

Leveraging GIS for battle against COVID-19 in Hong Kong

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SUMMARY

To support the Government of the Hong Kong Special Administrative Region in fighting Coronavirus Disease (COVID-19) with scientific evidence since February 2020, the Lands Department (LandsD) as the pioneer of geospatial technology in Hong Kong played a key role in leveraging GIS technology for strategic decision-making in COVID-19 pandemic. At the early stage of the pandemic, an interactive map dashboard for COVID-19 was developed within 3 days for effective dissemination of COVID-19 information with a view to better informing the community of the risk they have exposed so as to stay away from possible sources of information. Guided by the three key principles of "responding promptly", "staying alert to the situation" and "working in an open and transparent manner", we made use of demographic and 3D pedestrian network data to perform location-allocation analysis to facilitate the Government in determining the optimal locations for setting up the community testing sites in order to serve the most people within a walkable distance. To further strengthen the work on contact tracing, a Geospatial Information Portal (GIP) specifically designed for case investigation and contact tracing by linking up various relevant departments, agencies and existing information systems to gather the information of confirmed patients and contacts was developed to support link analysis for tracing upstream and downstream contacts based on exposure time and place of confirmed patients. Although the battle against COVID-19 has not over yet, GIS has well been proven as a powerful and promising decision-making tool for the Government in fighting COVID-19.

1 INTRODUCTION

1.1 Overview of COVID-19 pandemic in Hong Kong

1.1.1 Since the COVID-19 was first confirmed to have spread in Hong Kong on 23 January 2020, Hong Kong has commenced the battle against the pandemic by science and evidence (Chan, 2022). The Government of the Hong Kong Special Administrative Region (HKSAR) has leveraged the Geographic Information System (GIS) technology to keep the public informed of the latest situation of COVID-19 and support the implementation of key control measures over the time with a view to achieving "early identification, early isolation and early treatment" strategy.

1.2 Applications of GIS to fight against COVID-19 by LandsD

1.2.1 With its extensive geospatial technology expertise, the LandsD of the HKSAR has effectively applied GIS to support the Government in fighting the COVID-19 pandemic including the development of an interactive map dashboard for COVID-19 (Dashboard), geocoding services for the Case Information Portal for Department of Health (DHCIP) and GIP. Furthermore, LandsD provided spatial analysis services to support the planning and implementation of anti-epidemic measures.

1.2.2 LandsD has effectively demonstrated the power of spatial analysis with GIS for the COVID-19 pandemic. Take the site selection of community testing centres and specimen collection points as an example. With the use of 3D pedestrian network and the demographic data, LandsD has performed location-allocation analysis to assist the Government in determining the optimal locations for setting up the community testing centres and specimen collection points in order to serve the most people within a walkable distance. Another example is the use of spatial analysis to produce heat maps to facilitate visualization of clusters with most confirmed COVID-19 cases during the outbreak of the pandemic.

2 INTERACTIVE MAP DASHBOARD FOR COVID-19

2.1 Background

2.1.1 Effective dissemination of information about COVID-19 to the general public is a key measure to better inform the community about the risk they have been exposed to in order to stay away from potential sources of infection to prevent COVID-19 transmission.

2.1.2 Due to the outbreak of COVID-19 in Hong Kong, LandsD has swiftly developed the Dashboard within 3 days and which was launched on 3 February 2020 to show the latest epidemic situation such as the critical figures and the buildings with confirmed/probable cases of COVID-19 (The Government of the HKSAR, 2020). The content of the Dashboard has been enriched continuously to provide more useful information related to the epidemic to the public (e.g. information about the community vaccination and testing services, compulsory testing notices, quarantine and isolation facilities, statistics on COVID-19 infection, etc.) in response to the government policy. As of early April 2022, the Dashboard has reached more than 76 million view counts on mobile and desktop versions.

