Flood Risk Assessment of Jinan, China

Draft 1

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Abstract

In this project, I will assess the exposure and vulnerability of different communities of Jinan city to the possible flood hazard through spatial analysis and empirical analysis. The result can be a good reference for city council to improve their water management systems and preventive measures.

Problem Statement

1. Research Problem

In 2007, a thunderstorm attacked Jinan, a city with of 5 million people in China. The city was built 5000 years ago, while the water management systems were introduced in the late 19th century and early 20th century. With rapid urban expansion in the last 50 years, the sewage pipes and drainage systems have been considered problematic for a long time.

Each year, wet monsoons bring a lot of precipitation into the city, usually in the form of thunderstorms. During the 2007 Thunderstorm, a lot of people were blocked in an underground shopping mall, and some of them were injured. After this thunderstorm were actions taken to repair and reconstruct the water management system easily flawed.

In the downtown area or the urban village, rainfall accumulates easily. Under this scenario, pedestrians, bicycles, and scooters are in danger of falling into the sewage well. Although, there were some measures taken to mitigate the effects of heavy precipitation, in 2021, an unexpected thunderstorm still made the Urban Transit Metro Line 2 stop their services for a couple of days.

Figure 1 The Paper News. Jinan: a road section became the "sea" every time storms hit! Citizens: living in the "sea view room" ~

2. Research Question

Climate change has been influentially on the general weather patterns in China, especially during El Nino years and La Nina years. In some wet years, severe thunderstorms and typhoons are more impactful than normal. Jinan city has become more vulnerable to natural hazards.

However, I think the local government still has the responsibility to prevent hazards and lower losses as much as possible. In this project, I will examine and evaluate the exposure and vulnerability of different urban communities in Jinan city to possible flood hazard through spatial analysis and empirical analysis.

More specifically, I will explore the local spatial patterns of the regions that are exposed to flooding hazards. In this process, I will identify some key communities that are more vulnerable to flooding disasters and analyze how they correlated to the social and economic environments like education status, land price, population density, or land classification. With data visualized in maps and charts, the result can be a good reference for the city council to improve their water management systems and preventive measures.

3. Literature Review

Currently, there are few studies done about the flooding risk assessments of Jinan City in English. However, there is a lot of research on other Chinese cities. For example, in an article about Guangzhou's flooding risk, the authors utilized spatial interpolation and spatial regression models to analyze the sensitive areas of all metro lines in Guangzhou. My research will bring similar methodologies to the case study of Jinan.

In addition, I will consider the social dynamics of flood risk in Jinan, drawing an existing scholarship to define some key natural concepts in my research, such as the ways to define flooding risks. Framing the flooding hazard into a big picture can also help me identify how the flooding evolves. There are many studies about how flooding disasters affect differently to different communities based on their income levels, ethnicities, education levels, and administrative divisions. Many of them focus on a complex economic-social aspect of long-lasting flood impacts. In conclusion, the existing scholarship has provided plentiful information, frameworks, and insights for me to conduct my research.

Table 1. Preparation Data

#	**Requirement**	**Defined As**	**(Spatial) Data**	**Attribute Data**	**Dataset**	**Preparation**
1	Administrative Regions	Raw input dataset from OSM	Polygons	Name, Location, Level of Administration	OSM Data	Import from QGIS Plugin
2	Water Bodies	Raw input dataset from OSM	Polygons and Multi-lines	None	OSM Data	Import from QGIS Plugin
3	Monitor Stations Data	Raw input dataset through Governmental Website	Point data	Warning Water Tables	Self-Generated	Organize and Import from table
4	Digital Elevation	Raw input dataset from Copernicus 30m resolution	Raster TIF	Altitude	OSM Data	Import from Copernicus

4. Data Preparation

I will access and download the digital elevation data, administrative boundary data, and water bodies of Jinan from Copernicus and Openstreetmap. Also, I will make a table of the river monitor stations around the city, with their warning water levels.

