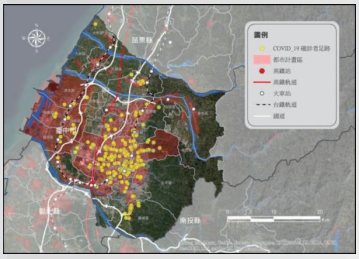
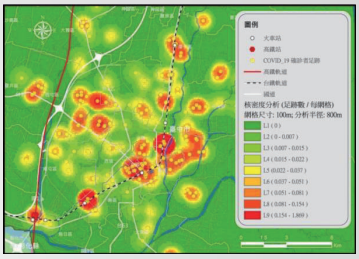
2022 International Conference of Asia-Pacific Planning Societies (ICAPPS)

Special session

Beyond Crisis: What should we do to overcome the crisis?





Facing global epidemic disease from spatial planning perspectives: a lesson from COVID-19 in Taichung City

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Speech Outline

- Introduction
  - COVID-19 in the world and Taiwan
  - Global research focuses about COVID-19
  - Influence factors of COVID-19 from spatial perspectives
- Background
  - COVID-19 in Taichung City
  - Urban planning and development in Taichung
  - Prevention policy of COVID-19 in Taiwan
- Research design
- Results (temporary)
  - Footprint numbers of confirmed COVID-19 cases
  - Variables from Land-use approach
  - Variables from transportation approach
  - Correlation and Regression analyses
- Discussion **with COVID-19**
  - Land-use diversity and mixed land-use policy
  - Development density and TOD policy
  - Public transportation with different influence
  - Open spaces in urban area
- Conclusion remarks

Introduction

- COVID-19 in the world and Taiwan
- Global research focuses about COVID-19
- Influence factors of COVID-19 from spatial perspectives

Introduction

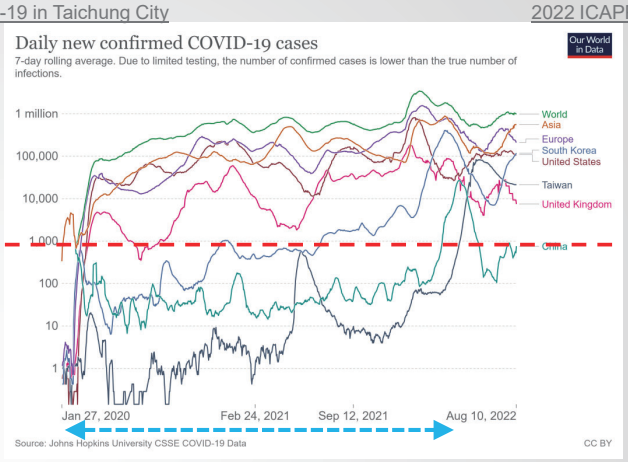
- COVID-19 in the world and Taiwan

  Global—

  - From 2020 to 2022, the most significant number of cases has confirmed in China, the United States, the United Kingdom, Germany and South Korea
  - Most of countries' daily new confirmed COVID-19 cases are over 1,000 and gave up detailed investigation of footprints for every COVID-19 case.

  Taiwan—

  - In the early stage of the outbreak, the number of confirmed cases was lower than most of the country
  - From May 2020 to Jun 2022, there are adequate footprints data for every COVID-19 case in Taiwan.
- Global research focuses of COVID-19
  - Most of analyses are from the perspectives of medicine, psychology, epidemiology, economics.
  - **Lack of the research on spatial planning and analysis**



Daily new confirmed COVID-19 cases in most country

Global research on COVID-19

Introduction

Table. Global research on COVID-19 in urban planning

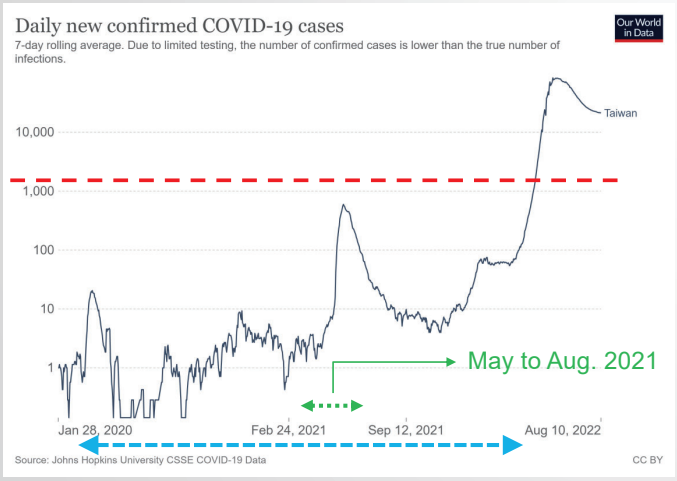
Research	Author、Year	Research Outline	Covid Metrics (Y)	Urban Factors(X)		Variable factors calculation	Methods
Associating COVID-19 Severity with Urban Factors: A Case Study of Wuhan	(Xin Li, et al. 2020)	Based on the help data from Weibo, infer the spatial distribution pattern and impact of the epidemic.	Dwelling address of the confirmed cases	Sociodemographic	Aging rate	Kernel Density Estimate	GWR model
				Urban sprawl	Volume rate		
				Urban facilities	Hospital density Subway station density Commercial facility density Road density		
				Land use	Shannon		
交通暴露與土地利用模式對社區covid-19傳播風險的影響	(Li, et al. 2020)	Based on modeling, inferred the key spatial parameters effecting community level covid-19 risk are the two aspects from traffic exposure and land use.	Dwelling address of the confirmed cases	Traffic exposure	Proximity of transportation facilities to important locations	Kernel Density Estimate	GLM model
				Land use	Mixed use		
Spatio-temporal analysis of COVID-19 incidence rate using GIS: a case study—Tehran metropolitan, Iran	(Nasiri, et al. 2021)	Build the spatial models of COVID-19 incidence, mortality, and mobility patterns, and encountered the relationship between COVID-19 and comorbidities, population density, and land use.	Incidence, mortality rate, Dwelling address of the confirmed cases	Sociodemographic	Population density	Hotspots Analysis	Inverse Distance Weighted GWR model