2.2 Location with cases tested positive for COVID-19

2.2.1 Apart from the latest daily figures of local situation of COVID-19, the buildings resided/visited by the cases tested positive for COVID-19 in the past 14 days were also mapped onto the Dashboard and associated with the case details to increase the public awareness of the locations at risk of infection more intuitively so as to prevent the spread of virus in the community (Fig. 1). To facilitate the public to locate high-risk locations nearby, a few add-on GIS features such as location search' and 'near me' functions were incorporated into the Dashboard over the time.

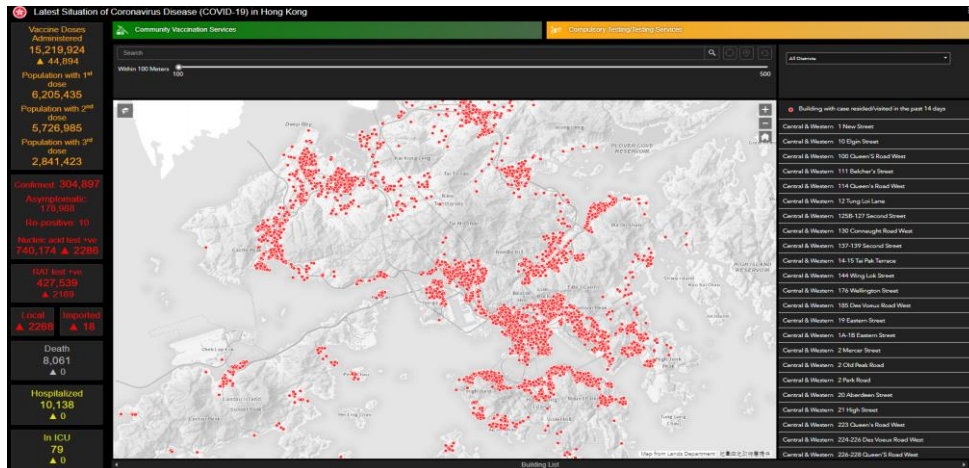


Figure 1 - Interactive map dashboard for COVID-19 - Building List
 (Retrieved from: <https://chp-dashboard.geodata.gov.hk/covid-19/en.html>)

2.3 Testing Services

2.3.1 With the prolonged local COVID-19 epidemic situation, the Government has exercised a series of preventive and control measures decisively to achieve the objective of "early identification, early isolation and early treatment" with a view to cutting the transmission chain and controlling the spread of COVID-19 in the community as early as possible.

2.3.2 In terms of early identification, the Government has continuously delineated the specified premises of compulsory testing notice and restricted areas with 'restriction-testing declaration' under the Prevention and Control of Disease (Compulsory Testing for Certain Persons) Regulation (Cap. 599J) to require any person suspected of having contacted with COVID-19 to undergo compulsory testing on a mandatory basis. In response to these regulatory measures, the specified premises and restricted areas have been plotted on the designated map of Dashboard to draw the public's attention where they are required for compulsory testing (Fig. 2).



Figure 2 - Interactive map dashboard for COVID-19 - Compulsory Testing (Retrieved from: <https://chp-dashboard.geodata.gov.hk/covid-19/en.html>)

2.3.3 In addition, a Universal Community Testing Programme was organized in September 2020 to provide continuous convenient testing services to the public in facilitating community testing by all possible means (e.g. Community Testing Centres, Mobile Testing Stations, distribution/collection points of specimen). Such information has been continuously uploaded to the Dashboard, so that the public could easily locate the most up-to-date venues providing testing services to cope with the “early identification” strategy.

2.4 Vaccination Services

2.4.1 To safeguard public health, the Government was implementing a territory-wide COVID-19 Vaccination Programme to offer two types of vaccines (i.e. BioNTech and SinoVac) free of charge to all Hong Kong residents to minimise the risk of COVID-19 infection. The vaccination services have been provided to various groups of the residents at different types of venues, including Community Vaccination Centres (CVCs), children CVCs, General Out-patient Clinics of the Hospital Authority (HA), District Health Centres, Mobile Vaccination Stations and private clinics, etc. The location information of vaccination venues have been continuously updated on the

Dashboard, enabling the public to find the venues providing their own suitable type of vaccines more conveniently and interactively (Fig. 3).

