate a commercial heat map and add consideration of floor area to the weights: both the density of commercial buildings and the size of each building are important in the assessment.

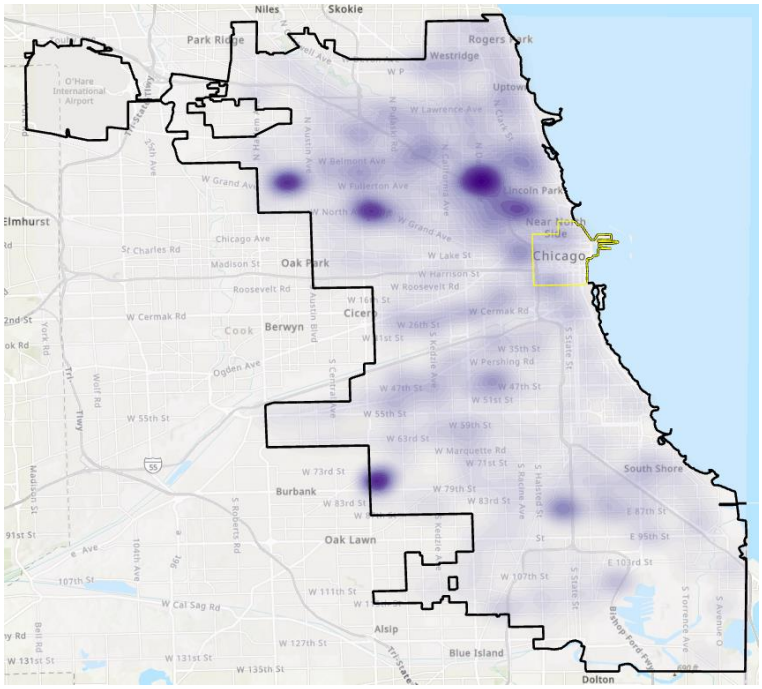
Calculate the area of each building and export to point data

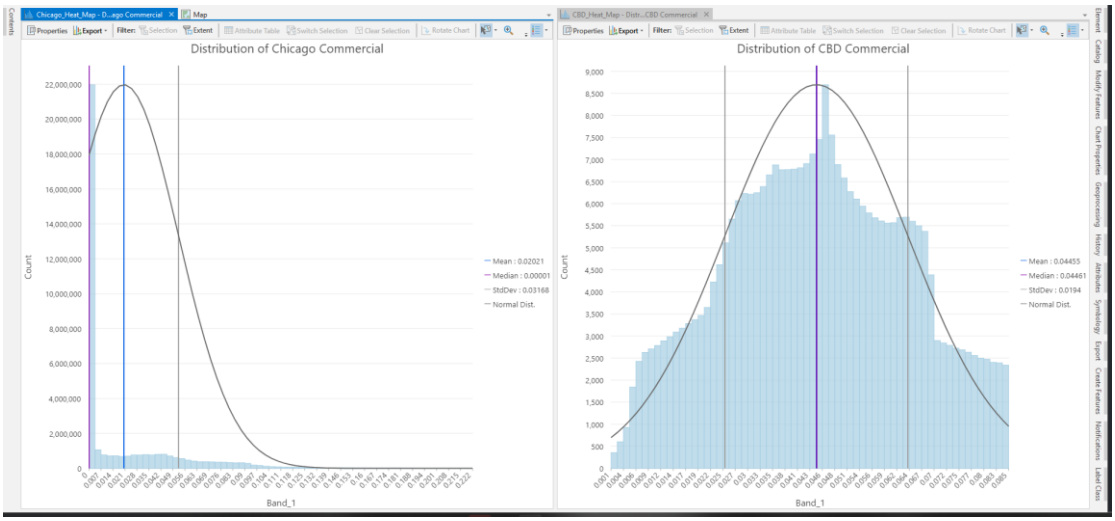




d. Same to the Whole City

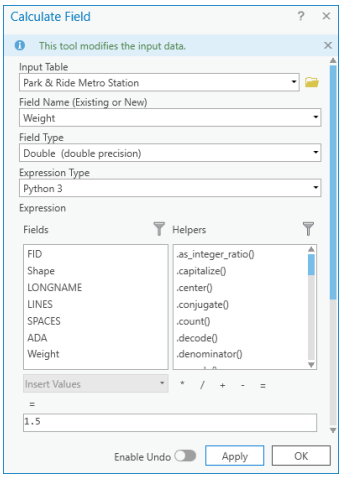
To facilitate comparison, the CBD area was recalculated, Cell Size was changed to 20, and the search radius was set to 5000 square meters