Background

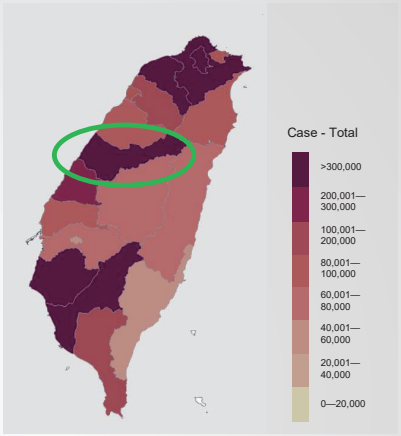
- COVID-19 in Taichung City
- Features of Urban Planning in Taichung
- Prevention policy of COVID-19 in Taiwan

Background

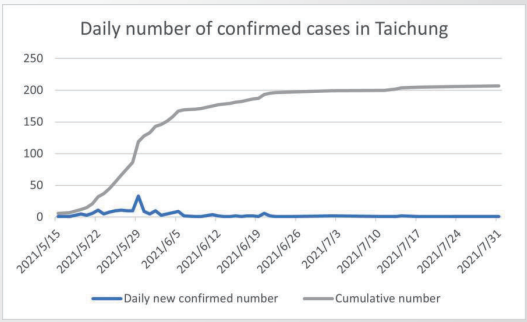
- COVID-19 development in Taiwan and Taichung
  - The COVID-19 spread from the capital (Taipei city) to the central and southern districts (like Taichung, Tainan, Kaohsiung and so on.)
  - Footprint data from May to August 2021 in Taichung are the only data that central and local government are willingness to release.



Daily new confirmed COVID-19 cases in Taiwan



Taiwan confirmed cases of COVID-19 (NCHC) / Retrieve date : 2022/08/08



Daily number of confirmed cases in Taichung

Background

- The second round of attack from COVID-19 was in May 2021 to August 2021.
- The only open data from the government are the confirmed cases footprint in Taichung from May 2021 to August 2021.

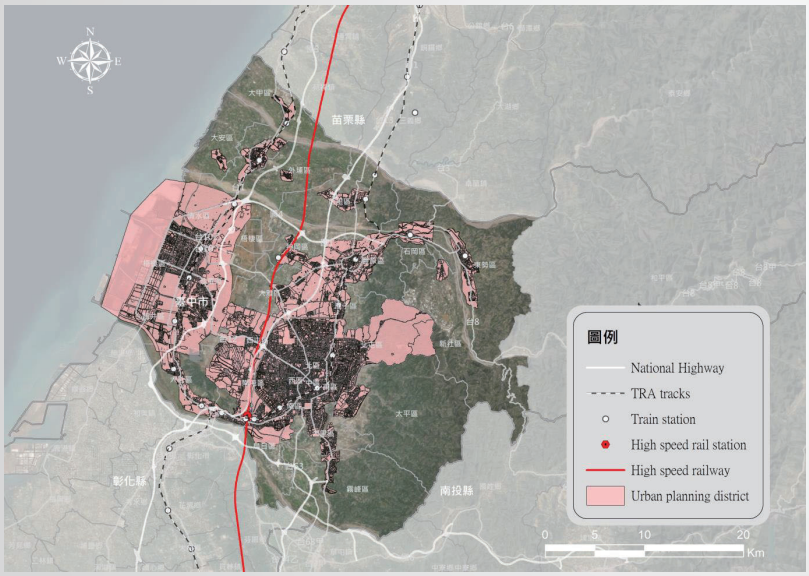


Fig.5 Urban planning district in Taichung

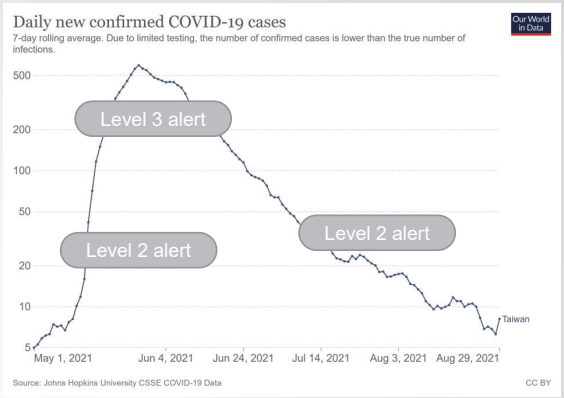


Fig.6 Daily new confirmed COVID-19 cases in Taiwan

- Taichung City: Population:2,800,000
  Area: 2,215 km^2
- Urban area: 538.7 km^2
- MRT (one line) was established in 2021.
- Most of people rely on private vehicles, bus and train system in Taichung.
- **Urban plans and zoning control from American urban planning system but allow mixed land-use.**

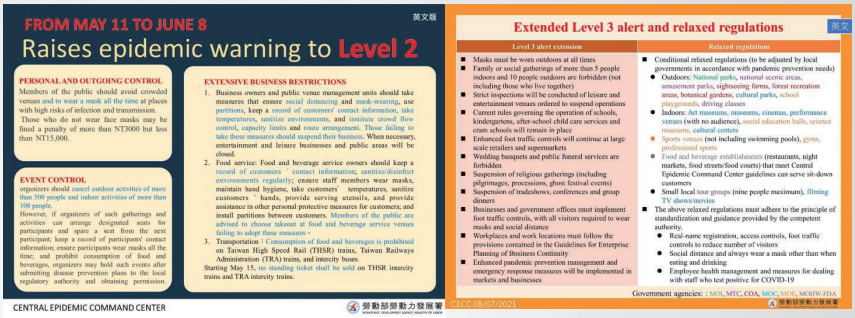
Background

Level 2 alert

- Ensure social distancing and mask-wearing.
- Cancel outdoor activities of more than 500 people and indoor activities of more than 100 people.
- Arrange designated seats for participants and spare a seat from the next participant and prohibit consumption of food and beverages.
- Consumption of food and beverages is prohibited on transportations and no standing ticket shall be sold.

Level 3 alert

- More than 5 people indoors and 10 people outdoors are forbidden.
- Leisure and entertainment venues are ordered to suspend operations.
- Enhanced foot traffic controls at large scale retailers, supermarkets, businesses and government offices.