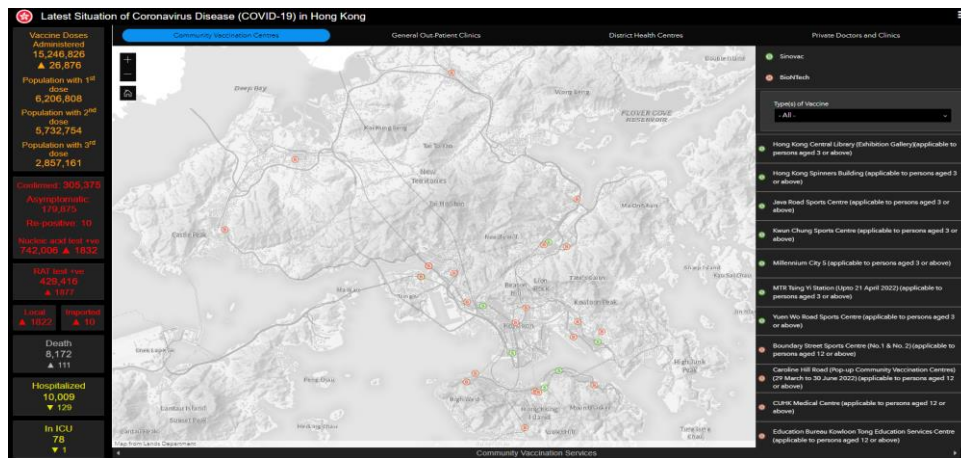


Figure 3 - Interactive map dashboard for COVID-19 - Vaccination Services (Retrieved from: <https://chp-dashboard.geodata.gov.hk/covid-19/en.html>)

2.5 Quarantine Locations

2.5.1 Besides mapping the quarantine centres for people who are close contacts of the confirmed cases, designated quarantine hotels were mapped on the Dashboard to help inbound travelers to look for the designated hotels to undergo compulsory quarantine after arrivals and make reservations for hotel rooms in advance. In addition, the residential buildings where persons under ‘StayHomeSafe’ home quarantine scheme have also been released onto the Dashboard.

2.6 Isolation and Treatment Facilities

2.6.1 To relieve the pressure on the demand for hospital isolation beds at the 5th wave of outbreaks, some of the confirmed patients were isolated in community isolation facilities (CIFs) subject to the health conditions, living environment, and some other factors. Also, a number of designated clinics were activated for treating patients with mild symptoms. To keep the general public abreast of the isolation measures, the relevant information has been extensively updated on the Dashboard from time to time.

2.7 Dissemination of Open Data

2.7.1 All the above information on the Dashboard has also been opened-up on the Hong Kong GeoData Store in open standard geospatial data interchange format (i.e. GeoJSON, GML) to facilitate the development of various innovative applications by external parties and promote the smart city development and geospatial data applications (Fig. 4).