Input Data

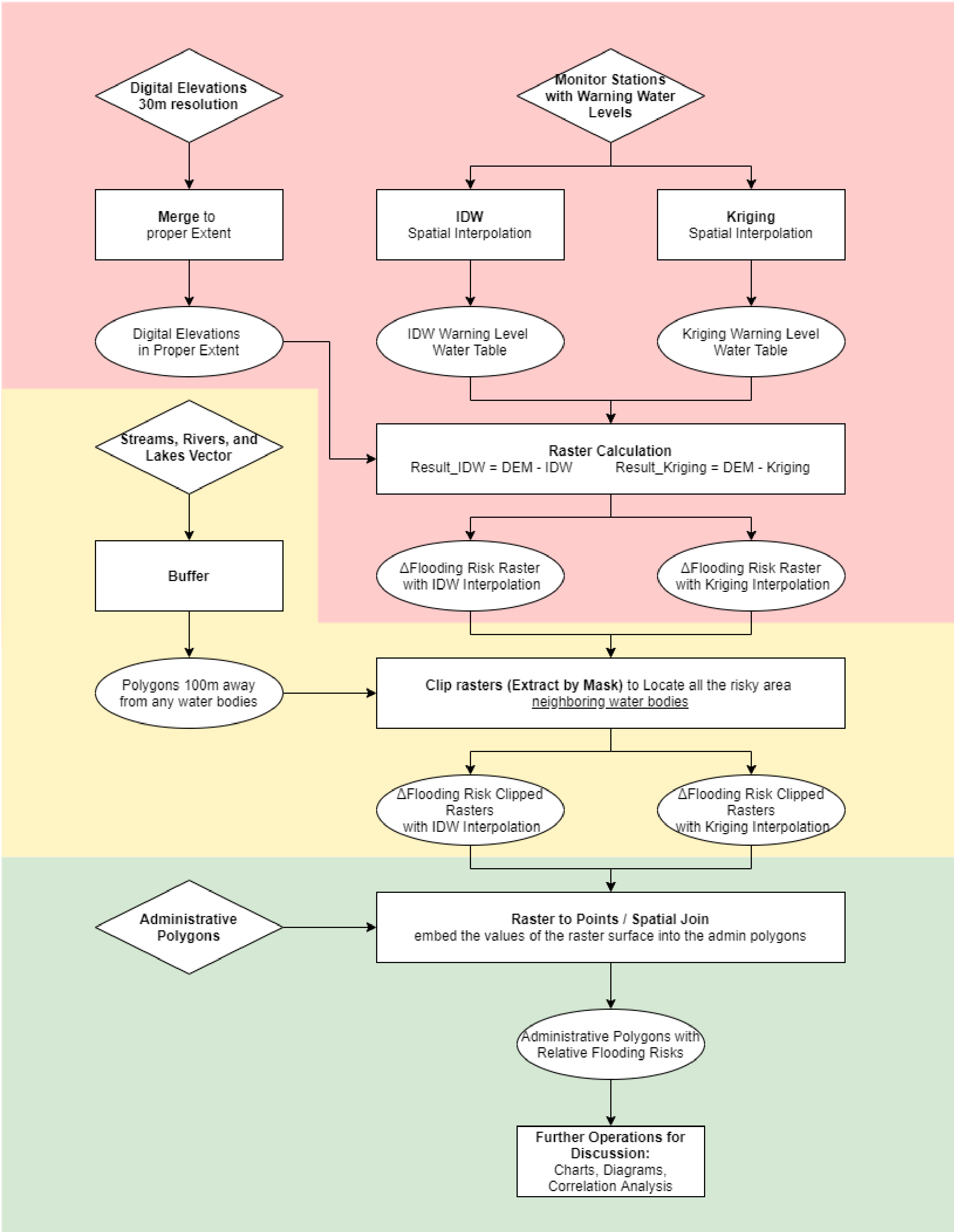
Table 2. Input Data

#	Title	Purpose in Analysis	Link to Source
1	Administrative Regions of Jinan	To frame the Flooding Risk data into each administrative communities of Jinan City, for analyzing the spatial pattern of the flooding area	Openstreetmap
2	Lakes, Streams, and Rivers in Jinan	To clip the raster data of flooding raster surface to those only closed to the water bodies, the source of the possible flooding	Openstreetmap
3	Monitor Stations Data of Rivers in Jinan	The warning water table of each monitor station is the main input data in this analysis. The warning water table is used to generate a raster table for the flooding risk.	Hydrology Bureau of Jinan
4	Digital Elevation	Major input data in this analysis. The elevation data is used to be subtracted by the warning water table to generate a raster table for the flooding risk.	Copernicus

Methods

The whole process can be divided into three parts, which are indicated with different colors in the diagram below.

Figure 2. Data flow diagram.