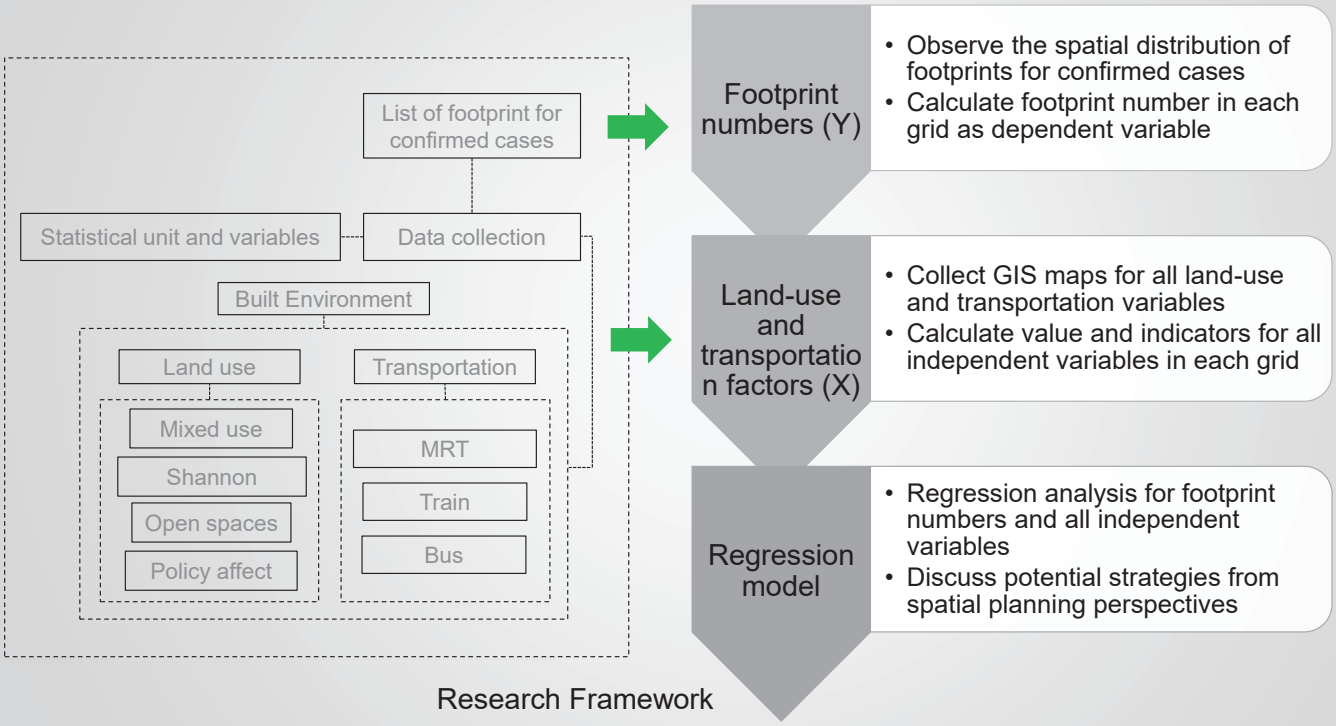


The COVID-19 level 2 and 3 alert (WDA)

The COVID-19 policy effect in Taiwan

Research Design

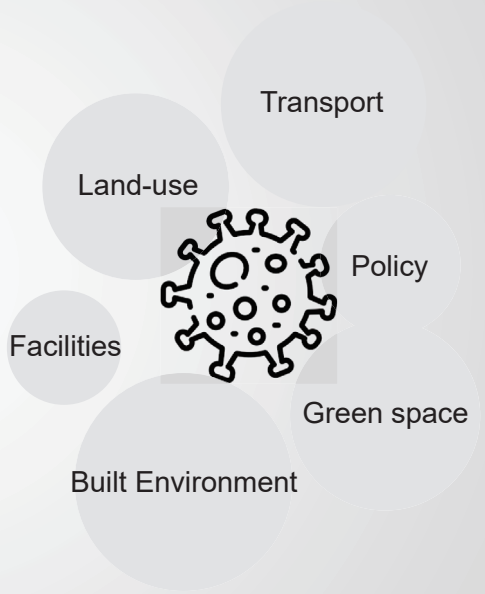
Research Design



Research Framework

Methods and data source

- Data Source
  - Government Open Data—
    - The footprint of COVID-19 in Taichung from 2021/05 to 2021/08（de-identification）
  - Construction and Planning Agency, Ministry of the Interior—
    - Land use survey and zoning maps in Taichung
  - Taichung Government, TRA, Open data and Open Street Map—
    - Stations and traffic (lines) volumes of MRT, Trains, and Bus data in Taichung
- Methods
  - Geographical Information System (GIS)
  - Regression Analysis Model
- Spatial Analysis
  - Spatial distribution pattern
  - Cross analysis of COVID-19 distribution pattern and spatial factors



Research Design

Variable definitions and calculation methods

		Code	Definition	Expected impact	Calculation	References
Dependent variable		Y_FPP	The footprint numbers of the confirmed COVID-19 cases	x	The numbers of the confirmed cases footprint in each grid	(Nasiri, et al. 2021；Azadeh Lak, et al. 2021)
Independent variables		X_mixeduse	Mixed land-use type	+	Ratio of mixed-use category area to the built environment in each grid	(Xin Li, et al. 2020；Li, et al. 2020；Behram Wali, Lawrence D. Frank. 2021)
	Land-use	X_openspaces	Open spaces	-	Ratio of open spaces category area to the built environment in each grid	(Boyeong Hong, et al. 2021)
		X_Shannon	Land-use diversity (Shannon index)	+	The diversity of the land use zoning in each grid	--
		X_built Env.	Area of built environment area	+	Area of built environment in each grid	--
	Policy	X_policy	Prohibited land-use area due to the epidemic prevention policy	-	Ratio of policy-impact category area to the built environment in each grid	--
	Transportation	X_MRT	MRT station amount	+	MRT station amount in each grid	(Xin Li, et al. 2020；Shuang Ma, et al. 2021；Azadeh Lak, et al. 2021)
		X_train_s	Train station and line amount	+	Total train station amount and line amount within neighborhood grids	
		X_bus_v	Bus station and line amount	+	Total bus station and volume (line) in each grid	

Results (temporal)

Results— Footprint points and grids

Table.3 The descriptive statistics of COVID-19 footprint point

Mean	Median	Mode	Standard Deviation	variance	Number
1.62	1	1	1.20	1.44	171
Kurtosis	Skewness	Range	Minimum	Maximum	Sum
18.34	3.59	9	1	10	277

- 703 Footprint points from 119 COVID-19 confirmed cases
- Select **171 grids** of **500x500 m^2** that have at least one footprint for statistical analysis.