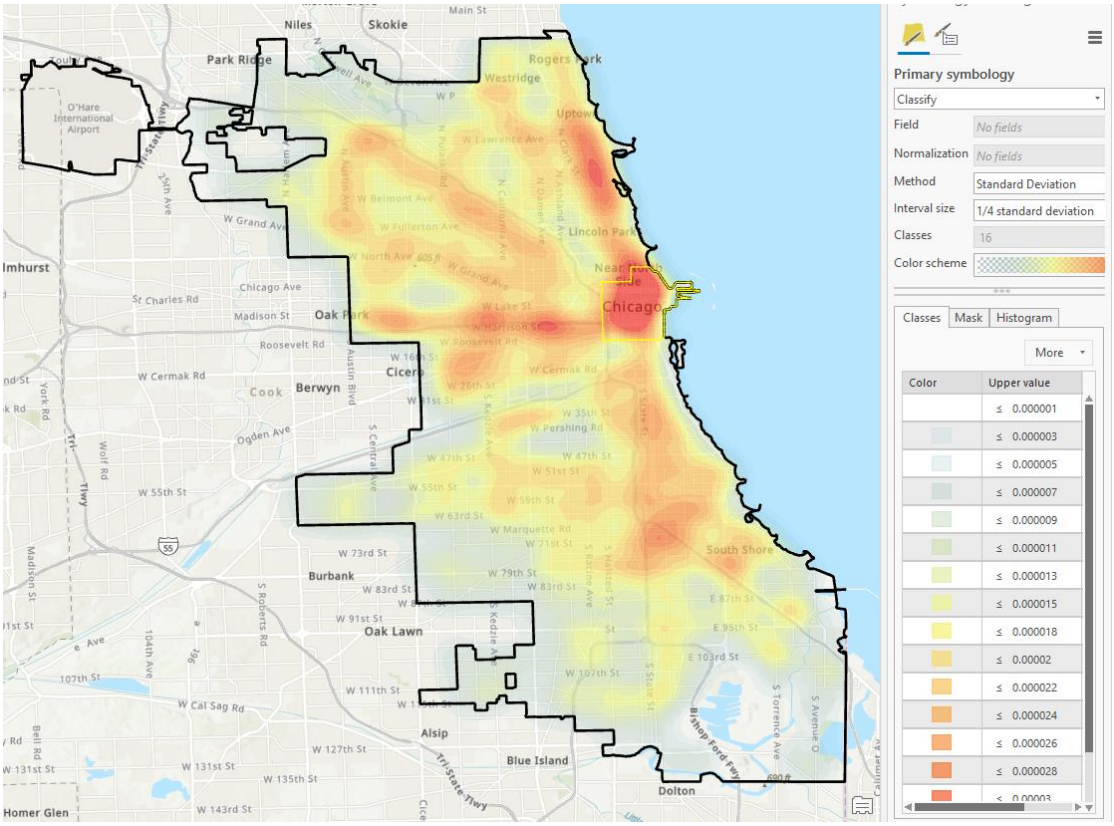


II. Traffic Accessibility

a. Insert the weight data into the shapefile.



b. Heat Map Creation (Cell Size: 20, search radius: 5000 square meters)

