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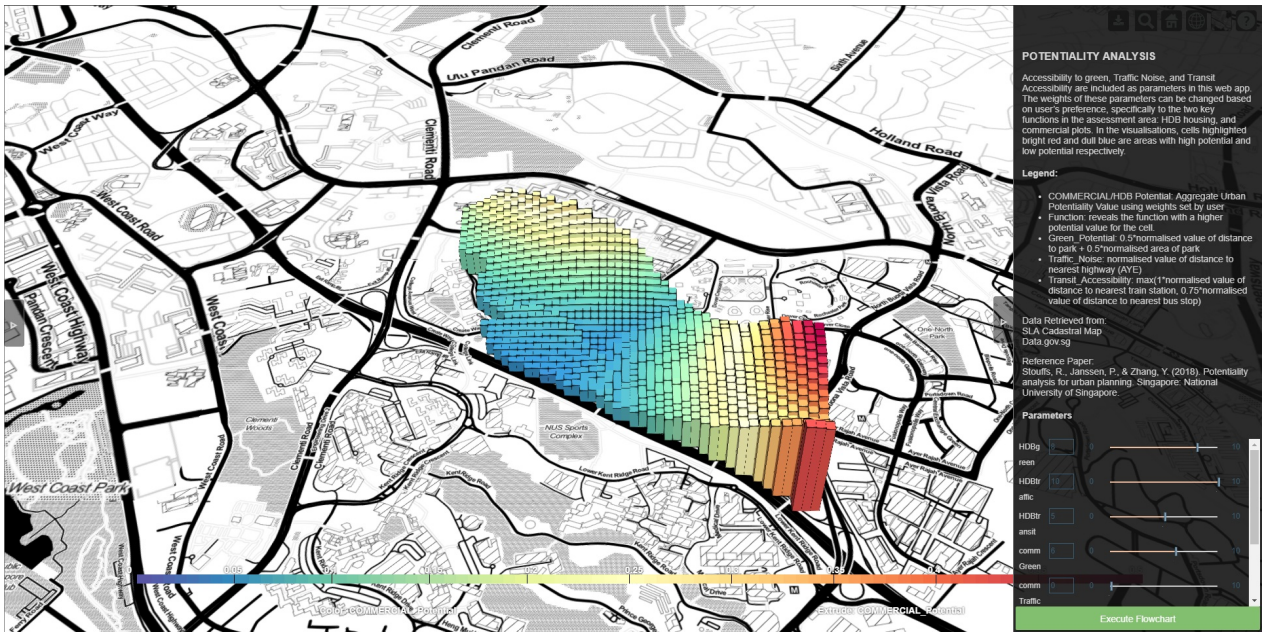
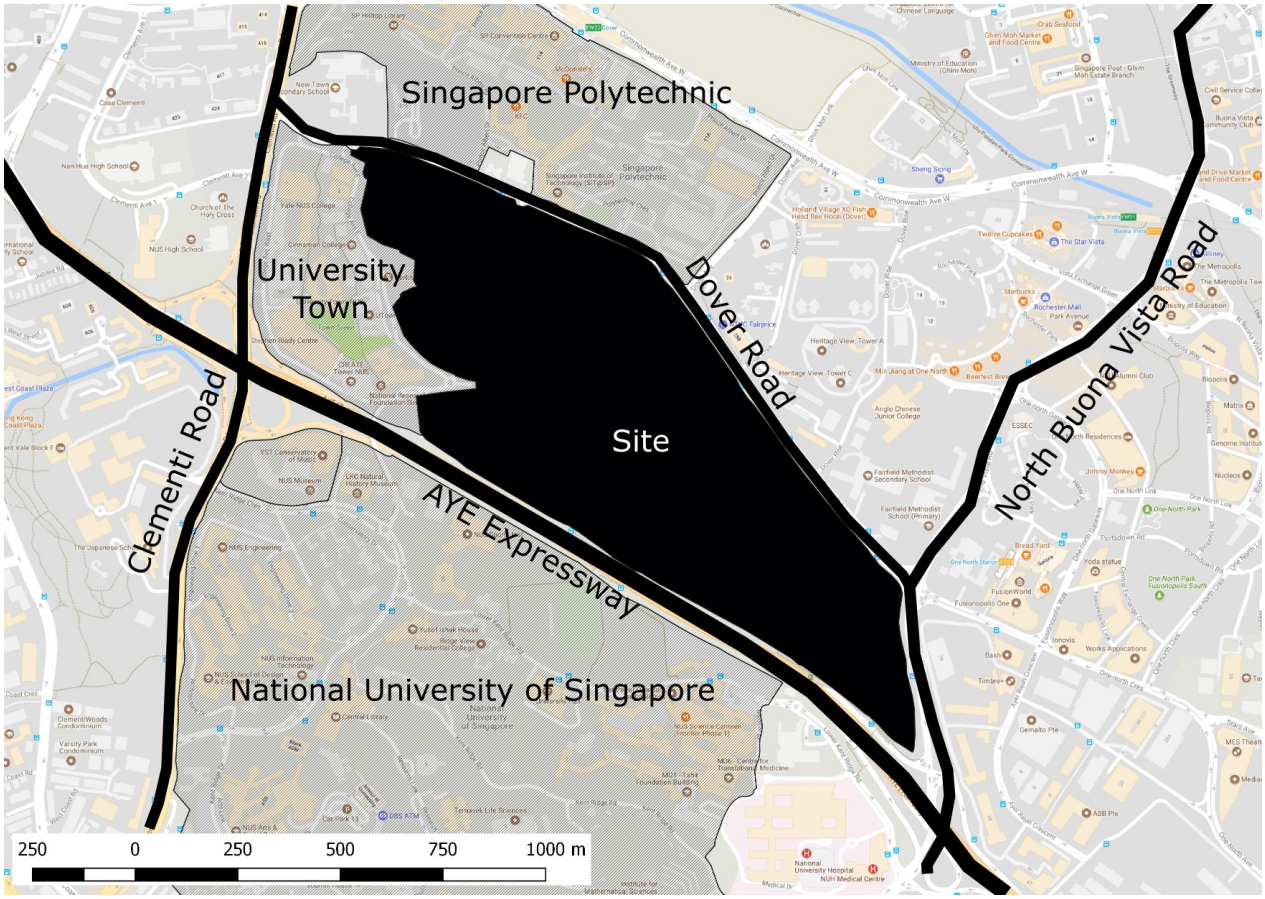
A Conceptual Guide to Learning Urban Prototyping



Introduction

This book documents a simple urban design example to illustrate the use of computational design methods in an urban design process. The example is used as teaching material for the Urban Prototyping Module taught at National University of Singapore, Architecture Department. The example is located along Dover Road in Singapore. The site is about 75 Ha. The target population for this site is 75,000 residents. The brief is to design a mix-used development consisting of residential, commercial, green and open spaces. Students are required to produce a range of feasible urban design proposals to satisfy the brief. We have divided the design process into three main stages 1) site analysis 2) planning concept development and 3) building typology design. From our experience in design and teaching, the design process is often non-linear, iterative and cyclical. It is more useful to see these stages as related but independent. Designers will often jump from stage to stage during design process. The simple example is used to illustrate such a design process and serves as a guide for the students through their learning.



The Urban Prototyping Module teaches computational methods to facilitate the urban design process. In the site analysis stage, we will introduce Geographical Information System (GIS) technology to support the use of geospatial data. These data are often unstructured and massive. They have to be manipulated through computational means in order for designers to extract information from them. These information will then contribute to the understanding of the site and context.

In the planning concept development and typology design stage, we will introduce the use of parametric modelling to support rapid virtual prototyping. This will require students to learn and practice computational thinking such as decomposition, abstraction and algorithm development. They will have to decompose their planning concept or building typology, extract the essence of their design and implement them as generative algorithm in the form of parametric modelling. Students can then assess many design alternatives rapidly generated from the model. The ability to generate and assess many design alternatives can facilitate the student understanding of their own design and inform their next iteration.