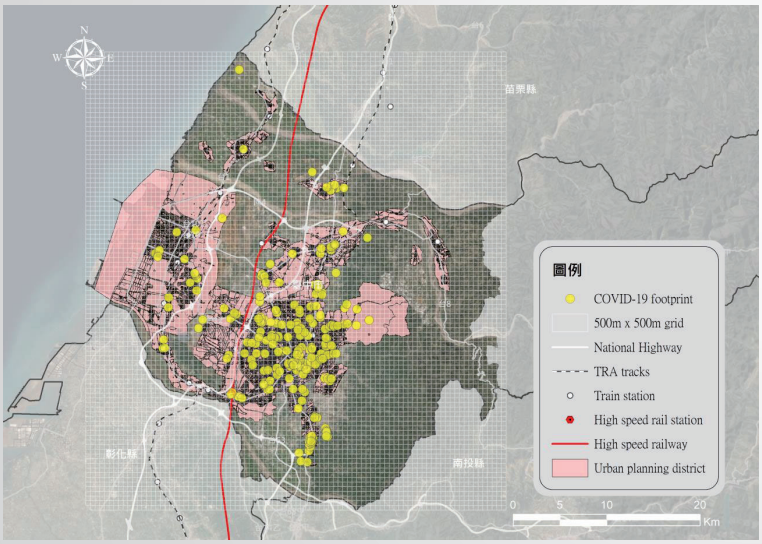


Fig. COVID-19 footprint points

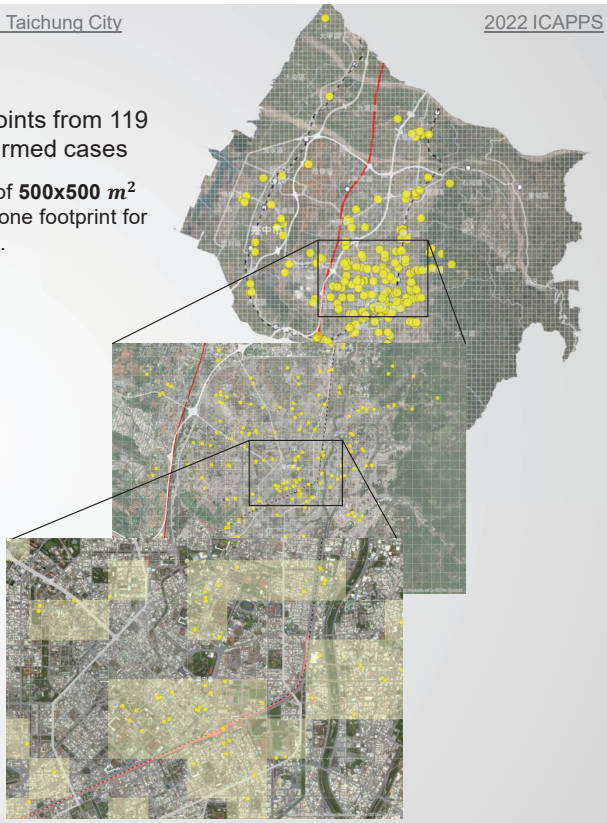


Fig.13 Example location

Results— Mixed land-use area

- Mixed land-use area presents positive correlation with footprint numbers

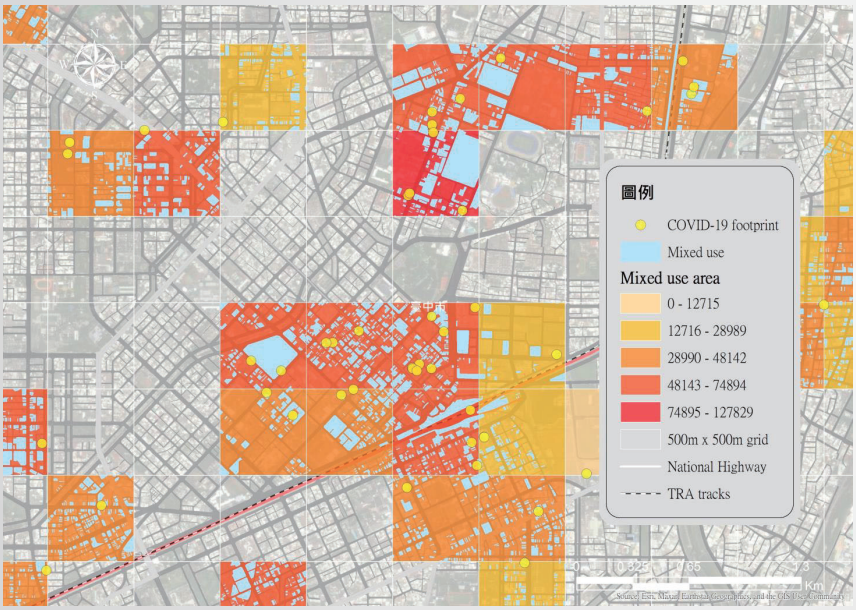


Fig. Mixed use area

- Mixed use
  - Mixed land-use may increase activity complexity and potential for cross-infection.
  - A special phenomena in Taiwan.

Table.4 The descriptive statistics of mixed use

Mean	Median	Mode	Standard Deviation	Variance	Number
0.16	0.14	0	0.14	0.02	171
Kurtosis	Skewness	Range	Minimum	Maximum	Sum
7.24	2.19	0.88	0	0.88	28.13

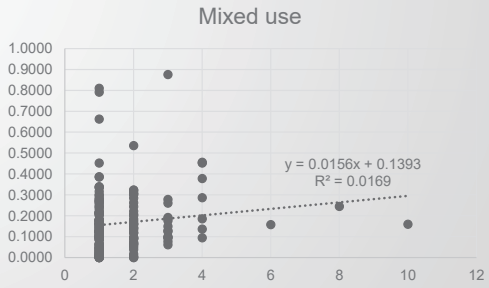


Fig.15 Mixed use scatter diagram

Results— Shannon index for land-use diversity

- The correlation between land use diversity and the footprint is not significant.