Part 1: Generate Raster Table of Flooding Risk

With the table of warning water levels, I will use spatial interpolation tools to make a raster surface of the warning water tables in the city. Then, I will use raster calculations to let the digital elevation subtract by the water tables to find which areas are in the flooding zone. Since the data is sensitive and DEM is in low resolution, the flooding zone is labeled with low risk, middle risk, and high risk. Please note that to get the most suitable results, I will use both deterministic data interpolation (IDW) and geostatistical method (Kriging) to generate the raster table.

Figure 3. Surface Result of IDW Method.

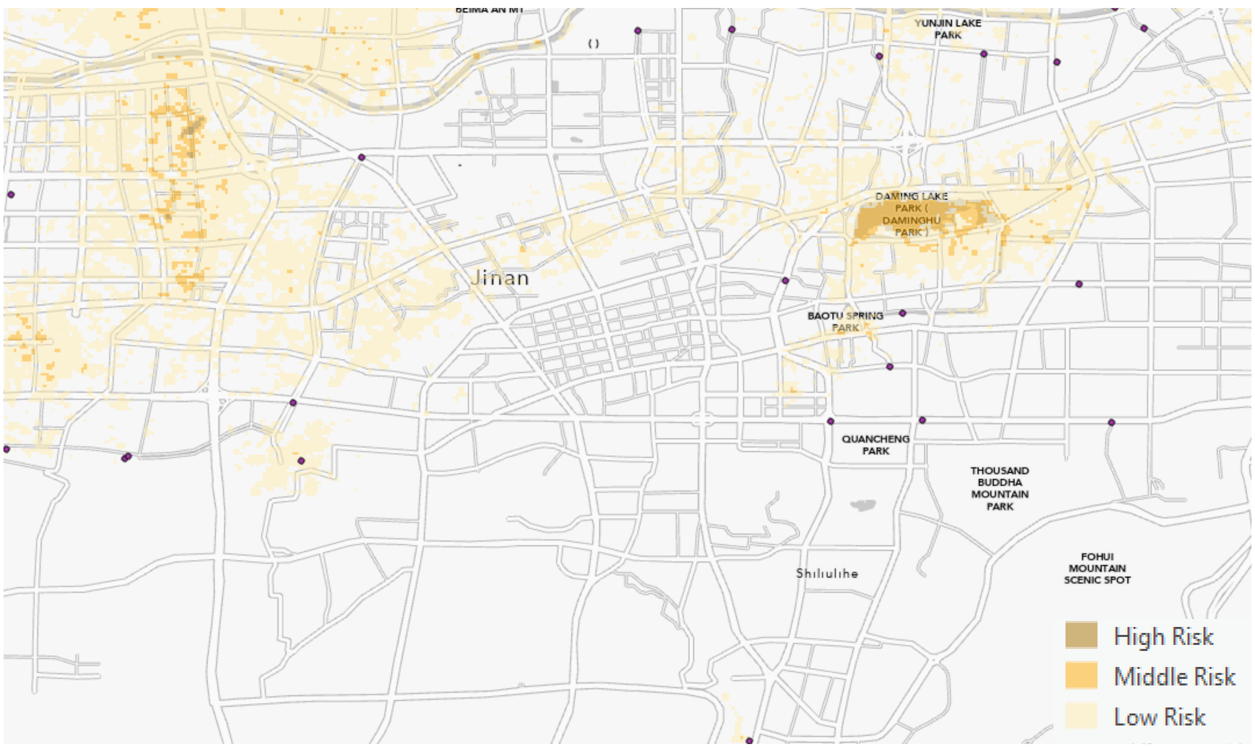
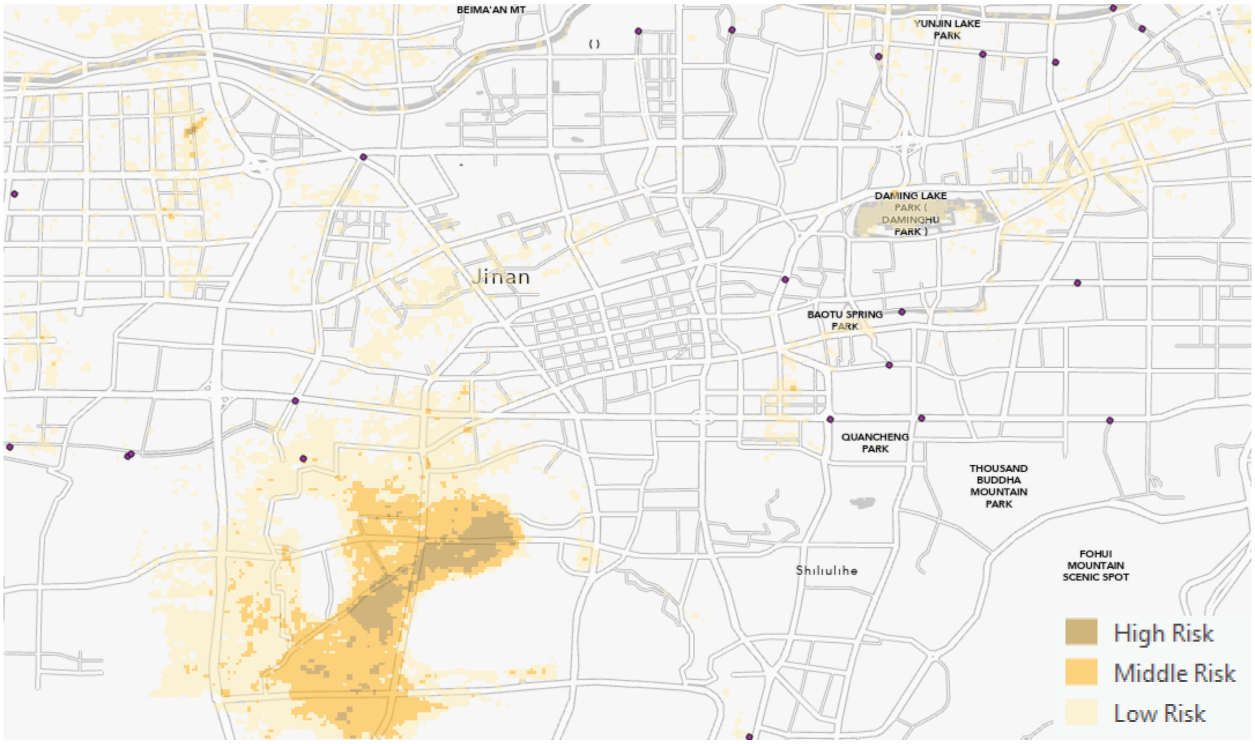