Site Analysis

Obtaining Open Geospatial Data

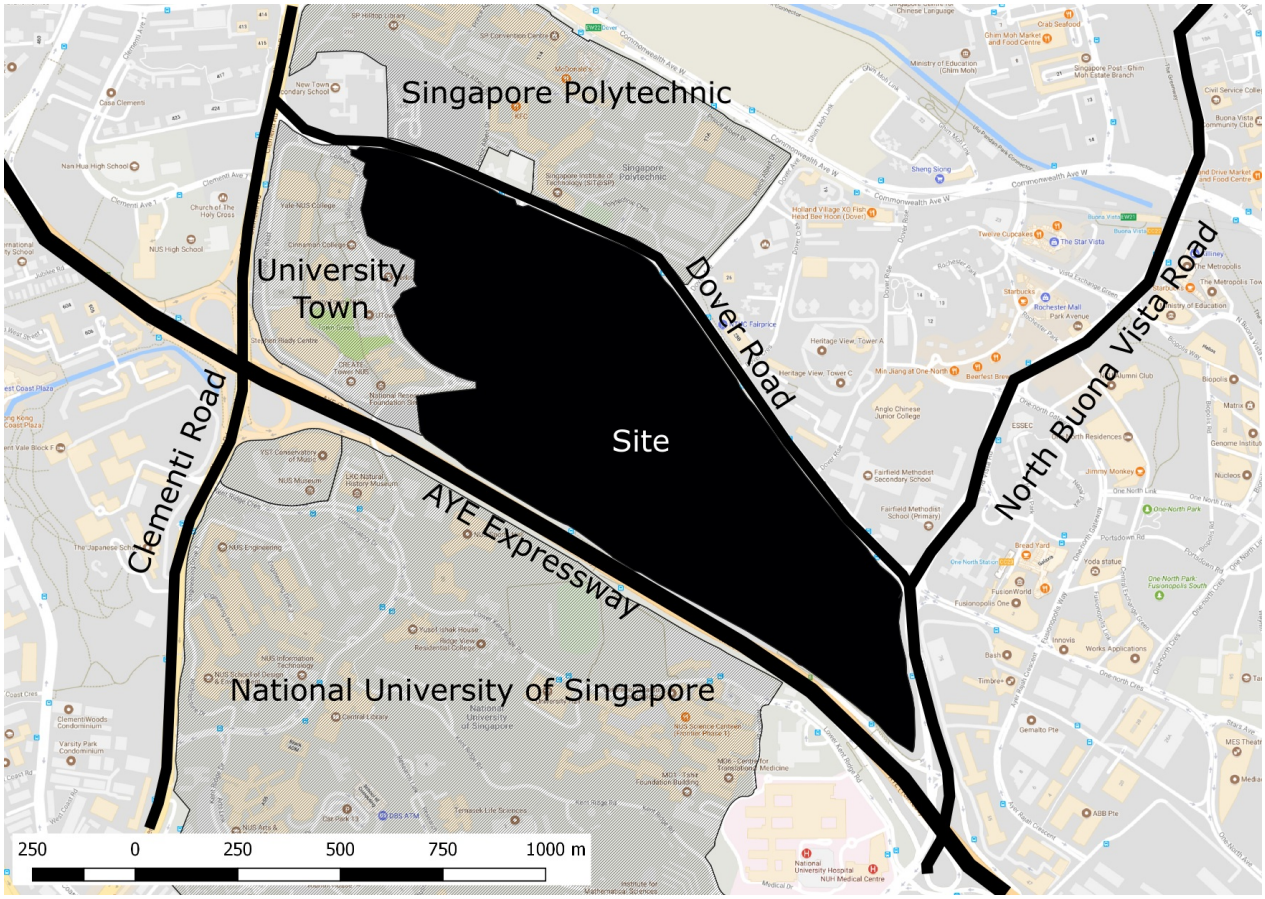
In order to perform site analysis, it is essential to have geospatial data of the site. Fortunately, these geospatial data are openly available on the data.gov.sg website. Through the portal, we are able to obtain the "Master Plan 2014 Land Use" data. The "Master Plan 2014 Land Use" data contains valuable information such as:

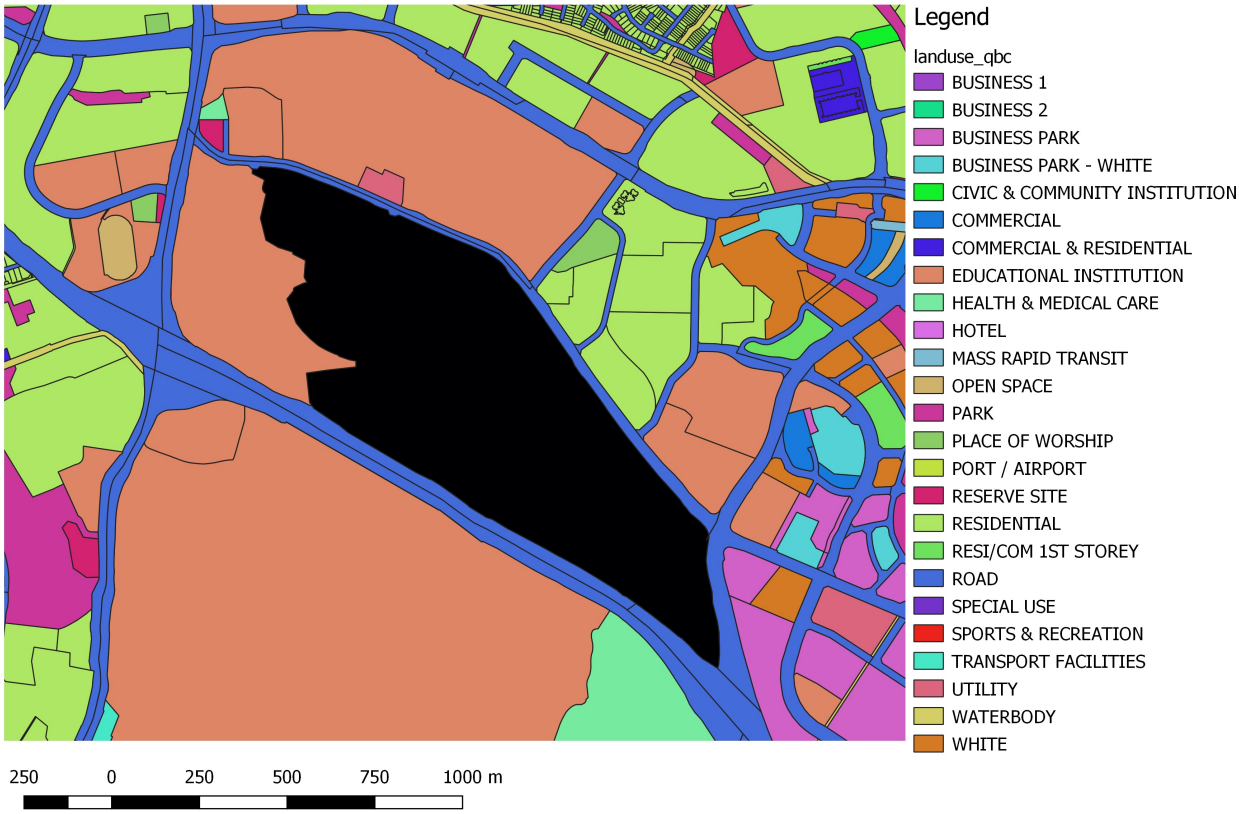
- Geometry of the plots
- Gross Plot Ratio (GPR)
- Land Use Type

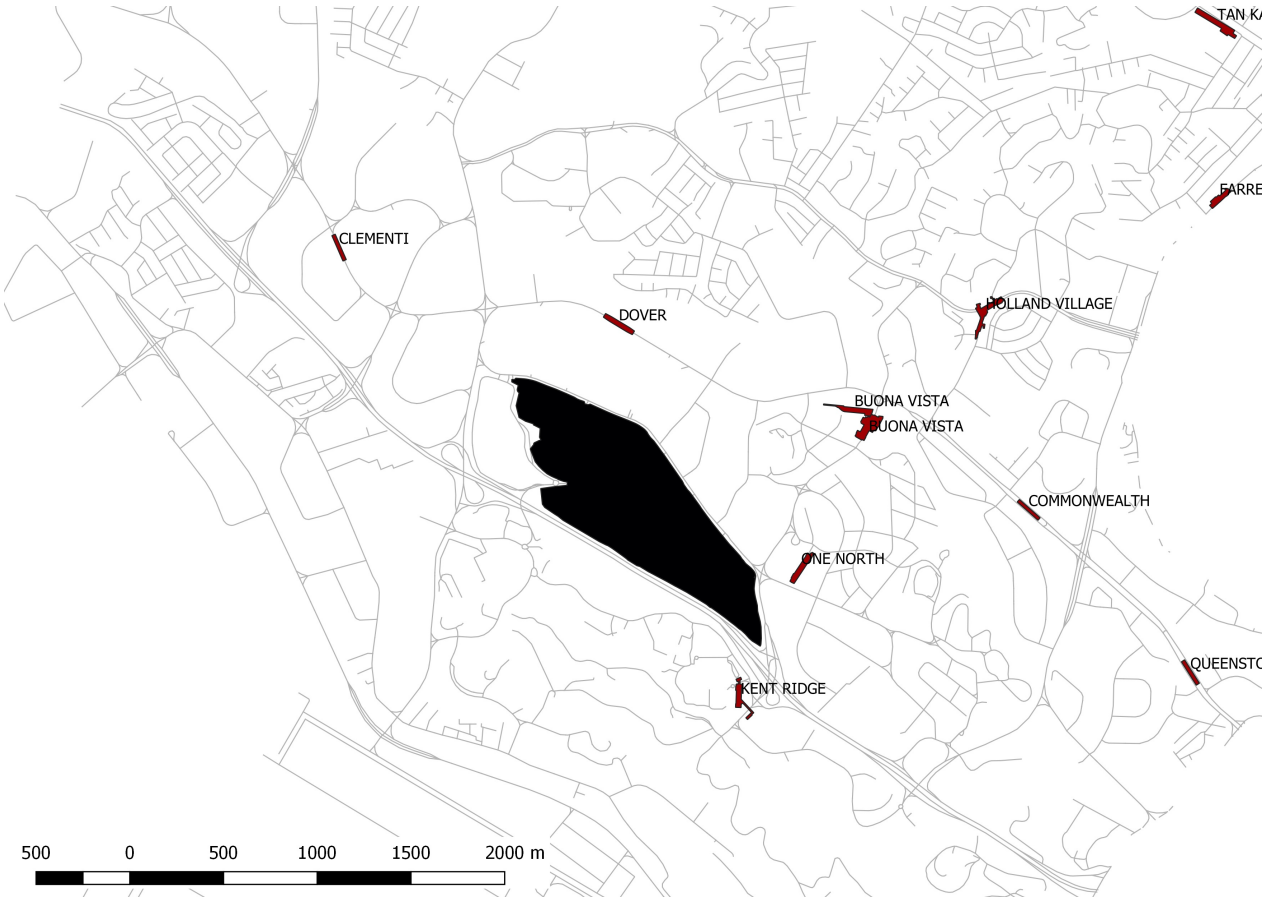
We can also obtain building footprints from the "Master Plan 2014 Building" data available on the portal. Another data source for obtaining building footprints is the Open Street Map website. There are many other data available on the portal that is useful for design. We encourage students to browse and explore through the data.