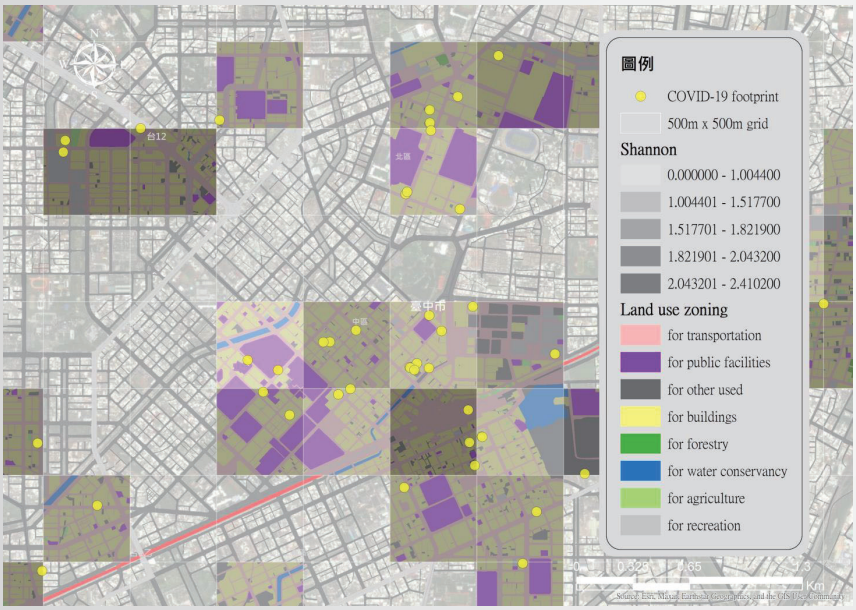


Fig. Land use zoning area

- Shannon index
  - More different land-se in the grid, provide more function to the neighborhood.

Table.6 The descriptive statistics of Shannon

Mean	Median	Mode	Standard Deviation	variance	Number
1.66	1.76	--	0.4	0.16	171
Kurtosis	Skewness	Range	Minimum	Maximum	Sum
2.44	-1.33	2.41	0	2.41	284.21

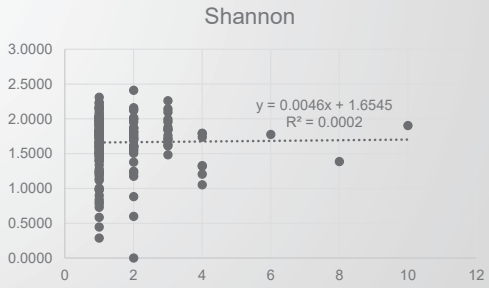


Fig.19 Shannon scatter diagram

Results— Open spaces area

- Open spaces area present slightly negative correlation with low R^2.

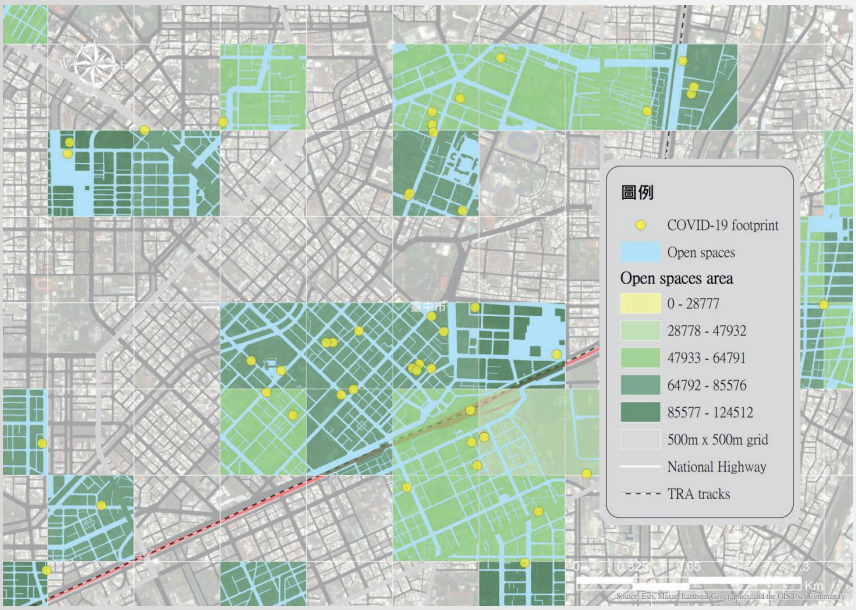


Fig. Open spaces area

- Open spaces
  - Where people could easily gain social distance.
  - Activities are not likely to be prohibited.

Table.5 The descriptive statistics of open spaces

Mean	Median	Mode	Standard Deviation	variance	Number
0.29	0.27	--	0.14	0.02	171
Kurtosis	Skewness	Range	Minimum	Maximum	Sum
5.80	1.89	0.94	0	0.94	49.95

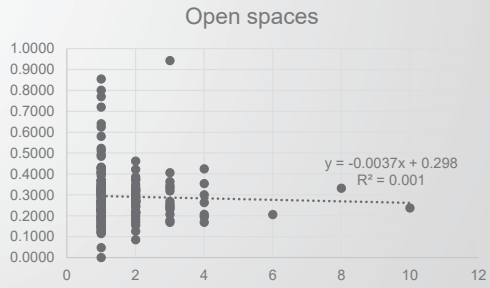


Fig.17 Open spaces scatter diagram

Results— Area of land-use which impacted by epidemic prevention policy

- The correlation between policy-impacted land-use and the footprint is slightly positive with low R2