Figure 4. Surface Result of Kriging Method.



Part 2: Clip the Surface to be matched with the actual River Flow

There would not be any flooding risk if the place is not closed to any waterbodies nearby. Based on this logic, I will use buffer tool to generate a set of polygons that are 100m (or more depend on the result) from the river. Then, I will use these polygons to extract the raster data to identify the regions that are more sensitive to the flooding risk.

Figure 5. Water Body Buffers.

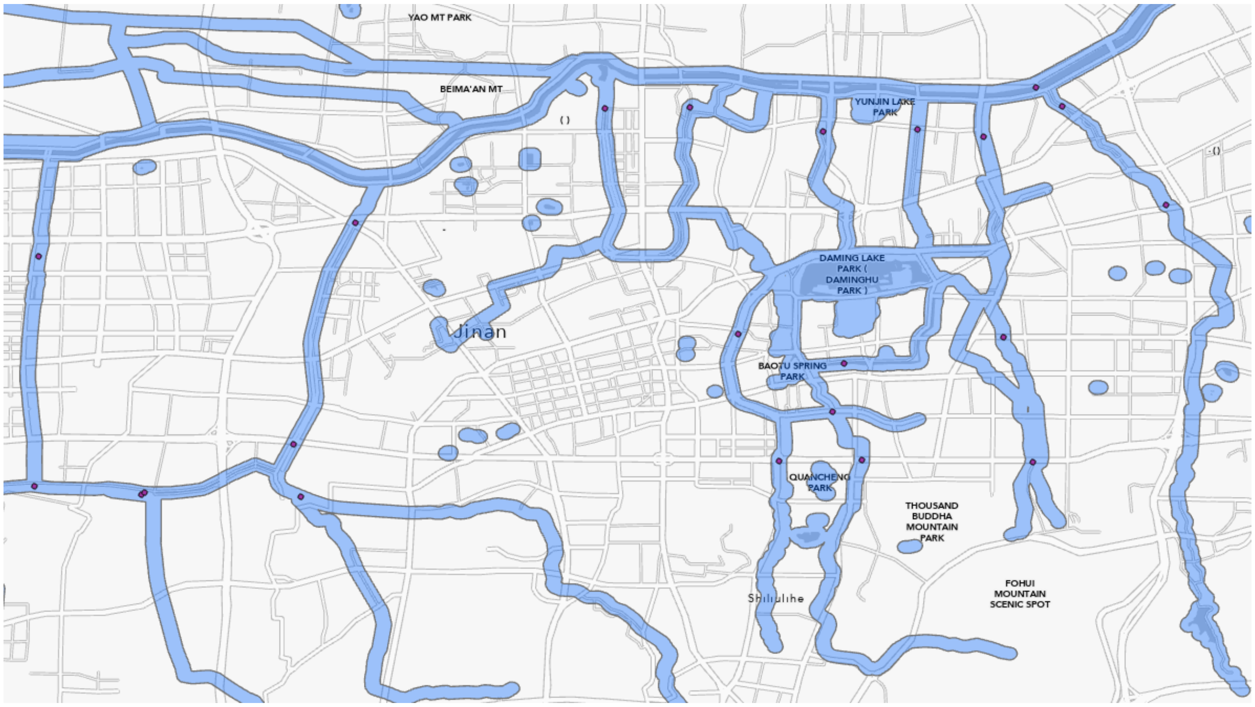


Figure 6. Extracted Result of IDW Method

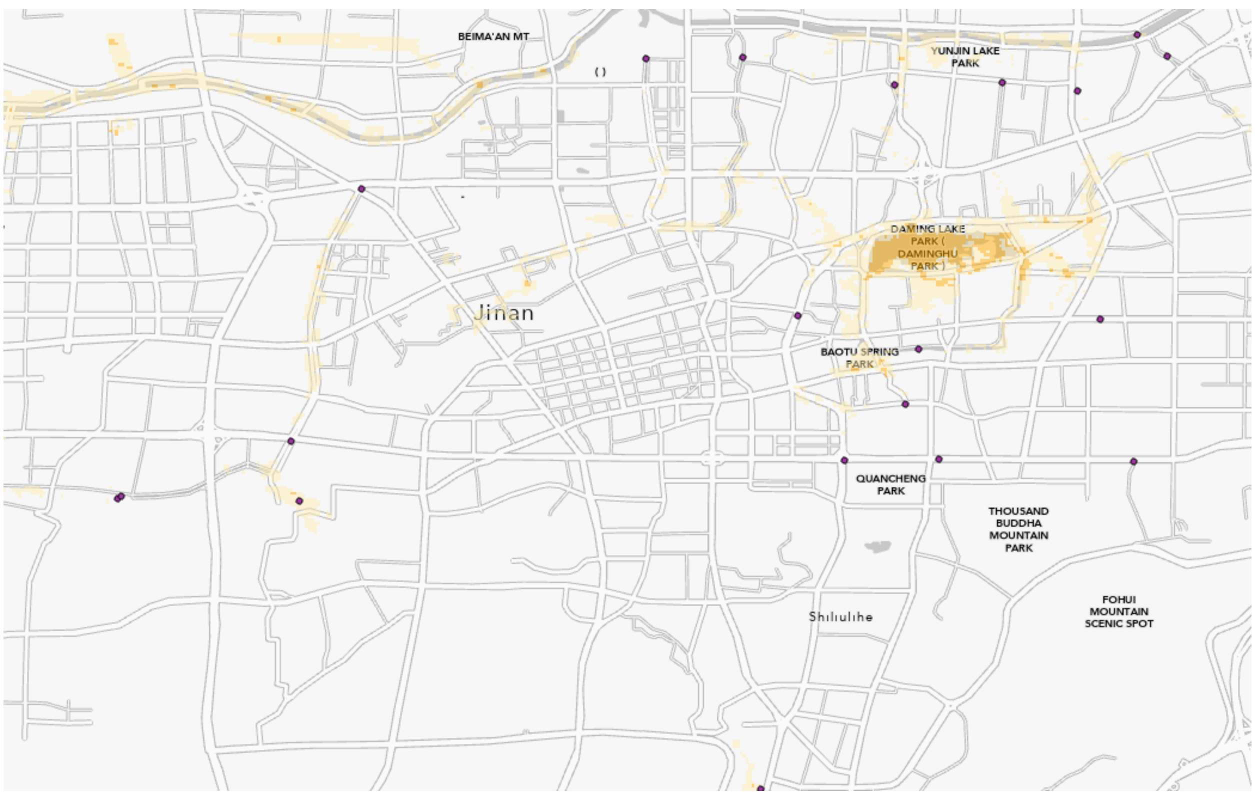
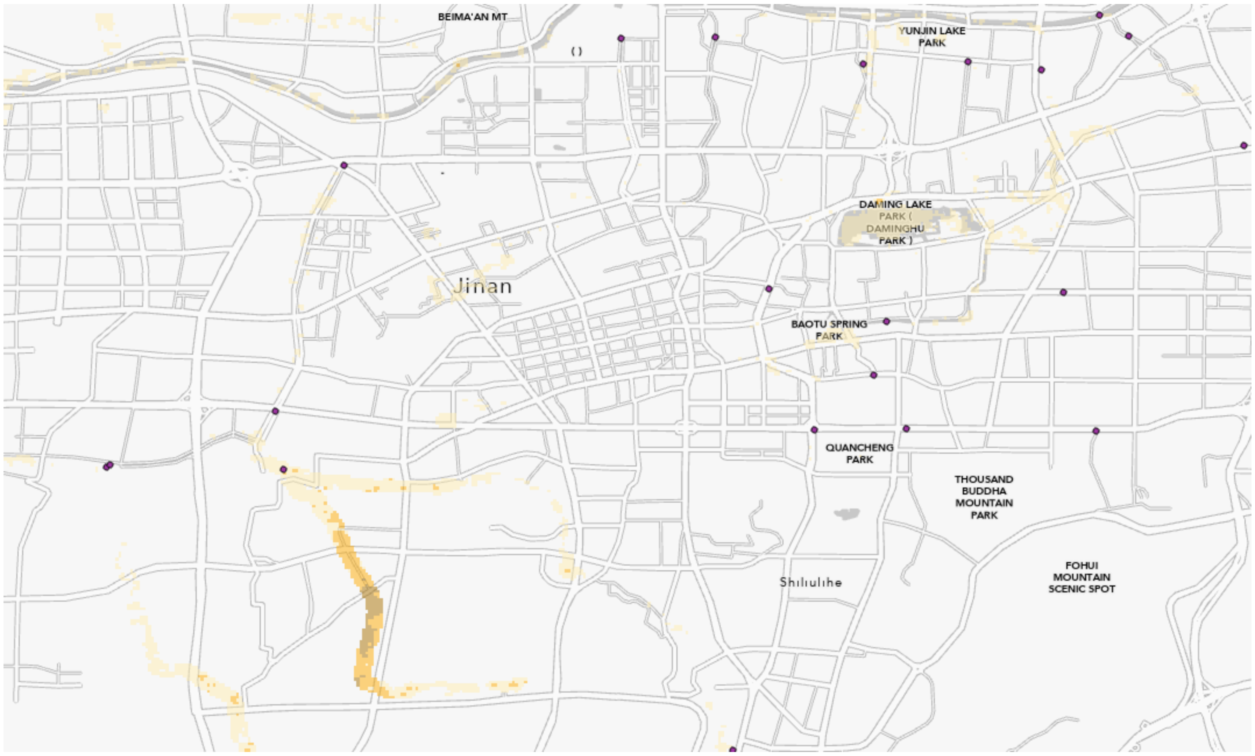