Site Analysis 2D

With the open geospatial data obtained, we can quickly perform basic site analysis on our site. The images below are generated from using GIS software with minimal graphic manipulation (Fig. 1-3). As we are interested in assessing the accessibility of the site, the location of all the MRT stations around the site is obtained from the open data portal. In addition, we have also obtained the road network data from SG One Map. Fig. 4 illustrates the accessibility of the site.


Singapore Polytechnic
University Town
Dover Road
Site
North Buona Vista Road
Clementi Road
AYE Expressway
National University of Singapore
250 0 250 500 750 1000 m


Legend
landuse_qbc
BUSINESS 1
BUSINESS 2
BUSINESS PARK
BUSINESS PARK - WHITE
CIVIC & COMMUNITY INSTITUTION
COMMERCIAL
COMMERCIAL & RESIDENTIAL
EDUCATIONAL INSTITUTION
HEALTH & MEDICAL CARE
HOTEL
MASS RAPID TRANSIT
OPEN SPACE
PARK
PLACE OF WORSHIP
PORT / AIRPORT
RESERVE SITE
RESIDENTIAL
RESI/COM 1ST STOREY
ROAD
SPECIAL USE
SPORTS & RECREATION
TRANSPORT FACILITIES
UTILITY
WATERBODY
WHITE
250 0 250 500 750 1000 m


TAN K
FARRE
CLEMENTI
DOVER
HOLLAND VILLAGE
BUONA VISTA
BUONA VISTA
COMMONWEALTH
ONE NORTH
QUEENSTO
KENT RIDGE
500 0 500 1000 1500 2000 m

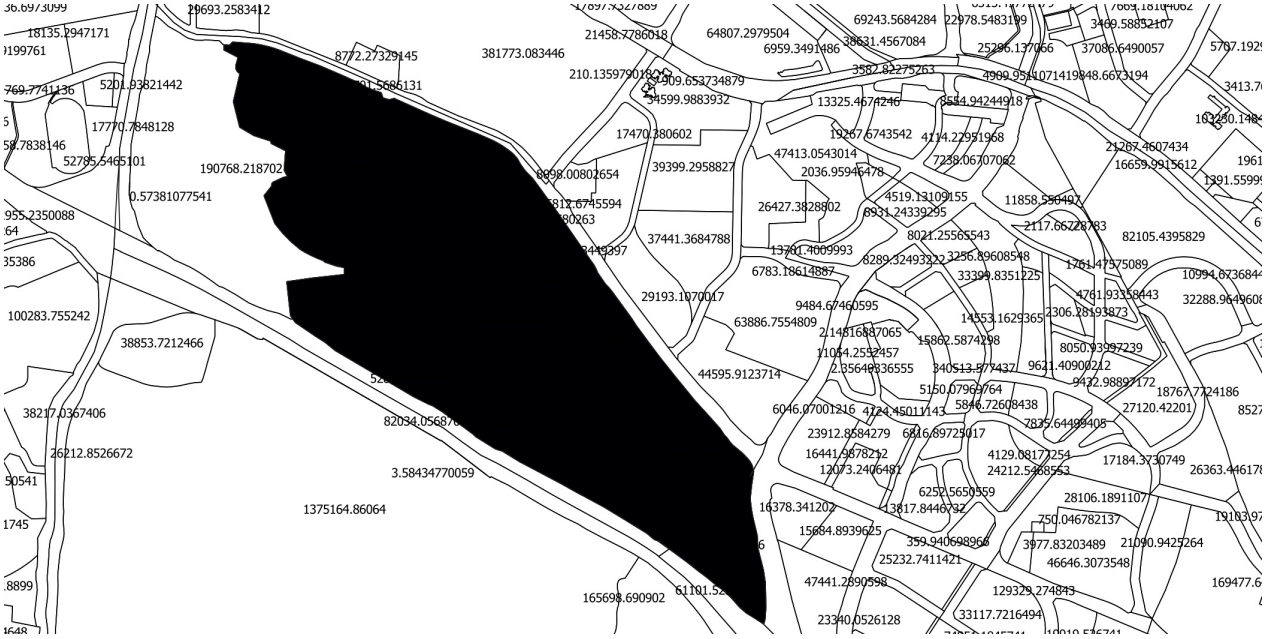
Generating 3D City Model

It is essential to have 3D information on top of the 2D information of the site for understanding the context. As building height data is usually not openly available, we derived the building height data from two main available data:

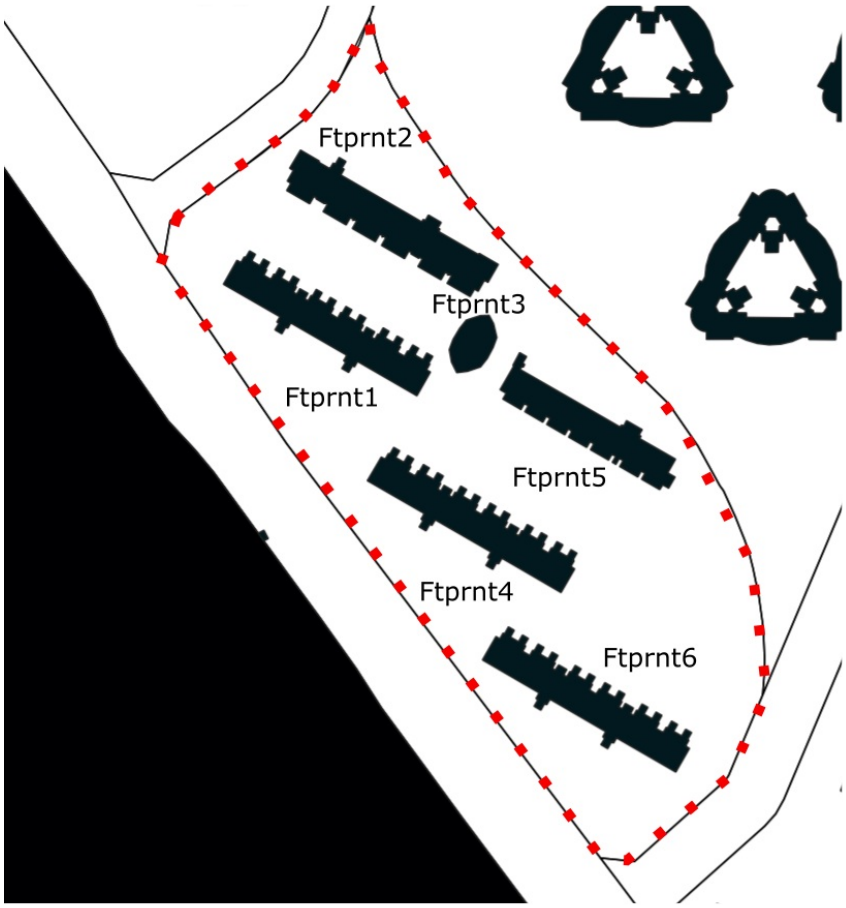
- Gross Plot Ratio (GPR)
- Plot Geometry
- Building Footprint Area
- Building Footprint Geometry

The procedure for the generation of 3D model is as follows:

1. For each plot, measure its area (Fig. 1).
2. Get the maximum permissible Gross Floor Area (GFA) by multiplying the plot area (Fig. 1) by the GPR (Fig. 2).
3. For each plot, identify the building footprints on the plot (Fig. 3).
4. Calculate the area of all the building footprints.
5. Distribute the GFA among the buildings based on their footprint area (Fig. 4).
6. For each building, divide the assigned GFA by their building footprint to obtain the number of levels for each building (Fig. 4)
7. Assuming a floor-to-floor height, calculate the building height by multiplying the levels by the floor-to-floor height (Fig. 4).
8. Extrude the buildings to get the 3D model (Fig. 5).