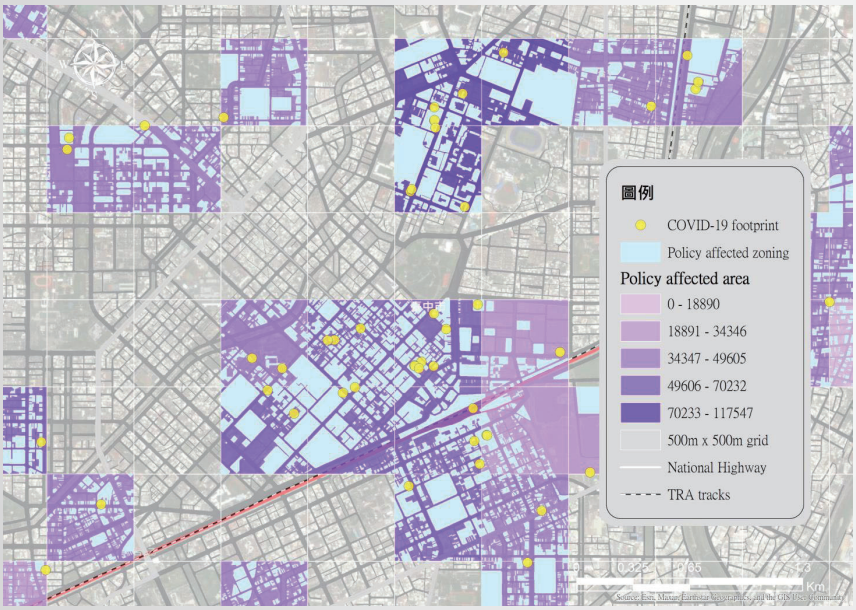


Fig. Policy-impact area

- Policy-impact
  - The epidemic prevention policies could reduce the activity intensity or reduce the opportunities for people to gathered.

Table.7 The descriptive statistics of policy-impact

Mean	Median	Mode	Standard Deviation	variance	Number
3.84	3.85	--	2.03	4.11	171
Kurtosis	Skewness	Range	Minimum	Maximum	Sum
0.74	0.44	11.75	0	11.75	656.63

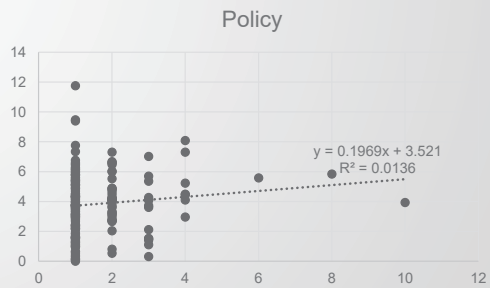


Fig.21 Policy-impact scatter diagram

Results— Built environment

- The correlation between built environment area and the footprint numbers is positive with low R^2

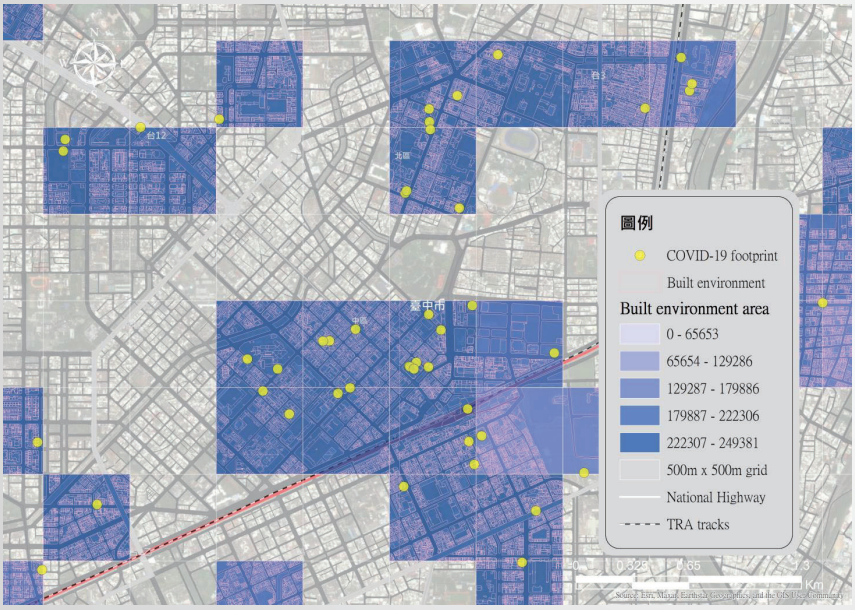


Fig. Built environment area

- Built environment
  - Built environment are the main area where people work or shop everyday.

Table.8 The descriptive statistics of built environment

Mean	Median	Mode	Standard Deviation	variance	Number
18.55	20.89	--	5.93	35.13	171
Kurtosis	Skewness	Range	Minimum	Maximum	Sum
0.6	-1.12	24.94	0	24.94	3172.66

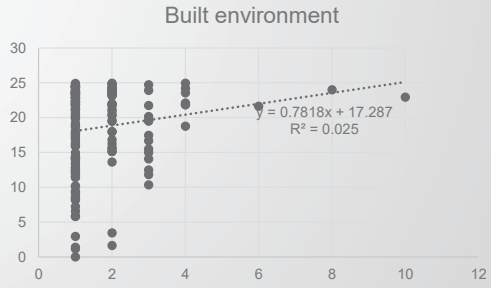


Fig.23 Built environment scatter diagram

Results— Train station and line amount

- The correlation between train station and the footprint were non-significant.

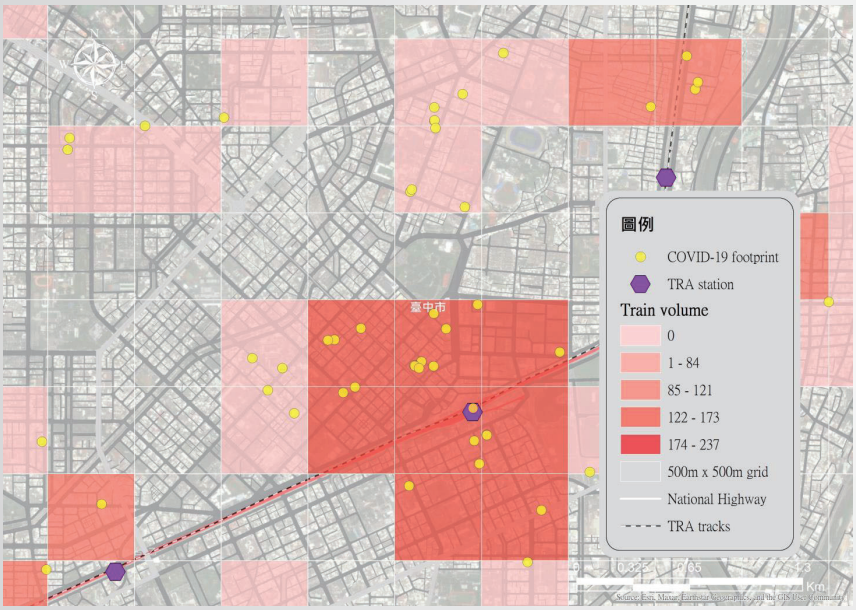


Fig. Train station and volume

- Train station and volume
  - Trains are the main transportation for people between the county.
  - The area around train stations has more footprint.