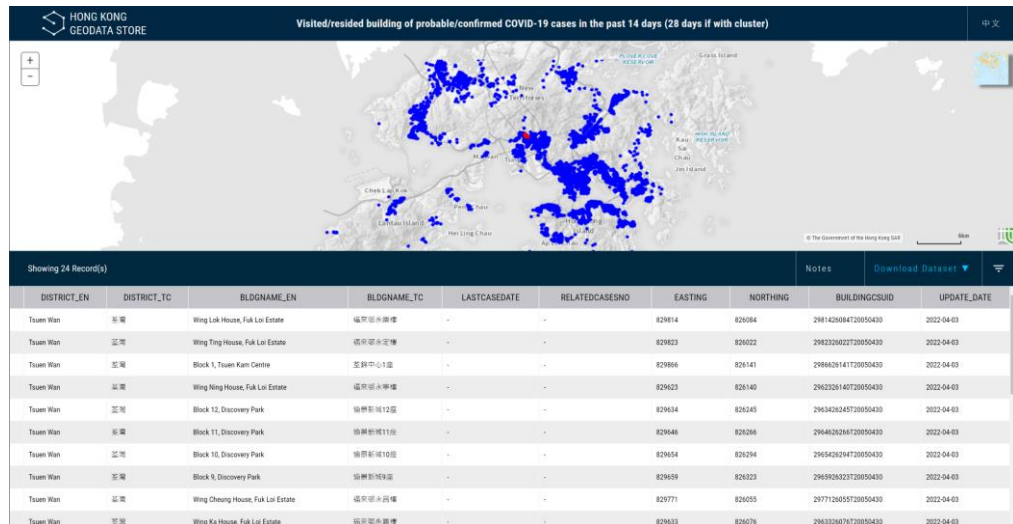


Figure 4 - Hong Kong GeoData Store
(Retrieved from: <https://geodata.gov.hk/gsl/>)

3 CASE INFORMATION PORTAL FOR DEPARTMENT OF HEALTH WITH GEOCODING SERVICES

3.1 DHCIP

3.1.1 The Government had realised the constraints and limitations of the traditional paper-based contact tracing approach adopted previously and has prepared for the next wave of outbreak. It was decided to leverage the IT/GIS technologies in collecting case information for enhancing the capability, efficiency and effectiveness of contact tracing in October 2020. It aimed to set up a centralized database system, namely DHCIP, which not only collected the case information in digital forms, but also shared the information among relevant systems (e.g. Dashboard) timely. It also supported geo-enabling the exposure locations of the confirmed cases and their close contact, to facilitate the subsequent contract tracing analysis.

3.2 LandsD's Geocoding Services

3.2.1 To help the frontline staff to record the exposure locations of confirmed cases and their close contact more efficiently and accurately, LandsD has customised a geocoding service and embedded in DHCIP, allowing frontline staff to acquire geographical locations and structured addresses easily by searching for building names, place names, and specific premises, etc. or by geotagging the location on-screen (Fig. 5).

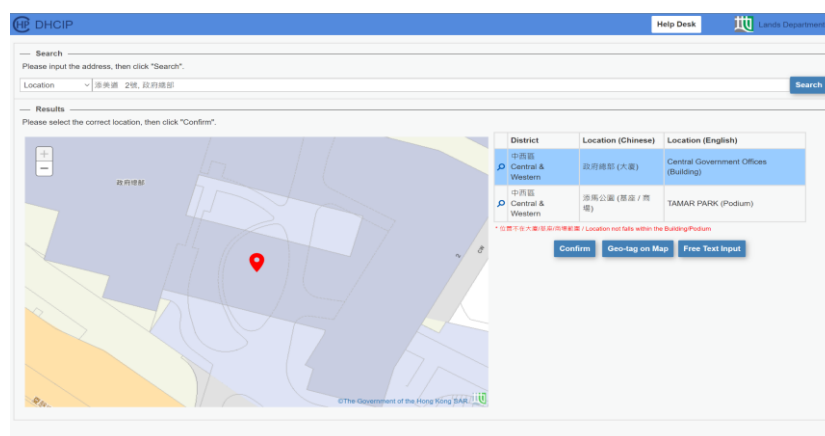


Figure 5 - LandsD's Geocoding Services for DHCIP

4 GEOSPATIAL INFORMATION PORTAL (GIP) FOR COVID-19

4.1 Background

4.1.1 In the meantime, LandsD has also developed the GIP for COVID-19, comprising case information and link analysis modules, to enable internal government bureaux and departments to visualise the spread of COVID-19 and correlate the exposure locations spatially with other geospatial information such as the sewage testing result, premises and restricted areas under compulsory testing, etc.; and identify possible sources of infection of cases and epidemiological links to other cases by ‘time’, ‘place’ and ‘person’ in order to cut the transmission link immediately.