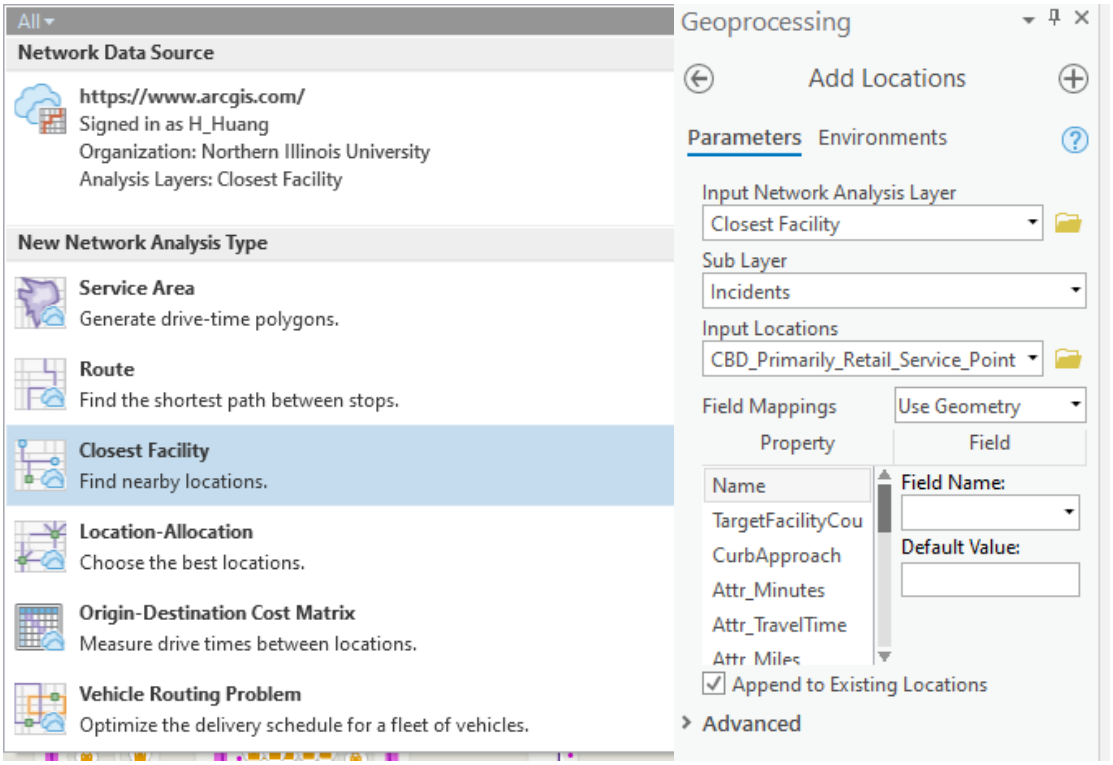


c. Network Analysis

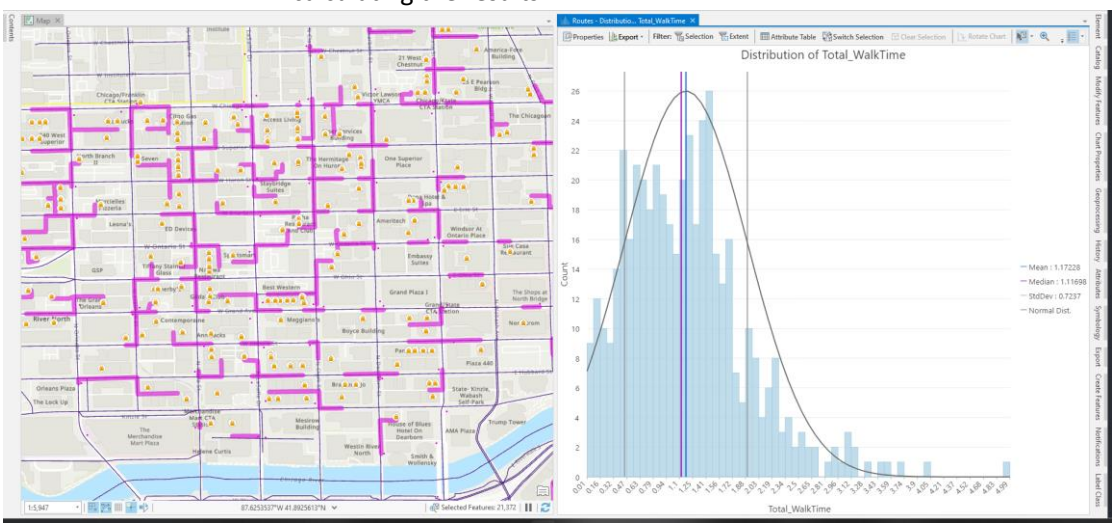
As the heat map already shows the transportation advantages of the CBD, the focus here is on the accessibility to public transportation within the CBD area. The specific result is the time to reach the nearest public transportation facility from these commercial buildings

i. Configuration

Use Closest Facilities, treating stations as Facilities and commercial buildings as Incidents