EVA
SDP
1.2
2.8
4.3
4.9
3.2
6.3
10.8
2.1
4.2
5.4
2.5
4.6
4.8
4.5
3.5
3.3
4.0
7.5
6.5
10.0
5.0
5.3
3.0



#Calcuate the GFA

GFA = Plot Area x GPR

#Calculate the footprint area

Bldg_Ftprnt = Ftprnt-1 +

Ftprint2 + ... FtprintN

#Distribute the GFA among

#buildings

GFAbldg-*x* =

Ftprint-*x*/Bldg_Ftprint x GFA

#Calculate the number of

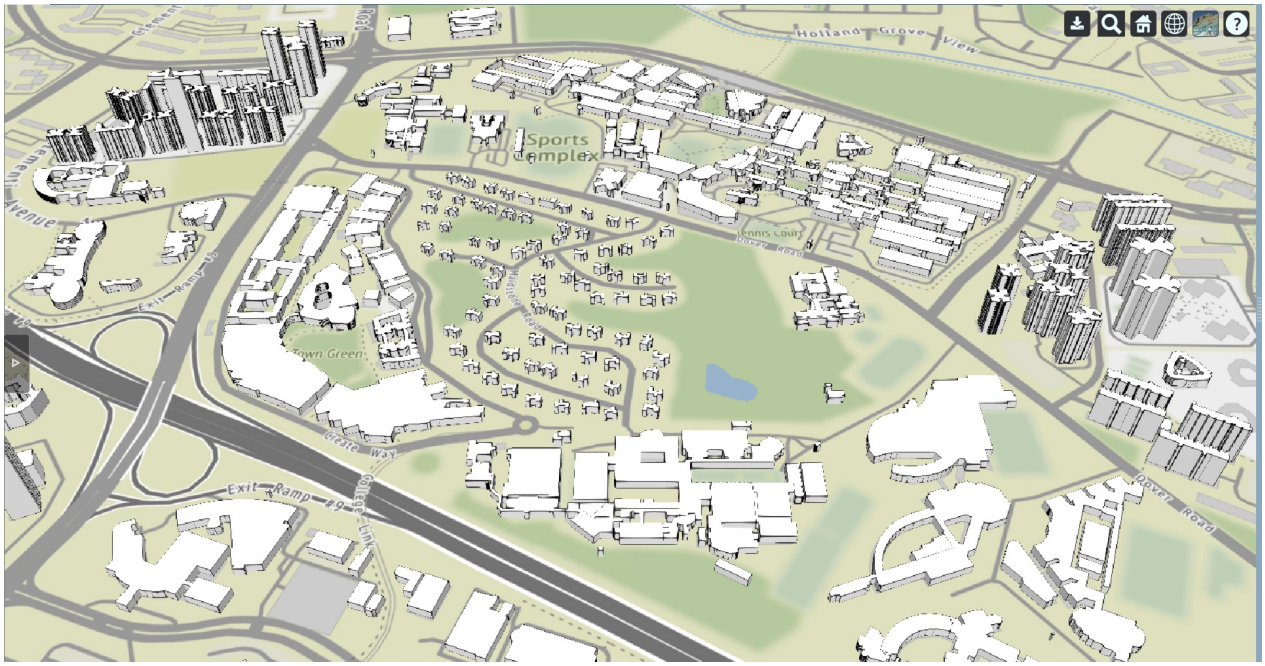
#levels

bldglvl_*x* = GFAbldg-*x*/Ftprnt-*x*

#Calculate bldg height

bldg_height =

flr2flr_height x bldglvl_*x*



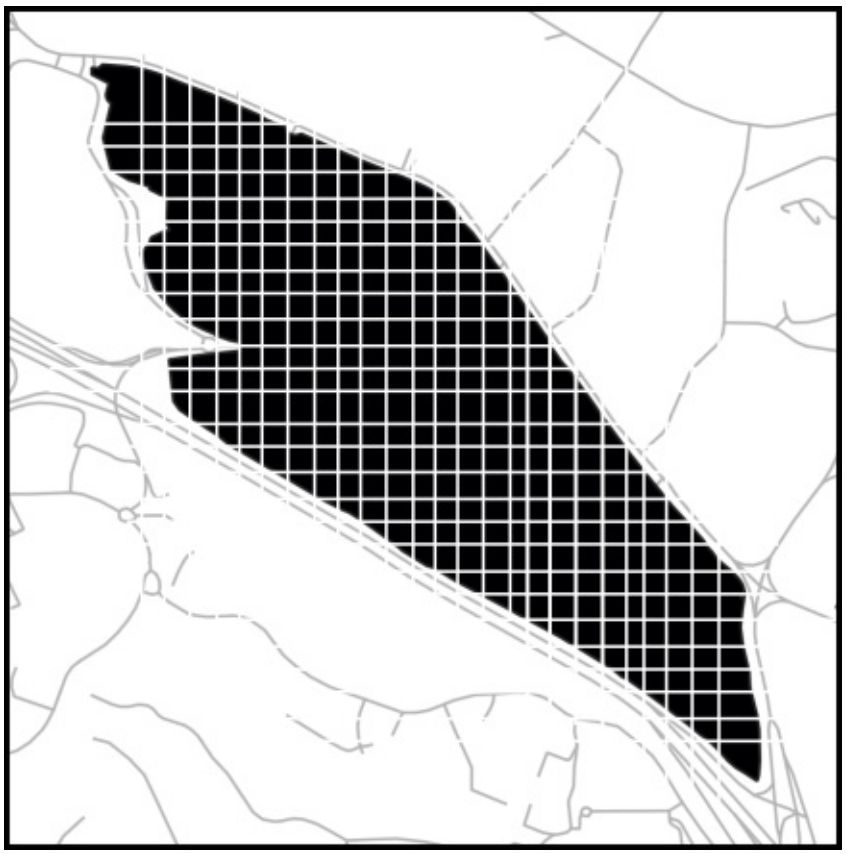
Distance Analysis

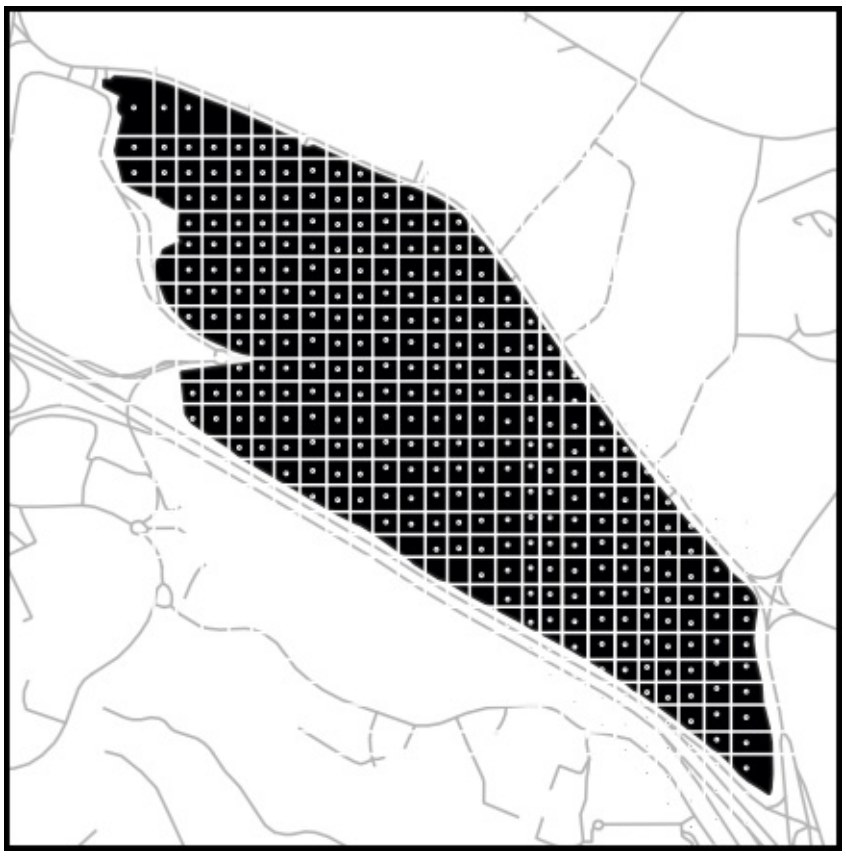
After obtaining a basic understanding of the site, we are interested in diving deeper into analysing the closeness of the site to the surrounding MRT stations. For this analysis, we will need these data:

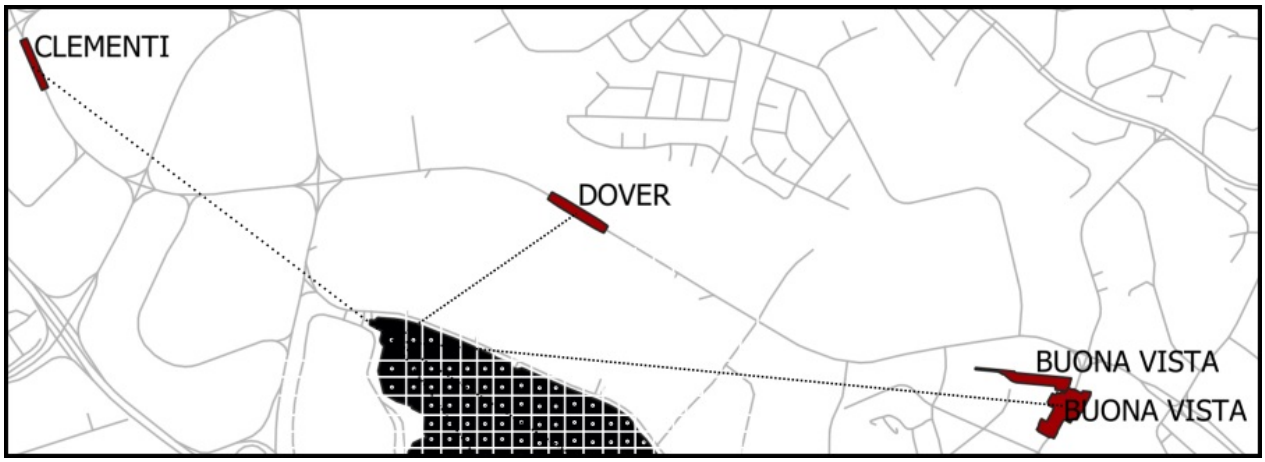
- The site geometry
- The location of the MRT stations

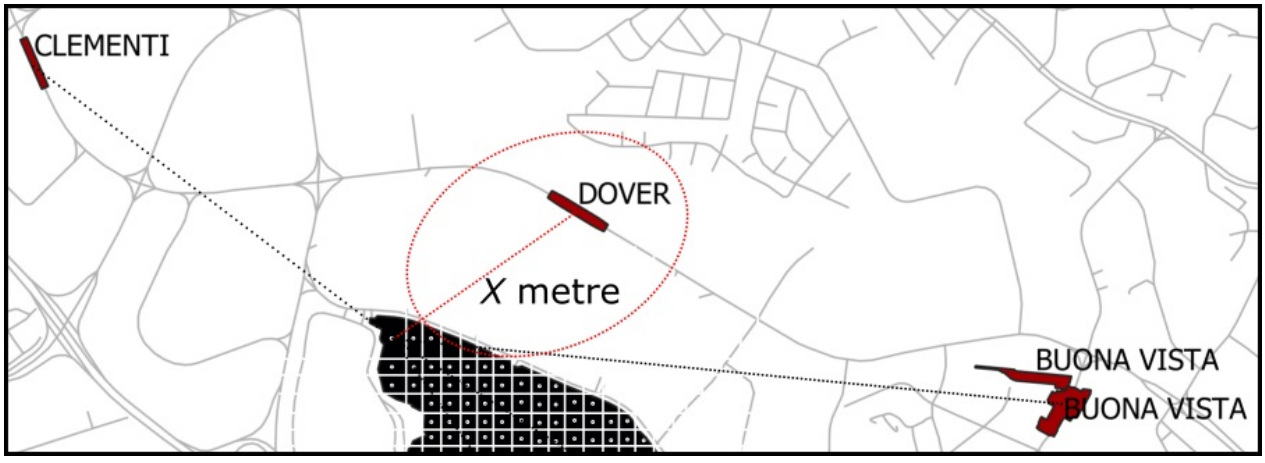
We performed a distance analysis of the site to the MRT stations as follows:

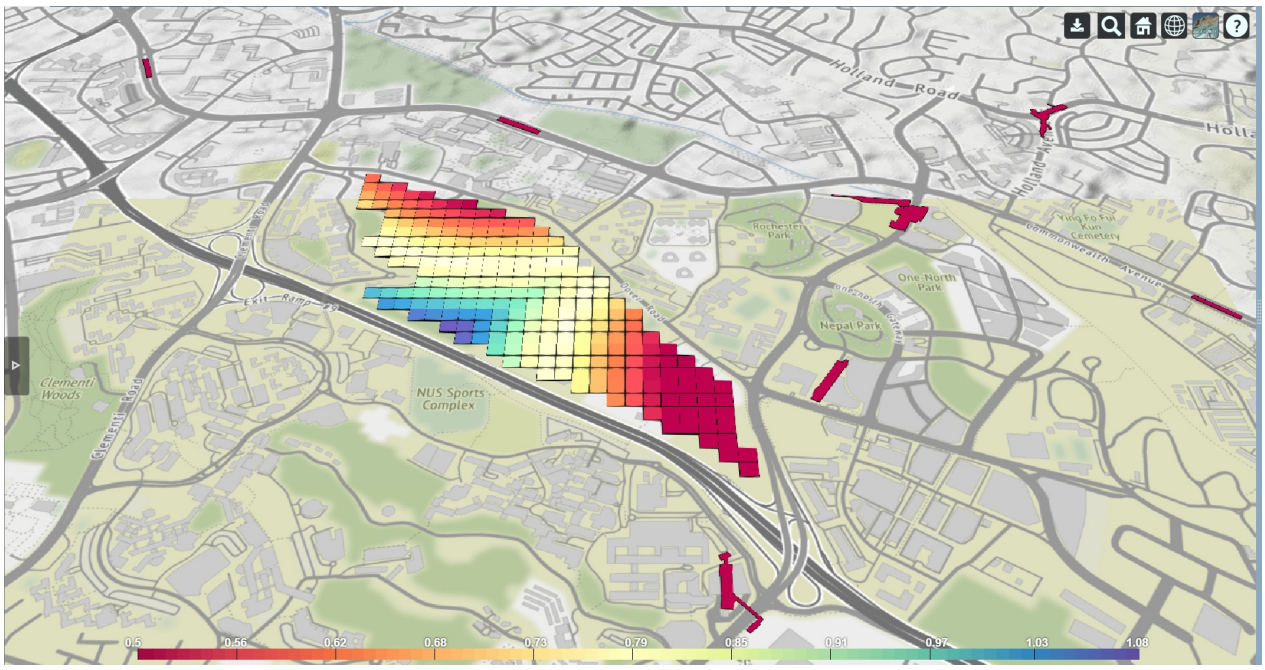
1. Divide the site into grids of 50m x 50m (Fig. 1).
2. Get the centroid for each grid (Fig. 2).
3. For each centroid, measure the distance of the centroid to all the MRT stations.
4. Of all the measured distance, choose the shortest distance and append it onto the grid.
5. A false-colour image will be generated based on the closeness to MRT.