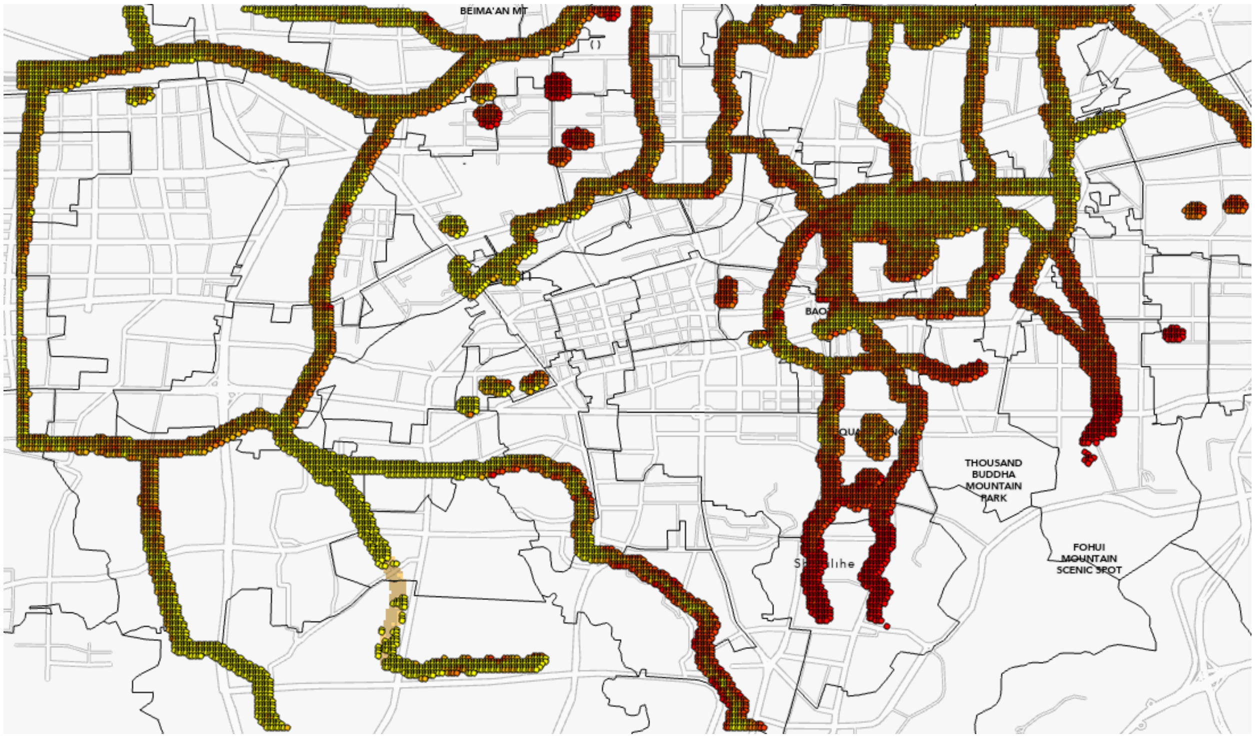
Figure 6. Extracted Result of Kriging Method