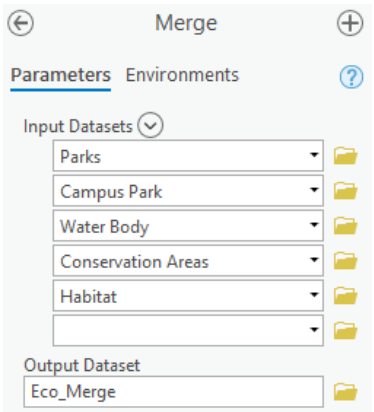


ii. Check the walking time to the nearest station in each area after calculating the results

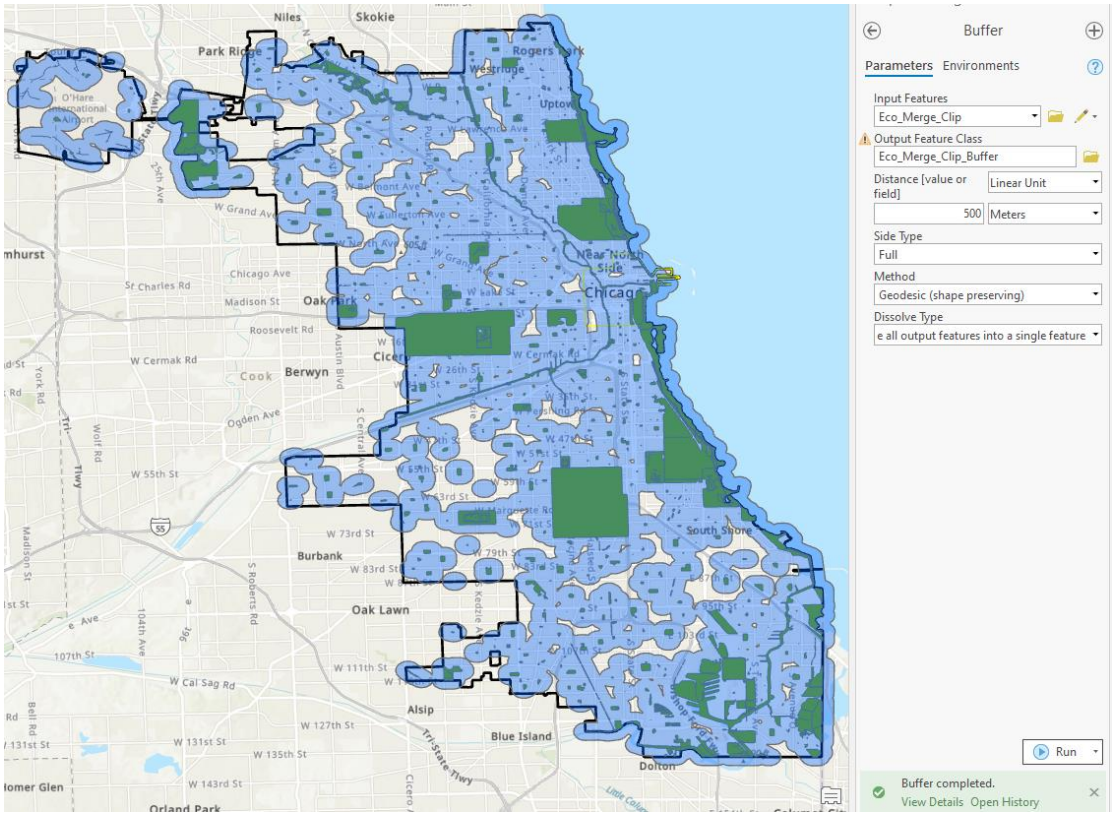