4.2 Case Information

4.2.1 The case information module of GIP provides a wide range of the most up-to-date COVID-19 information and operational data, such as the details and resided/visited locations of each confirmed case, locations of sewage and its testing results, premises and areas under compulsory testing notice, etc. This collaborative information was more important for the specialists to analyse the spread of COVID-19, to identify high risk areas, and plan for appropriate anti-epidemic measures and operations to support the fight against COVID-19 (Fig. 6).

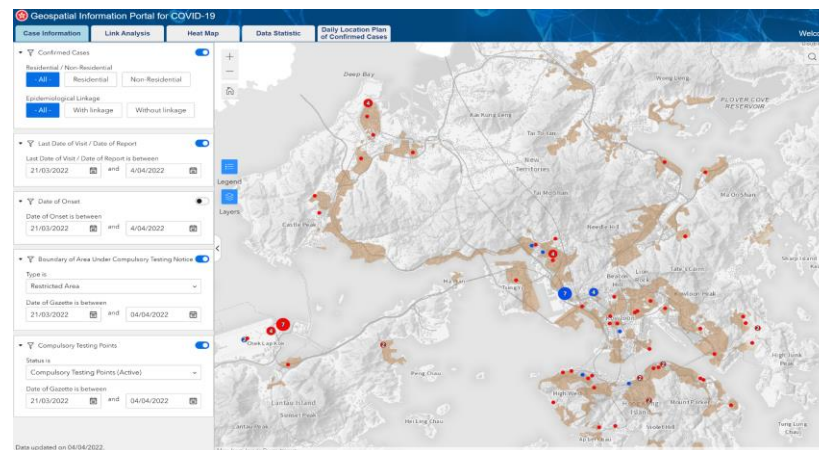


Figure 6 - Geospatial Information Portal - Case Information

4.3 Link Analysis

- 4.3.1 Link Analysis and epidemiological investigations are the keys to cut the transmission chain and control the spread of COVID-19 in the community. With the exposure history of all the confirmed cases, including the traveling period, the place(s) visited and the person(s) met during the incubation period, the link analysis module of GIP showed not only the relationship between confirmed cases in a schematic diagram and indicated the large cluster where it occurred.
- 4.3.2 With the domain knowledge of infection establishment provided by epidemiology specialists, COVID-19 infection network graph illustrating linkage of confirmed cases based on the business logic shown on Figure 8 has been generated automatically to enable contact tracing officers tracing upstream and downstream contacts of confirmed cases interactively with the geolocation on map so as to facilitate the investigation on individual behavior and activities and prediction of the spread of the COVID-19 virus transmission (Fig. 7).