Part 3: Following-up data management and visualization

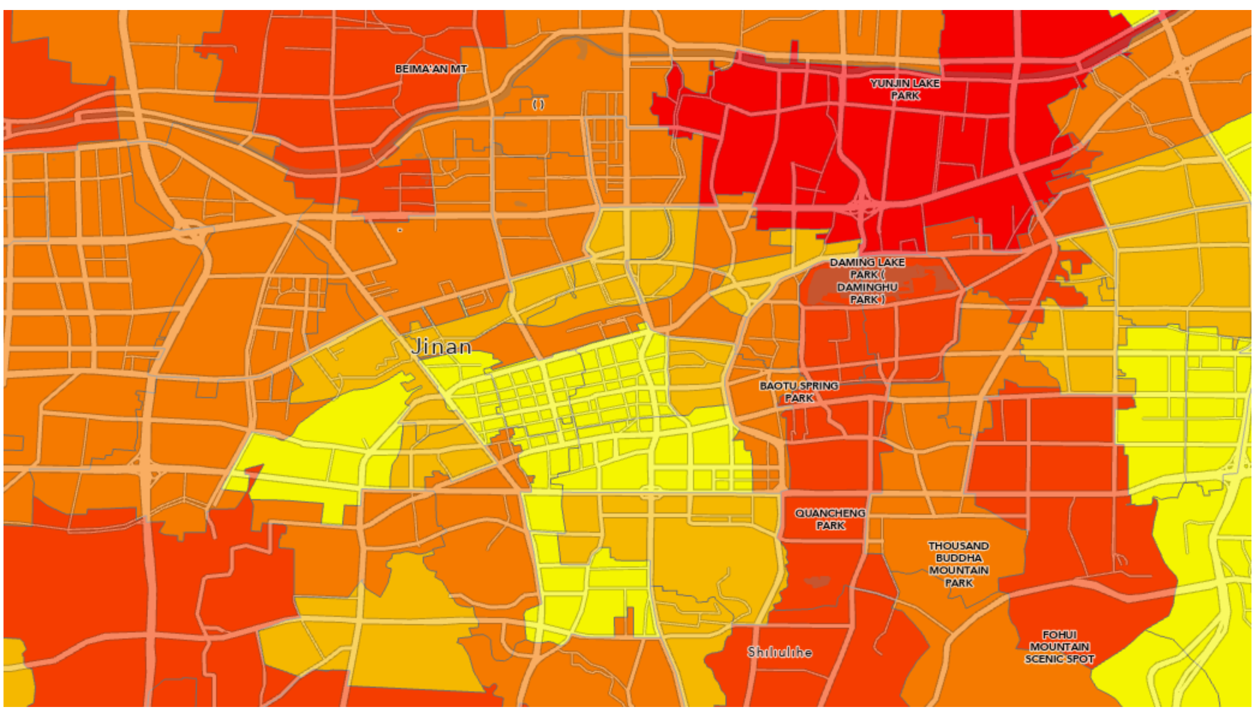
After finishing all the flooding risks data, I will use two different functions, raster to points and spatial join, to embed the value of the raster into the administrative communities in Jinan. With these data available, I can expand the topic to the following-up empirical socio-economic discussions of the flooding risk assessment if it is possible.