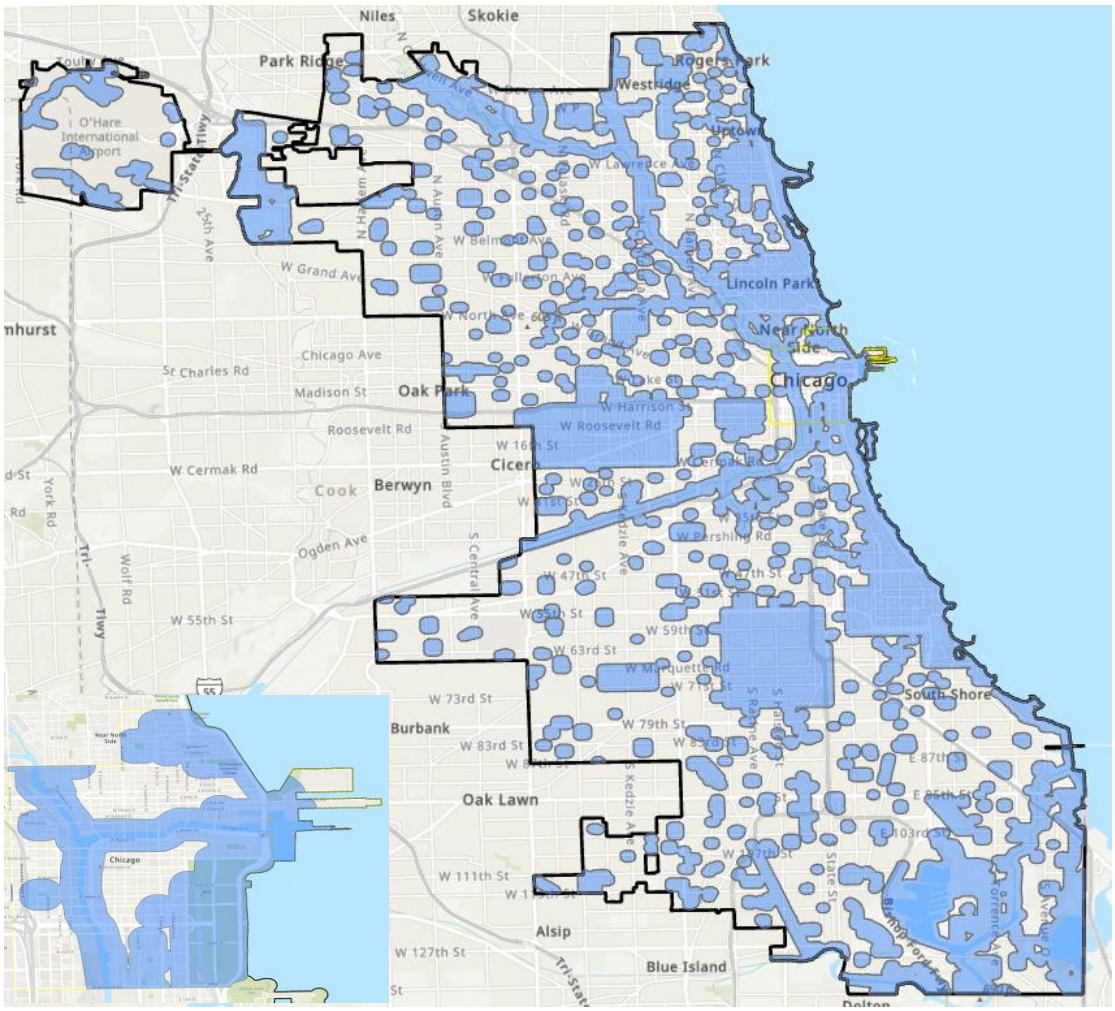
III. Green Land Service Coverage

a. Data Consolidation



b. Buffer Establishment