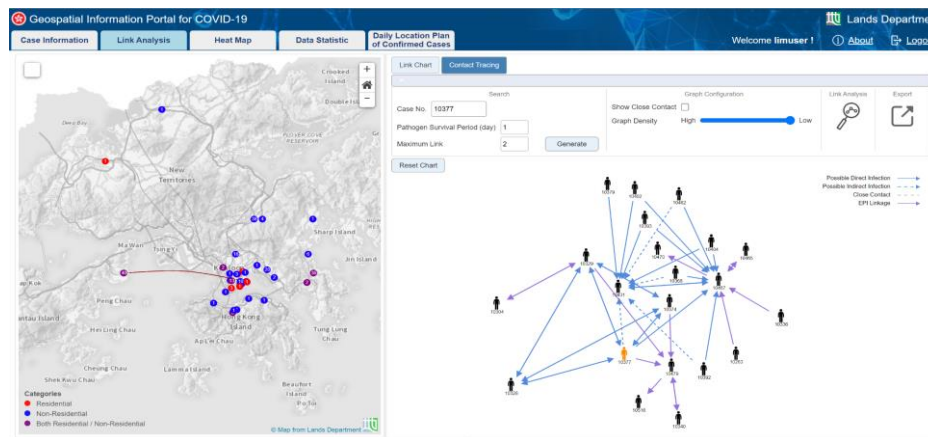
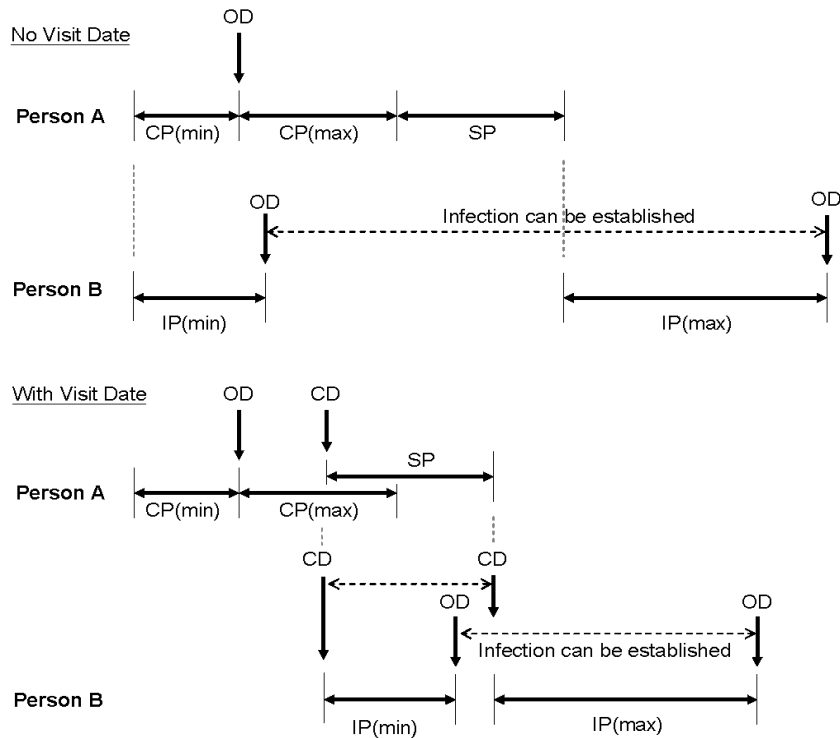


Figure 7 - Geospatial Information Portal - Link Analysis



- Where
- OD* = *Onset Date*
 - CD* = *Contact Date or Visit Date*
 - IP_(min)* = *Incubation Period (minimum)*
 - IP_(max)* = *Incubation Period (maximum)*
 - CP_(min)* = *Communicable Period (minimum) (can be < OD)*
 - CP_(max)* = *Communicable Period (maximum) (can be < OD)*
 - SP* = *Pathogen Survival Period (SP ≥ 0)*
 - A* = *Person A*
 - B* = *Person B*

Figure 8 - Link Analysis by time, place, and person

5 PROVISION OF SPATIAL ANALYSIS SERVICES

5.1 Location-Allocation Analysis for Testing Services

5.1.1 In view of the 4th wave, with over a hundred of new cases reported daily in November 2020, the government has strengthened relevant regulations to require certain categories of persons at higher risk of infection to undergo COVID-19 testing on a compulsory basis for the purpose of preventing, combating or alleviating the current public health emergency and protecting public health in Hong Kong. To facilitate the public to submit specimens more conveniently, additional testing locations have been proposed and set up using spatial analysis.

5.1.2 To determine the optimal locations for the proposed community testing centres and specimen collection points for serving the most people within a walkable distance, LandsD has performed location-allocation analysis, with the use of 3D pedestrian network data and the demographic data (i.e. population), to rank the proposed locations so as to ensure the new community testing centres and specimen collection points to be set up are easily accessible and serving the most people in the community (Fig. 9).