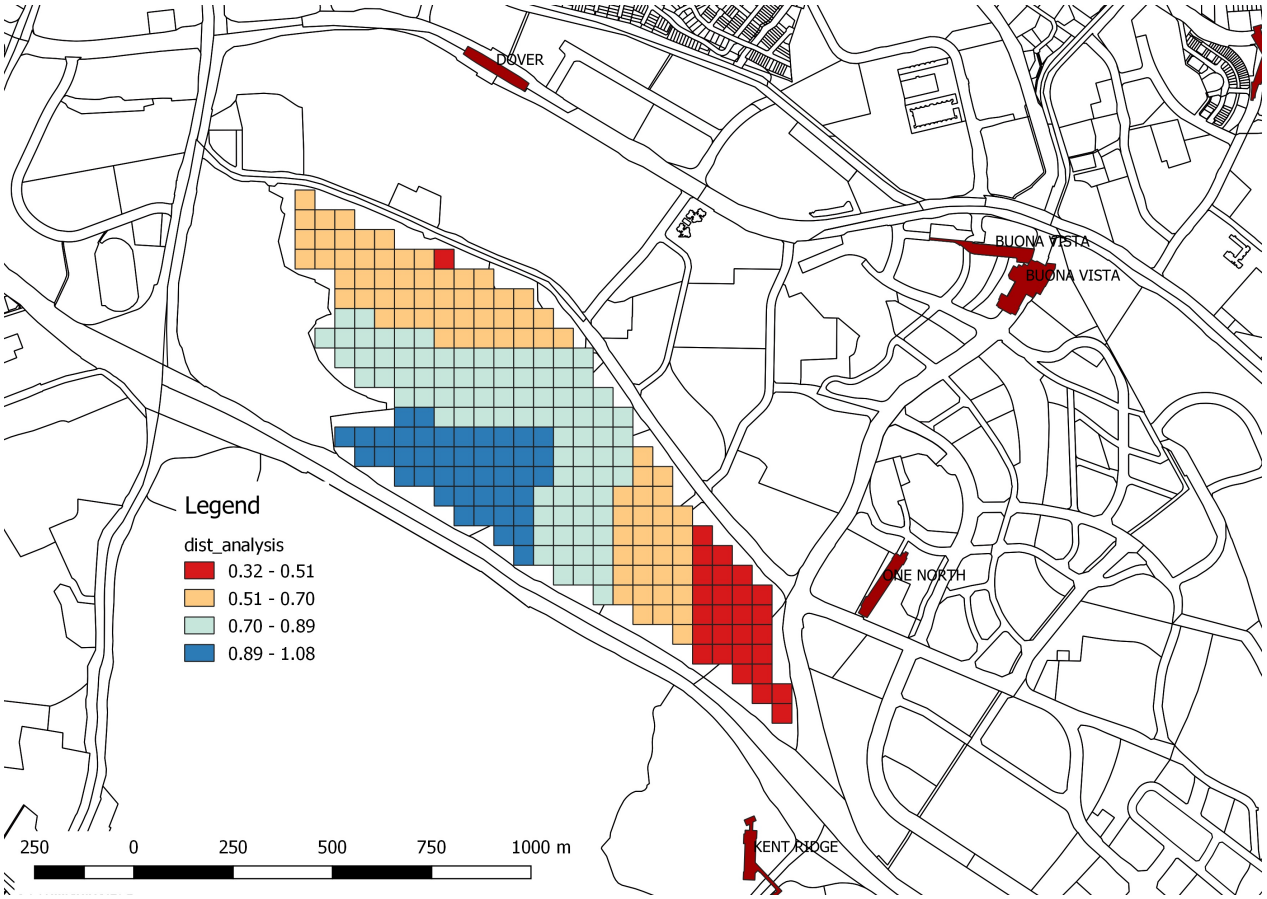

CLEMENTI
DOVER
BUONA VISTA
BUONA VISTA

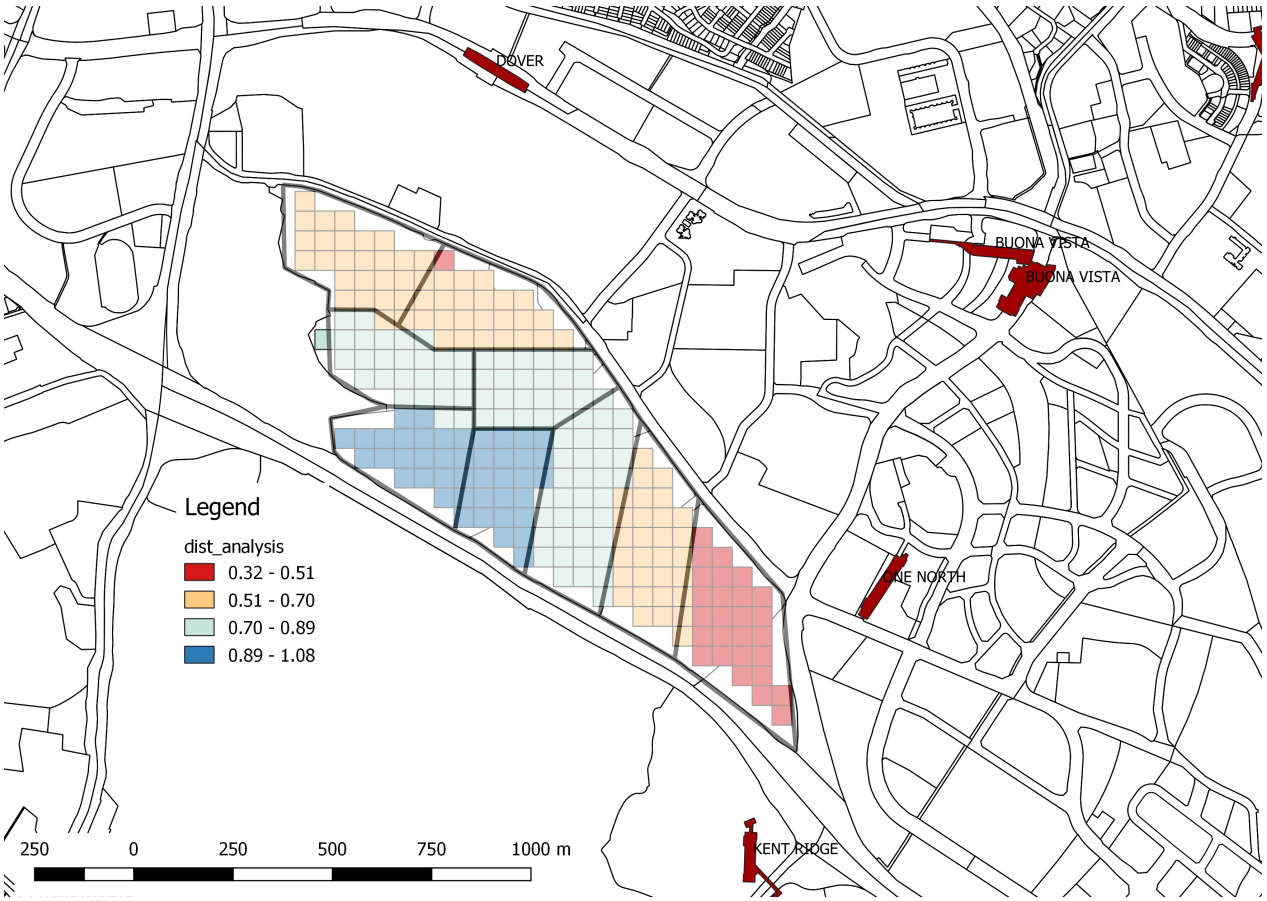

CLEMENTI
DOVER
X metre
BUONA VISTA
BUONA VISTA


Holland Road
Rochester Park
One North Park
Nepal Park
Clementi Woods
NUS Sports Complex
Clementi Road
Commonwealth Avenue
0.5
0.56
0.62
0.68
0.73
0.79
0.85
0.91
0.97
1.03
1.08

Planning Concept Development

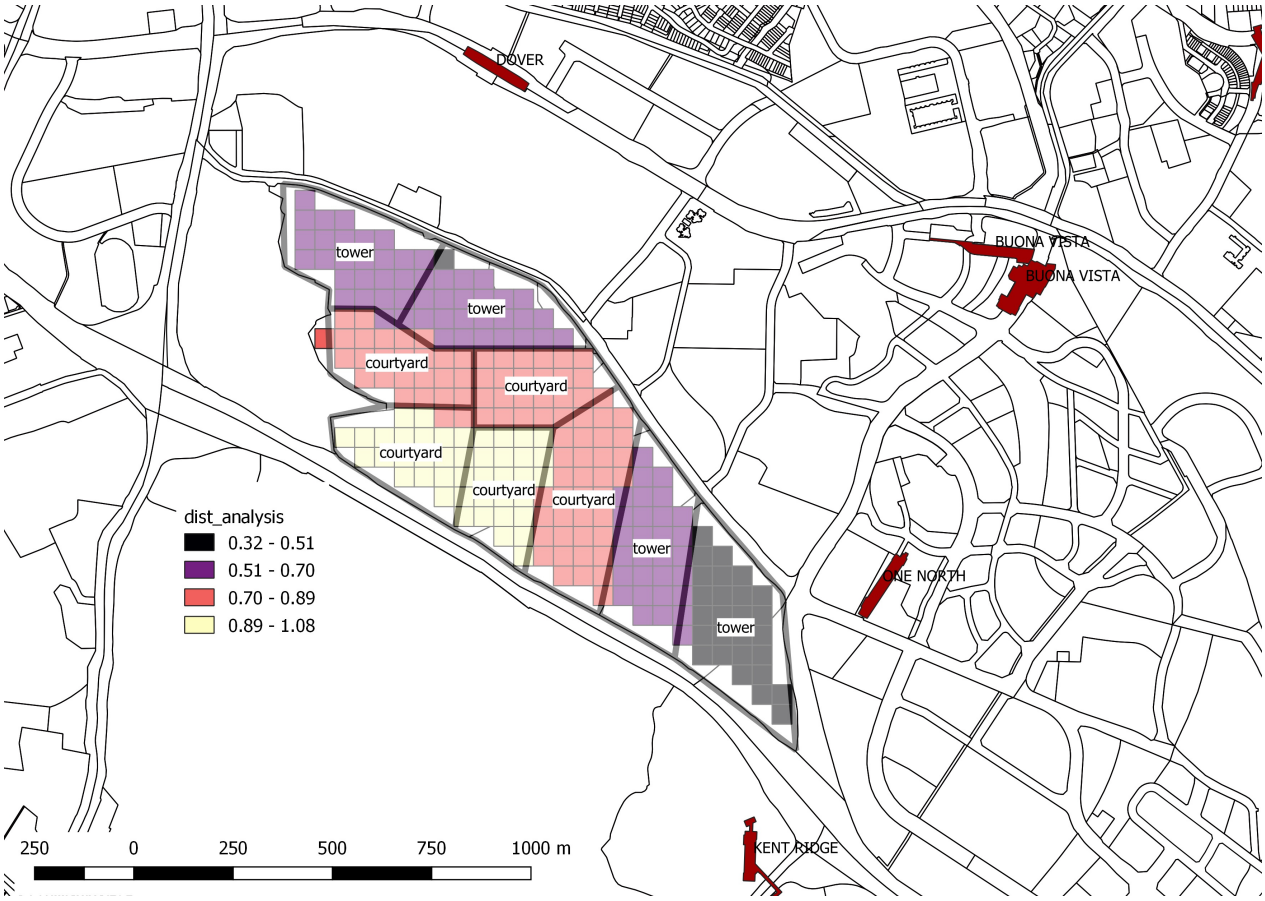
Hello wworld In this chapter, we will use the distance analysis result for developing planning concepts. Fig. 1 shows the distance analysis results categorised into 4 categories. The site is manually divided into plots based on the closeness to MRT, (Fig. 2).