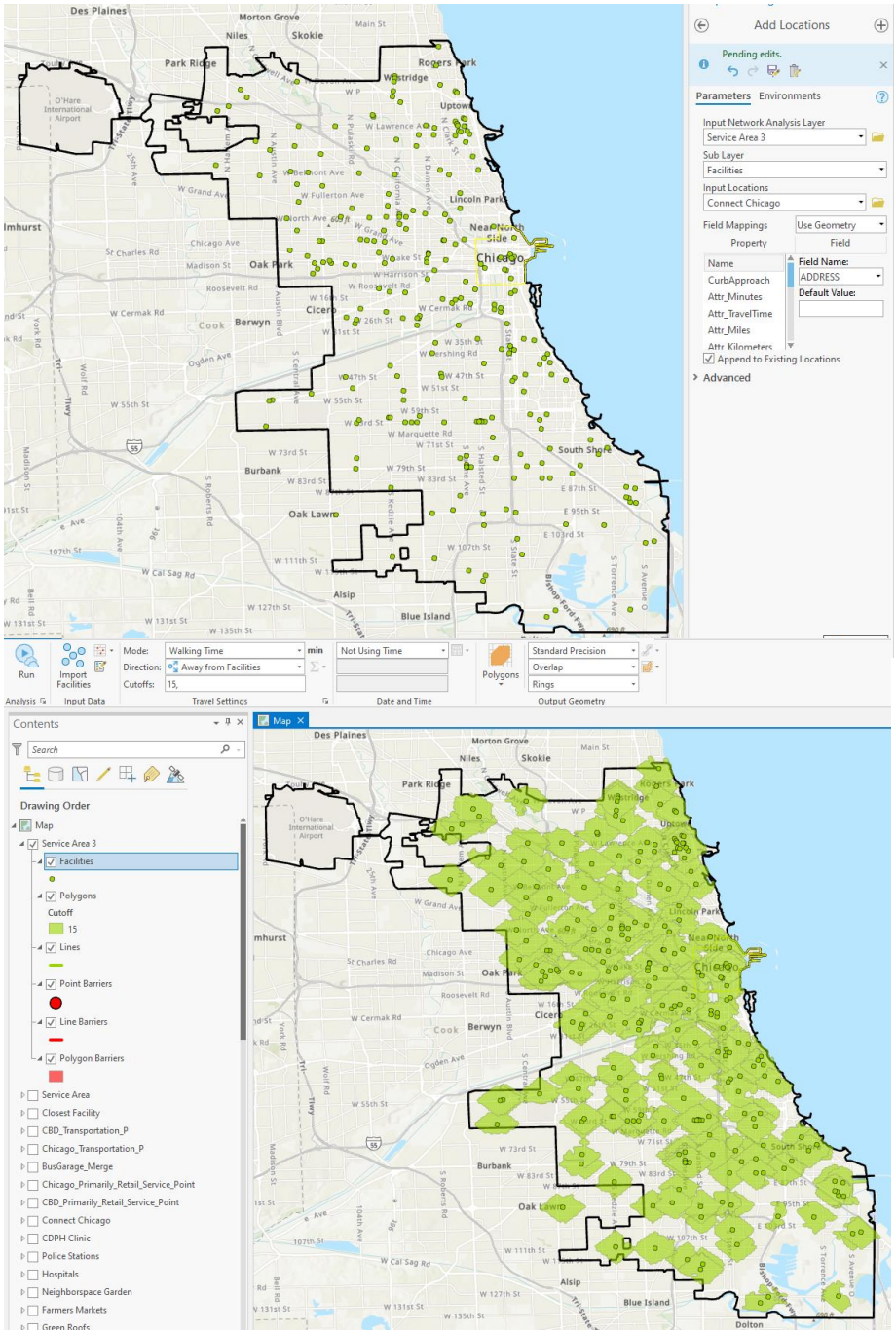
c. Coverage Calculation

(Square Meter)	Green Buffer	Total	Ratio
CBD	6822256	10430897.71	65.40%
Chicago	279663000	599239453.7	46.67%