Table.9 The descriptive statistics of train station

Mean	Median	Mode	Standard Deviation	variance	Number
0.18	0	0	0.43	0.18	171
Kurtosis	Skewness	Range	Minimum	Maximum	Sum
4.85	2.32	2	0	2	31

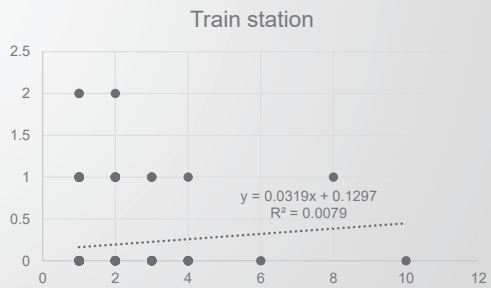


Fig.25 Train station scatter diagram

Results— Bus station and volume

- Bus volume presents positive correlation with footprint numbers

Fig. Bus station and volume

- Bus station and volume
  - Bus stations makes the more mobility in the neighborhood.
  - Frequent contact via transportation can exacerbated the epidemic in the area.

Table.10 The descriptive statistics of bus volume

Mean	Median	Mode	Standard Deviation	variance	Number
35.44	20	0	47.15	2223.3	171
Kurtosis	Skewness	Range	Minimum	Maximum	Sum
11.97	3.01	304	0	304	6061

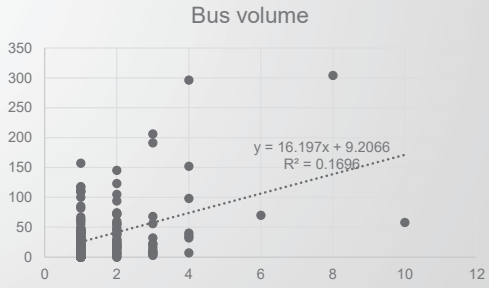


Fig.27 Bus volume scatter diagram

Results—Correlation and Collinearity of Explanatory Variables

- Correlation analysis
  - Except for built environment and policy, there is no significant collinearity between independent variables.

Correlation of explanatory variables

	Y_AFF	X_mixeduse	X_openspaces	X_shannon	X_policy	X_BE	X_train_s	X_bus_v
Y_AFF	1							
X_mixeduse	0.130	1						
X_openspaces	-0.032	0.441	1					
X_shannon	0.014	0.071	-0.041	1				
X_policy	0.116	0.391	-0.192	0.128	1			
X_BE	0.158	0.270	-0.246	0.130	0.702	1		
X_train_s	0.089	0.123	-0.126	-0.061	0.136	0.146	1	
X_bus_v	0.412	0.231	-0.045	0.033	0.405	0.385	0.172	1

Results

- Regression model
  - Compared to other variables, mixed land-use and bus volume has a higher explanation ability.
  - R^2 0.18. There are still some other variables we should consider.

Table.12 Regression model test

	Test1	Test2	Test3	Test4	Test5	Test6	Final test
	係數(t)	係數(t)	係數(t)	係數(t)	係數(t)	係數(t)	係數(t)
截距	1.2260(2.15)	1.4308(2.71)	1.1707(2.70)	1.4372(3.56)	1.1876(4.16)	1.4325(3.53)	1.4230(2.69)
X_mixeduse	1.2847(1.49)	0.9318(1.17)	0.5276(0.82)	0.9325(1.18)	0.5287(0.82)	0.9205(1.16)	0.9194(1.15)
X_openspaces	-0.7252(-0.84)	-0.6914(-0.87)	--	-0.6920(-0.87)	--	-0.6787(-0.85)	-0.6778(-0.85)
X_Shannon	0.0159(0.07)	0.0042(0.02)	0.0112(0.05)	--	--	--	0.0061(0.03)
X_policy	-0.0282(-0.41)	-0.0883(-1.37)	-0.0754(-1.21)	-0.0883(-1.38)	-0.0752(-1.21)	-0.0881(-1.37)	-0.0881(-1.37)
X_BE	0.0094(0.38)	0.0102(0.49)	0.0135(0.66)	0.0102(0.49)	0.0135(0.67)	0.0102(0.49)	0.0101(0.49)
X_train_s	0.0947(0.43)	--	--	--	--	0.0166(0.08)	0.0171(0.08)
X_train_v	--	0.0000(-0.02)	0.0002(0.10)	0.0000(-0.02)	0.0002(0.10)	--	--
X_bus_s	0.1204(1.78)*	--	--	--	--	--	--
X_bus_v	--	0.0108(5.27)**	0.0107(5.24)**	0.0108(5.29)**	0.0107(5.26)**	0.0108(5.35)**	0.0108(5.33)**
X_tmrt_s	-0.9365(-1.32)		--	--	--	--	--
R^2	0.0660	0.1820	0.1782	0.1820	0.1782	0.1821	0.1821

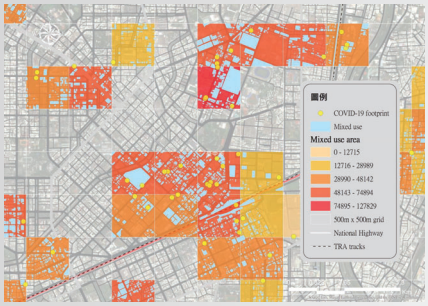
*：表示相關性在0.1層級上顯著
**：表示相關性在0.05層級上顯著

Discussion with COVID-19

- Land-use diversity and mixed land-use policy
- Development density and TOD policy
- Public transportation with different influence
- Open spaces in urban area