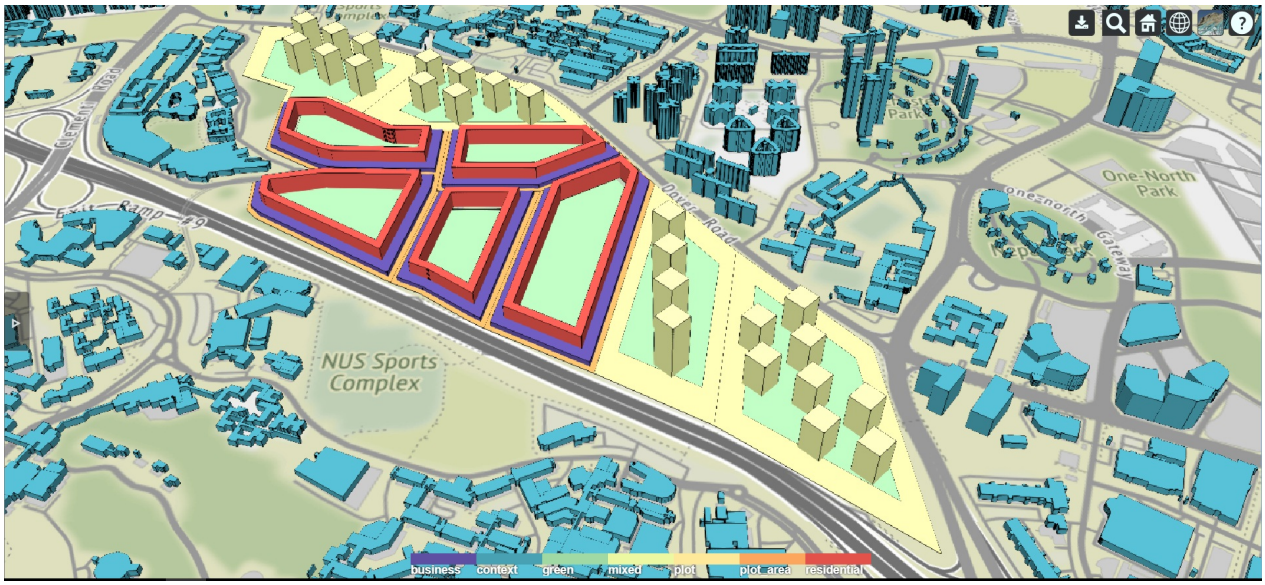



DOVER
BUONA VISTA
BUONA VISTA
ONE NORTH
KENT RIDGE
Legend
dist_analysis
0.32 - 0.51
0.51 - 0.70
0.70 - 0.89
0.89 - 1.08
250
0
250
500
750
1000 m

Building Typology Design

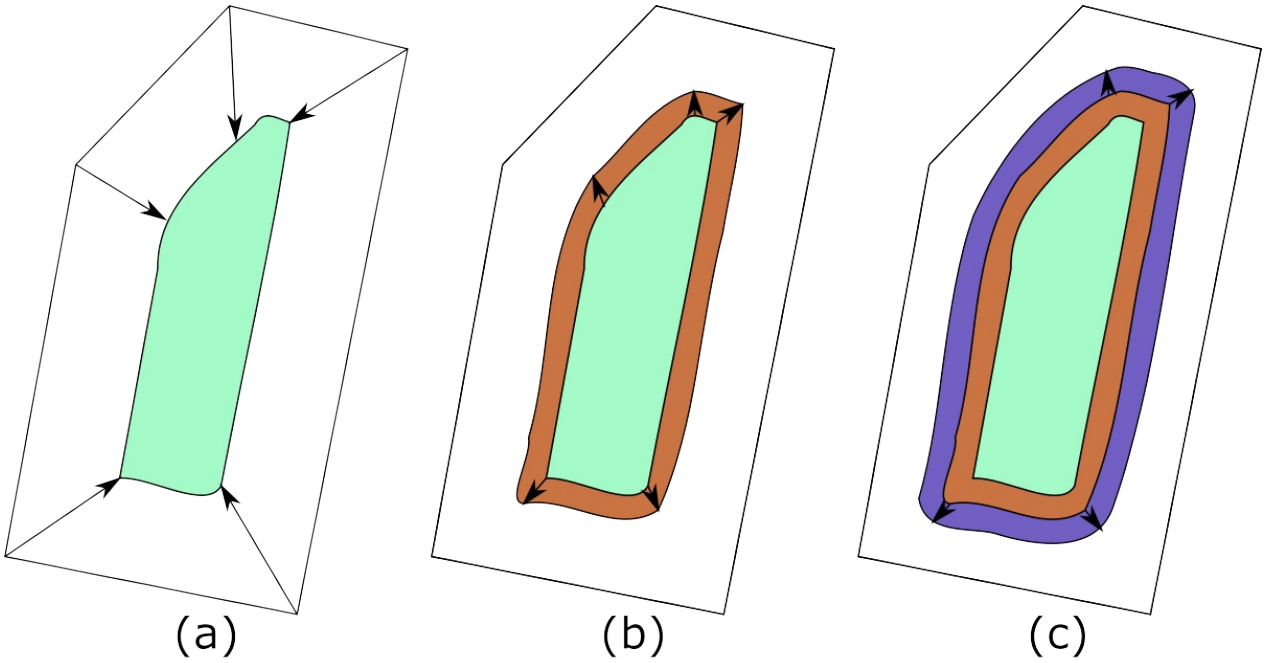
The typology for the site is decided based on its closeness to the MRT station. The sites closer to the MRT station have tower typology, while those further away have courtyard typology (Fig. 1). Fig. 2 shows the typology generated based on the assignment. The typology is generated based on the requirement of accommodating 75,000 people. Based on Singapore census data, a household has 3.2 people. Thus, 75,000 people is equivalent to 23,438 households. Usually, each household will have 2 working adults. That would amount to 46,876 working people. The floor space requirement for accommodating these people are each person requires 20m2 of living area and 5m2 of green/open area. Each working person requires 10m2 of office/working space. The population is distributed based on each plot's size. The bigger the plot size, the bigger the population assigned to the plot.

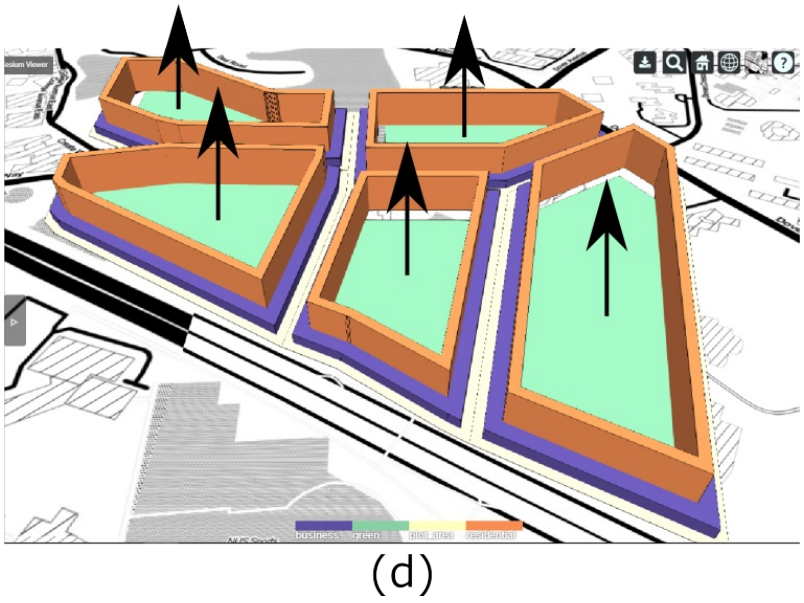




The courtyard typology is generated according to these procedure:

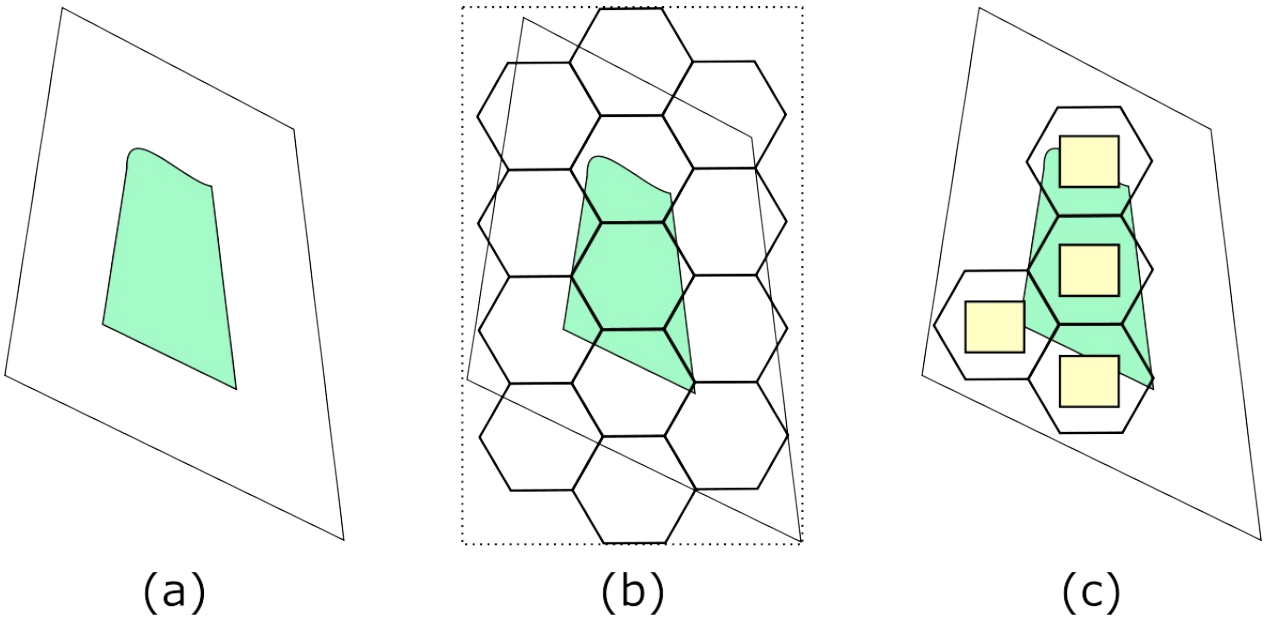
1. Offset the plot inwards to create the inner courtyard (Fig. 3a). The amount of inset is based on the required green/open area for the residents living on the plot.
2. Offset the courtyard polygon outwards to create the inner courtyard buildings (Fig. 3b). These are residential buildings. The amount of outset is based on the building depth specified by the designer.
3. Offset the residential polygon outwards to create the outer courtyard buildings (Fig. 3c). These are commercial buildings. The amount of outset is based on the building depth specified by the designer.
4. The polygons are extruded to fulfill the GFA requirement to accommodate the desired density (Fig. 3d).

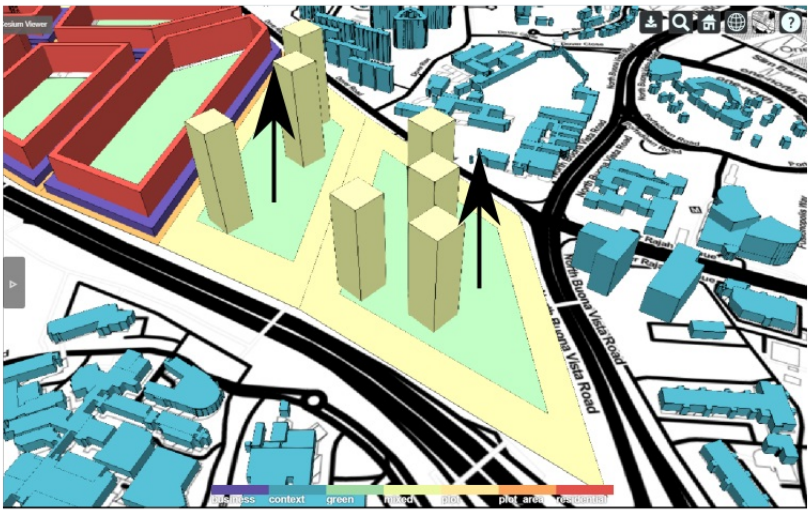




The tower typology is generated according to these procedure:

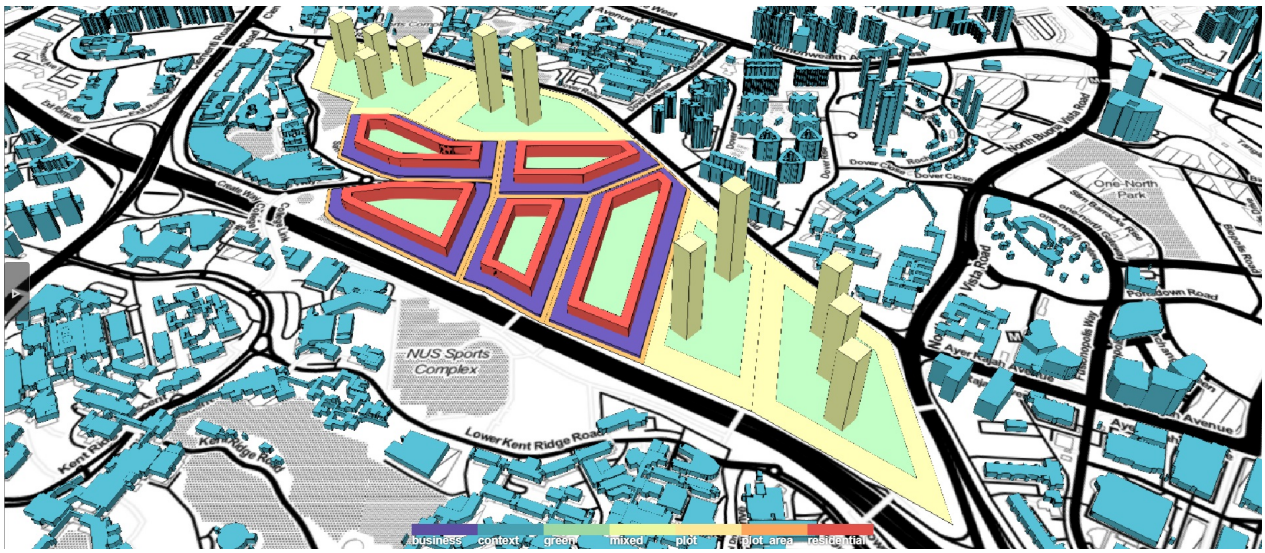
1. Offset the plot inwards to create the inner courtyard (Fig. 4a) . The amount of inset is based on the required green/open area for the residents living on the plot.
2. A hexagon grid is created based on the plot's bounding box(the dotted line in Fig. 4b).
3. Hexagon grid that is not fully enclosed within the plot is removed. A square tower footprint is generated on the centroid of each hexagon grid. The size of the footprint is generated based on the building width specified by the designer (Fig. 4c).
4. The footprints are extruded to fulfill the GFA requirement to accommodate the desired density (Fig. 4d).

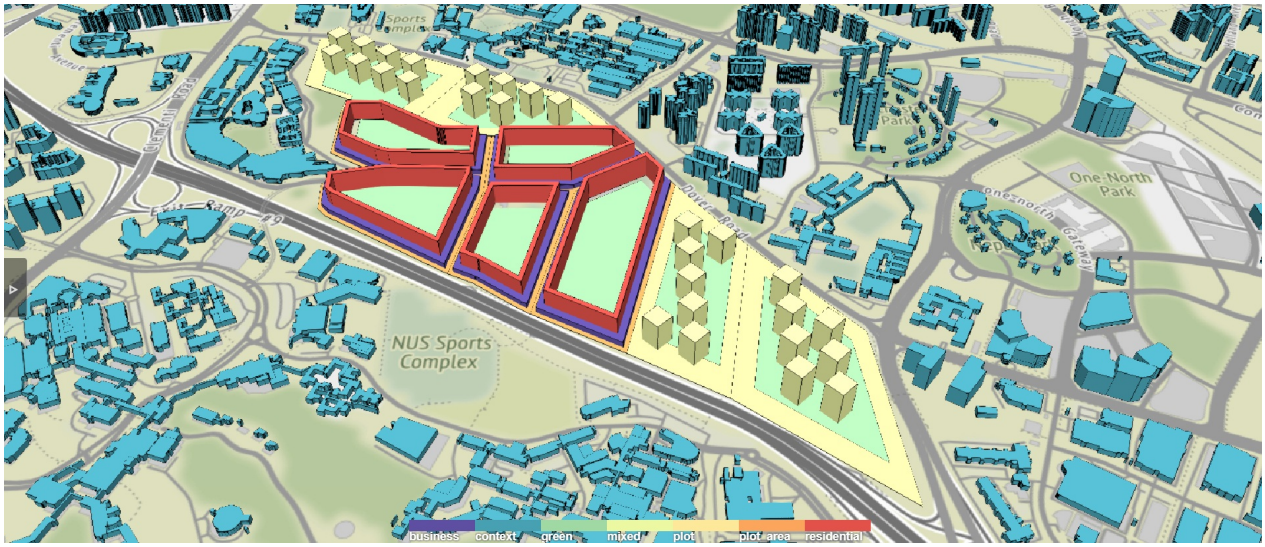




(d)

The parameters controlling the generative model can be adjusted to generate different design alternatives (Fig. 5 & 6).




NUS Sports Complex
One North Park
business
context
green
mixed
plot
plot area
residential