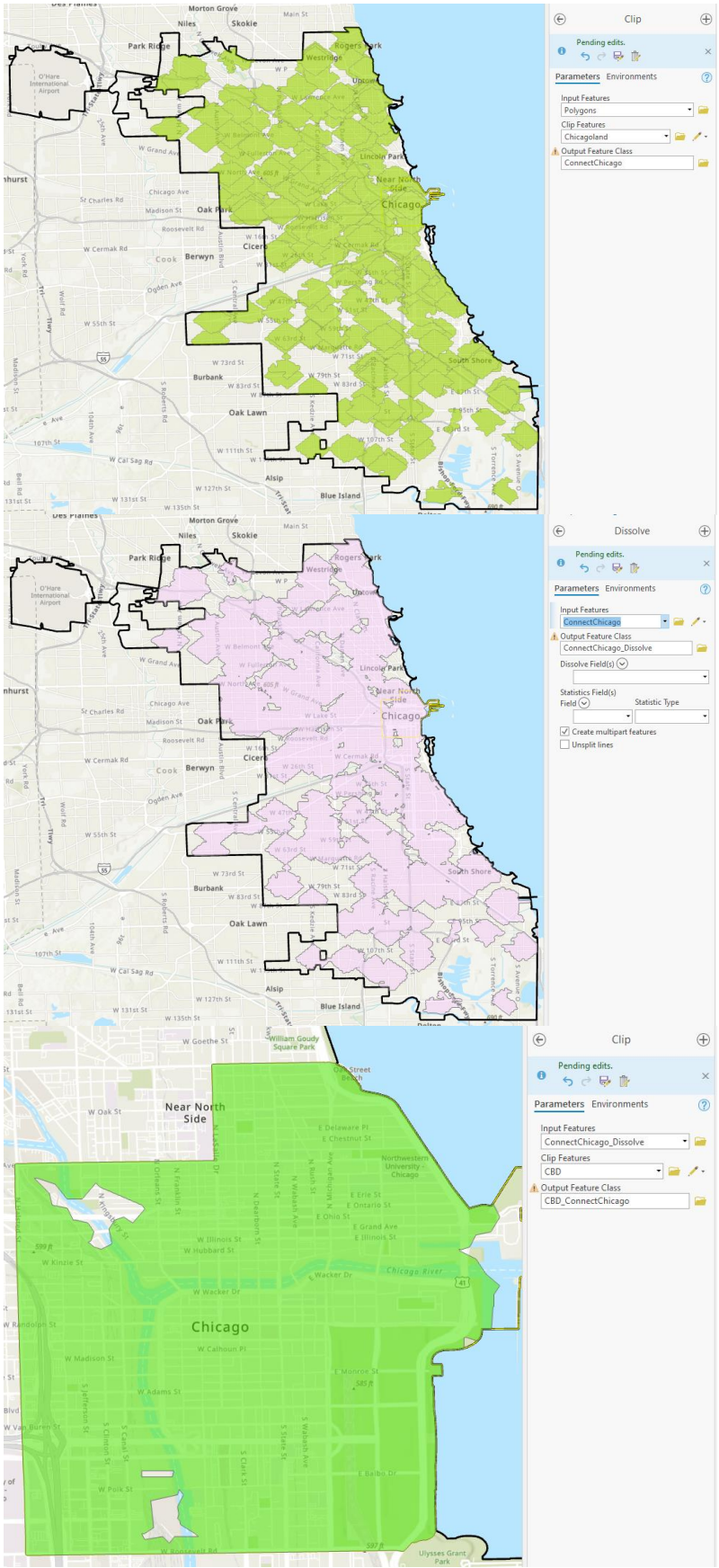
IV. Digital Schooling Convenience

In smart cities, access to digital technology is particularly critical. Unlike students who are still in school. Connect Chicago is a network of more than 250 places in the city where people can access internet and computer services, digital skills training, and online learning resources for free, which is especially critical for people who cannot afford mobile internet and electronic devices. It represents the maximum amount that a smart city can benefit its residents. Only the areas that Connect Chicago can serve are discussed here.

a. Network Analysis (Within 15 mins walking)