Discussion

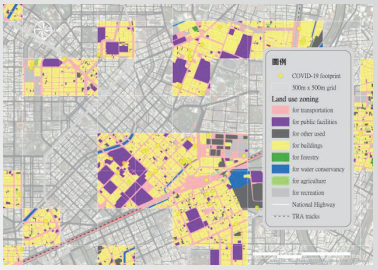
- Land-use diversity and mixed land-use policy



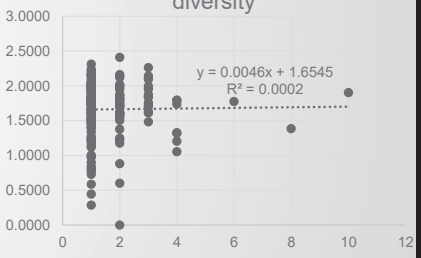
- There is no adequate evidence to prove that land-use diversity will increase footprint numbers and affected risk in Taichung.
- Mixed land-use policy significantly increase footprint numbers.
- Coefficient of elasticity

$$E(Y_i \cdot mixeduse) \equiv \frac{\Delta\%\delta Y_i}{\Delta\%\delta mixeduse_i}$$

$$= 0.81\ \%$$



Shannon index for land-use diversity



- Decrease 1% mixed land-use area may decrease 0.8% footprint numbers
- Direction of potential strategies to built up a safer urban environment to epidemic diseases.

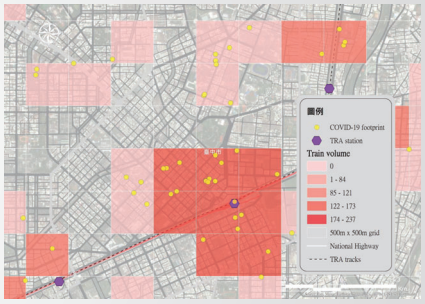
Discussion

- Public transportation with different influence on footprint numbers

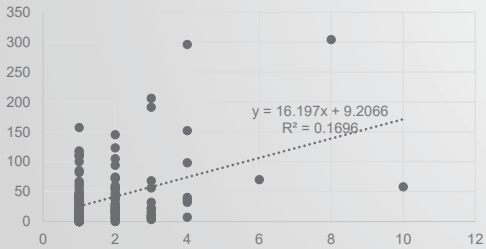
- Train system in Taichung is an transfer tool for citizens and stations is usually not a destination for a trip. Therefore, There is no significant correlation with footprint numbers.
- However, bus station and line volume significantly increase footprint numbers.
- Coefficient of elasticity

$$E(Y_i \cdot bus) \equiv \frac{\Delta\%\delta Y_i}{\Delta\%\delta bus_i}$$

$$= 0.20\ \%$$



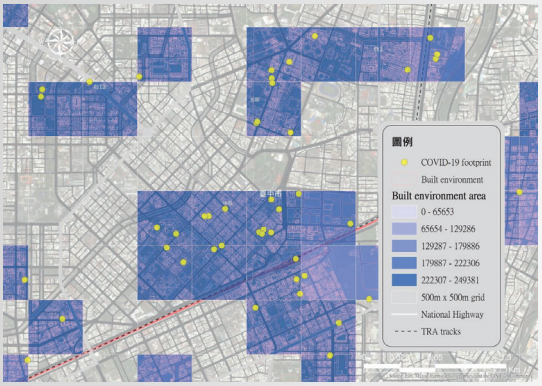
Bus line volume

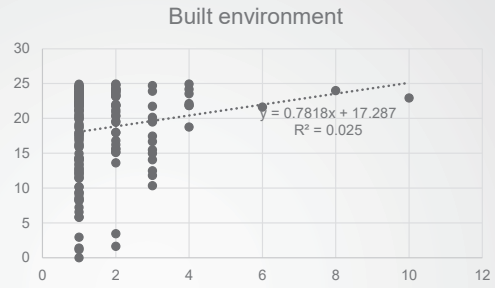


- Decrease 1 % bus line volume may decrease 0.2 % footprint numbers
- Epidemic prevent policy with spatial heterogeneity can help us to focus on high risk area.

Discussion

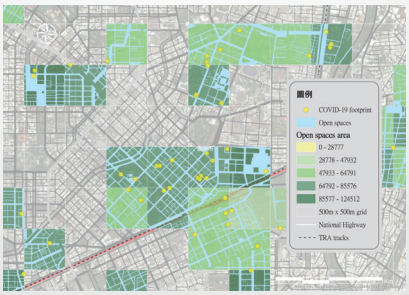
- Development density and TOD policy

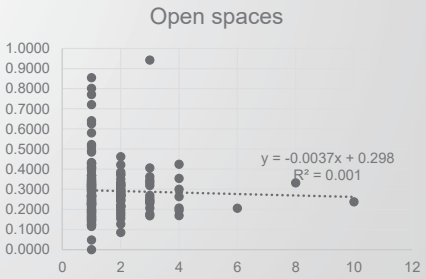


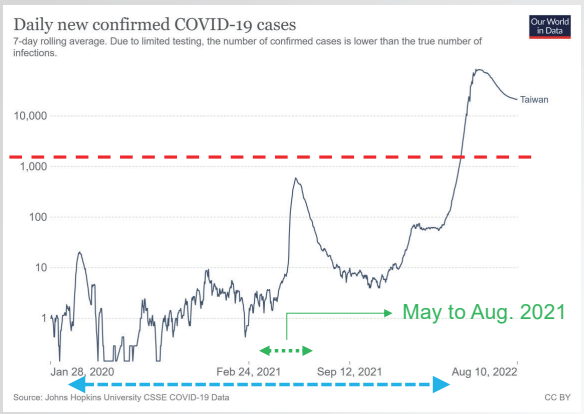


- We have no adequate evidence to prove the correlation for development density and open spaces to footprint numbers at present in Taichung.
- Still need more footprint data, effort, and vertical approach to understand development density and intensity.

- Open spaces in urban area







Conclusion Remarks

- If global epidemic disease (COVID-19) is an once-time attack to us, we can get used to it and survive. But if it becomes a “new normal” to our society, we need to reconsider our urban and spatial planning policy and help to adjust urban structure to a safer and easier environment to fight with the disease.
- Release more COVID-19 footprint data for urban and spatial researchers. They will help to propose COVID-19 prevention policy with spatial heterogeneity and rethinking open spaces, mixed land-use, and TOD policy.