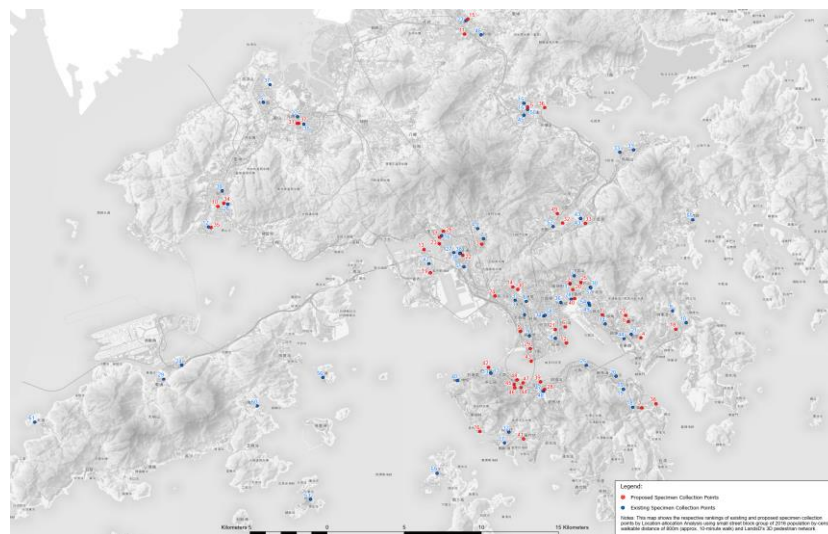


Figure 9 - Location allocation analysis for proposed specimen collection points

5.2 Heat Map Analysis of COVID-19 confirmed cases

5.2.1 In addition, LandsD has conducted heat map analysis, using an intuitive data visualization technology, to illustrate the spatial distribution density of epidemic situations through color variations, so that the Government can visualise where the spatial aggregation and clusters of COVID-19 confirmed cases occurred. The heat map was also generated onto the GIP dynamically (Fig. 10).

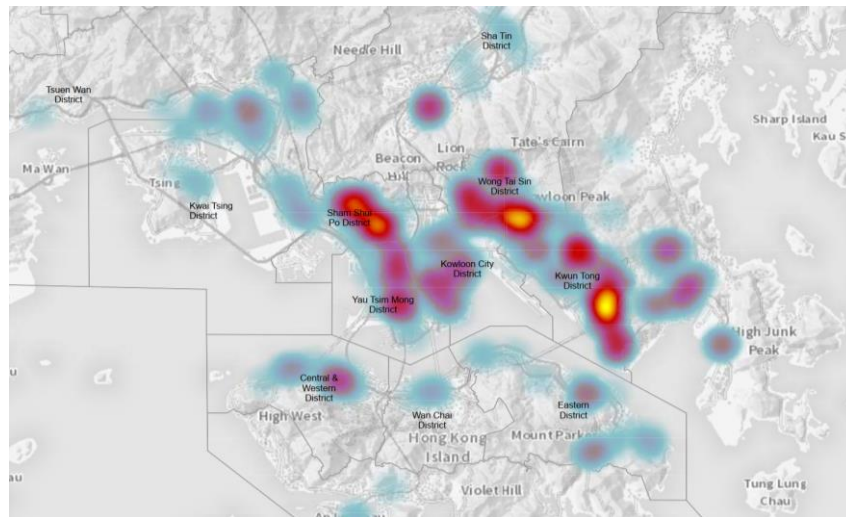


Figure 10 - Heat map analysis of the cluster of COVID-19 confirmed cases

6 CONCLUSION

- 6.1** Since the outbreak of COVID-19 in early 2020, the anti-epidemic measures by the Government have been guided by science and evidence, with the application of innovation and technology. The powerful application of GIS played an indispensable role in visualising and analysing the vast amount of data and attributes of COVID-19-related information, supporting the Government to make strategic and targeted decisions promptly and accurately to break the chain of virus transmission and protect public health.
- 6.2** In summary, LandsD has extensively utilised GIS to support the Government's measures in response to COVID-19 and has effectively demonstrated the power of GIS by providing various types of spatial analysis services. GIS has proven to be a powerful and promising decision-making tool, contributing to Hong Kong's internationally recognised achievements in the fight against COVID-19. We look forward to extending the applications of GIS and geospatial analysis functionalities in other types of communicable diseases with a more holistic approach in future.

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