b. Dissolve & Clip

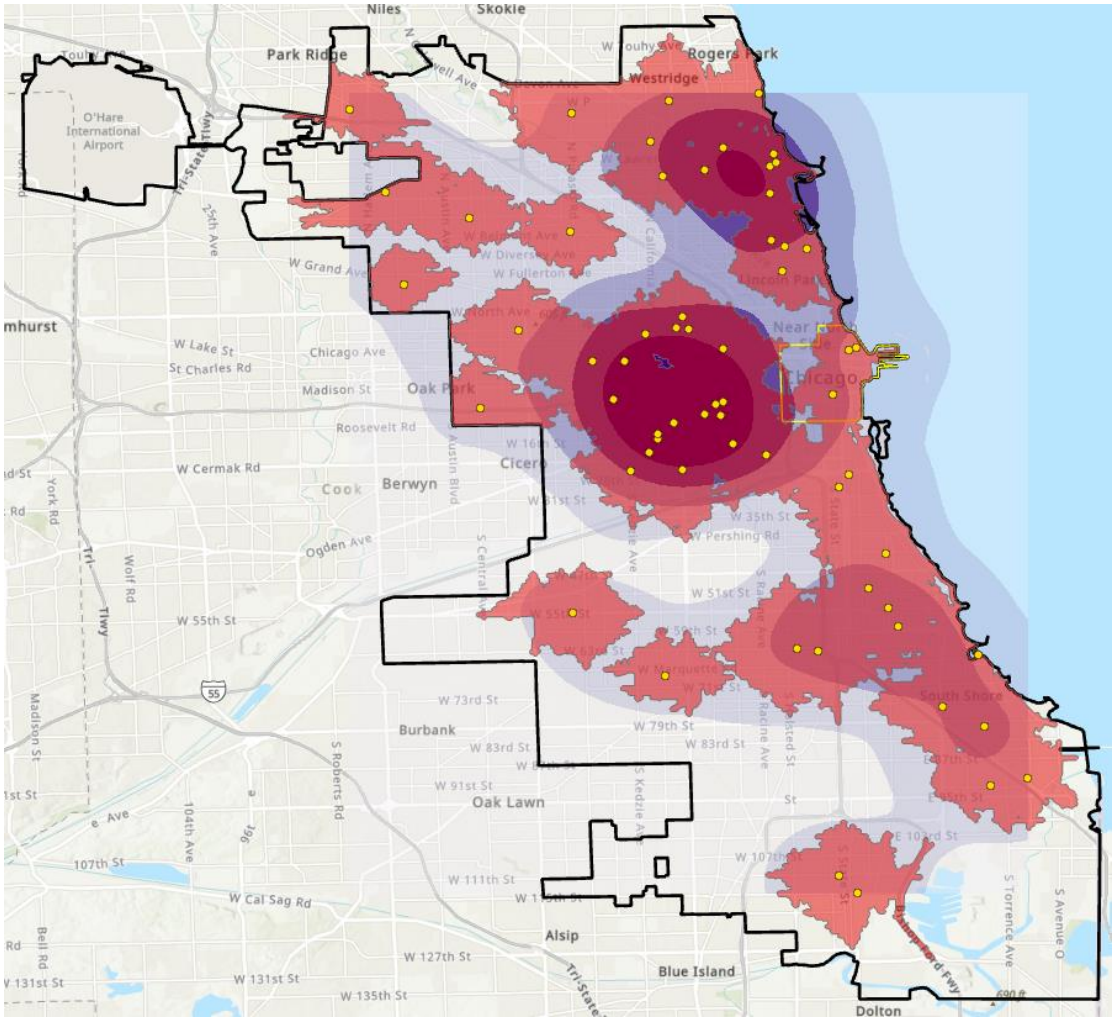


c. Coverage Calculation

	Square Meter	CC Coverage	Total	Ratio
	CBD	9585161.469	10430897.71	92%
	Chicago	366890934.4	599239453.7	61%

V. Health Sustainability Evaluation

Applying kernel density and 5 minutes' drive distance buffer



	Square Meter	HS Coverage	Total	Ratio
	CBD	8072949.636	10430897.71	77%
	Chicago	282809132.1	599239453.7	47%

5. Conclusions and discussion

In this report, we can see the differences between the City of Chicago and CBD in each index. In the first part of commercial land, we can see that the CBD area has twice the average percentage of commercial land per unit area than the city of Chicago.

As you can see from the public transportation station density graph, even after reducing the weight of the general bus stations, which are dense in the city center, and increasing the weight of Bus Garage, Bus Turnaround, Metro Station and Park & Ride Metro Station, the CBD still has an

incomparable advantage in terms of transportation.

The network analysis of the CBD shows that the nearest bus stop can be reached within 2 minutes' walk in the CBD most of the time, which's network covers the whole city.

In addition to public transportation, people who work in the CBD will also have better access to open spaces with a good environment (within 500 meters walking distance) and also better free digital services (within 15 minutes' walk) than those outside the CBD.

It is worth noting that in the area of medical assistance, although for the CBD area, the 5-minute one-way, 10-minute ambulance round trip EMT coverable area is better than the city of Chicago overall, it is clear from the graph that it is not as good as the coverage in central Chicago.

In conclusion, this report demonstrates the use of spatial data analysis tools to evaluate and compare the smartness of different areas in Chicago. The results show that Chicago's CBD is a leading example of a smart city that leverages technology, innovation and collaboration to improve the quality of life and sustainability of its residents and businesses. Chicago's CBD showcases how spatial data can be used to inform and optimize urban planning and decision making. Chicago is a smart city that strives to be smarter every day.

Acknowledgments

While communicating on technical matters with Mofan, I found that the database was far more sophisticated in researching Chicago than the vast majority of cities in the world. While finding the right index to evaluate smart cities revealed a large amount of data redundancy in the database, which greatly increased the data pre-screening and pre-processing time, fortunately the Chicago Data Portal provided all the data I needed.

I am also grateful for ArcGIS Pro a lot since it provides an effective platform for data processing and visualization.