Figure 7. Raster Extraction into Vector Points



Results

Figure 8. The Result of the values of Flooding Risks embedded into each community



The Final Result would be a map of labelling some of the most sensitive communities to the flooding risk. The value will be unclassed in a continuous surface. The data nominalization or standardization by area is not included in this draft, nor standardization by population.

However, I will include some degree of socio-economic correlation analysis in my final draft to try to discuss how the socio-economic landscape influence the degree of river flooding risks in the city, and how the vulnerability of river flooding affects the socio-economic landscape too.

Results Verification

In the history of Jinan, there are not many flooding disasters documented, or at least, not open to public. Thus, it is different to validate whether the data is correct.

By retrieving all the news related to the heavy precipitation, it is possible to trace some sensitive area of river flooding. By tracing and georeferencing flooding areas in Jinan and mapping out the frequency of the areas reported, it is possible to compare and verify whether the results are precise. Please notify me if there are better verification method here.

Discussion and Conclusion

The research is not only a flooding risk spatial analysis but more like a starting point on how the flooding risk assessment can reveal the disparities of different communities and groups of people on their different resilience towards a looming natural hazard by bringing insights of Environmental Justice or Urban Political Ecology. This analysis can help local government and city council to identify the vulnerable communities toward flooding risks, but also focus on how the social-economic resource and infrastructures are unevenly distributed into different communities.

My research on river flooding can help the current scholarships identify and characterize the patterns of river flooding zones in the Chinese urban area. The analyses of how the communities that are more vulnerable to flood correlate to other socio-economic factors can also help the current scholarship discuss further and deeper the environmental justice in China.

Peer Reviewed Feedbacks

1. Whether I should take current water table or warning water table?

Comments from group: It is not realistic to take the current water table since the current water label changes frequently, but the warning water table do not change during a long-time span, so it is more suitable to use the warning water table.

2. Whether I should take the warning water table of one single river or I can do multiple?

Comments from group: The data is limited, as far as they noticed, most rivers only have one monitor stations, so it is unable to use the warning water table for a single river.

3. Whether I should use the warning water table of Yellow River?

Comments from group: The Yellow River would be the desired one, since the river is wide and long, the DEM data resolution is enough for conducting spatial analysis. However, I found there is not enough data for Yellow River alone, too, to conduct the analysis.

4. Other comments from the group：

Re-working on the diagram and made it more easily to understand.

Consider more about the validation measures.

References

Cheng, T., Xu, Z., Hong, S., & Song, S. (2017). Flood Risk Zoning by Using 2D Hydrodynamic Modeling: A Case Study in Jinan City. Mathematical Problems in Engineering, 2017, 1–8. https://doi.org/10.1155/2017/5659197

Cui, B., Wang, C., Tao, W., & You, Z. (2009). River channel network design for drought and flood control: A case study of Xiaoqinghe River basin, Jinan City, China. Journal of Environmental Management, 90(11), 3675–3686. https://doi.org/10.1016/j.jenvman.2009.07.010Jinan Hydrological Bureau. (2019). Hydrological Information Monthly Report of Jinan City. http://www.jnsww.com.cn:36789/ms-mcms/upload/1/editor/1557039568598.pdf

Feng, S., & Li, Q. (2018). Urban Flood Prevention and Early Warning System in Jinan City. E3S Web of Conferences, 38, 03047. https://doi.org/10.1051/e3sconf/20183803047

Lin, W., Sun, Y., Nijhuis, S., & Wang, Z. (2020). Scenario-based flood risk assessment for urbanizing deltas using future land-use simulation (FLUS): Guangzhou Metropolitan Area as a case study. The Science of the Total Environment, 739, 139899–139899. https://doi.org/10.1016/j.scitotenv.2020.139899

Major River Properties Report. Jinan Hydrological Information System. Last Retrieved on November 2, 2021. http://www.jnswj.net/htmlcache/jnsw-hdsq.html