ES2802 GIS Project 1

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Question 1

How were these datasets collected, and in what ways are they similar or different? What are potential sources of error due to these differences?

The 1961 topo dataset was generated by digitizing the contour lines from the 1.25k topo maps of Singapore, which were produced by a ground survey, combined with an aerial photo survey in the 1950's and revised in 1960 by the British.

The 2000 topo dataset was collected using the Shuttle Radar Topography Mission (SRTM), which is an international research effort that obtained digital elevation models (DEMs) on Earth roughly from 56°S to 60°N on an 11-day mission (Paul, et al., 1999). SRTM consists of a specially modified radar system that that was installed on board a space shuttle. The technique employed is known as interferometric synthetic aperture radar (inSAR), which requires two antennas separated by a baseline. Signals from both antennas are recorded and processed to yield two complex SAR images of the same area. The difference between phases measured in each of the scenes are calculated on a pixel-by-pixel basis to obtain additional geometrical information about the area (Christopher, 1995). The elevation models are arranged into tiles, each covering one degree of latitude and one degree of longitude. On the internet, processed three arcsecond (90 m) DEM data using SRTM is available (Gorokhovich & Voustianiouk, 2006). Each data posting of the final DEM created represents a height in meters above the WGS84 ellipsoid (PI Processor) or the WGS84 geoid (Production Processor) in the WGS84 geographical co-ordinate system (Bridget & David, 2003).

Similarities

Both data collection methods cover area of Singapore and make use of DEMs. Variation of SRTM data and ground survey data is small in flat areas and increases in high elevation areas.

Differences and Potential Sources of Error

The 2000 SRTM method only used satellite imagery as data, while the 1961 ground survey gathered data using standard apparatus on the ground, as well as aerial data. SRTM might not be able to obtain elevation data in sheltered areas, such as forested areas, for example. This is because it only takes elevations from above and thus might only detect the canopy, producing a potential source of error as accuracy is reduced. In this case, ground survey might be more accurate as it considers elevation below the canopy layer.

Another difference is that the 1961 ground surveying was done via human measuring and thus could be prone to human error. The 2000 SRTM data collection method was done digitally and thus might be more accurate as there is less human error.

Question 2

What is the area of reclaimed land in km^2, and where has land been reclaimed?

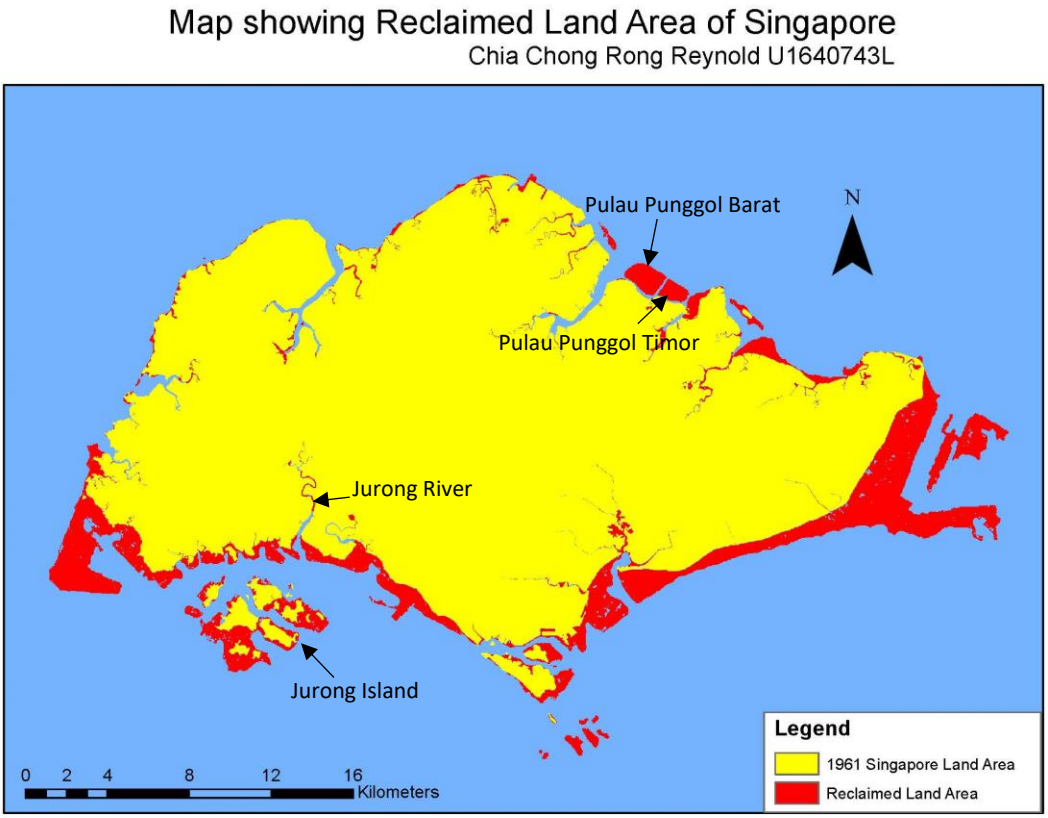

Figure 1. Map showing Reclaimed Land Area of Singapore.

The area of reclaimed land in Singapore is **85.5 km^2** (3 s.f.) in 2000. From the map above (Figure 1), most reclamation occurs on the lower half of Singapore, with little to no reclamation on the upper half. There seems to be most reclaimed land in the South West, presumably near the Jurong area, and in the East, presumably near the Changi/Loyang area. There is some reclamation done in the North East, near the Punggol Area. Also, we can see that there are some land added to fill rivers in Singapore, for example, the Jurong River, as indicated above. Some land has also been added to existing offshore islands, such as Jurong Island (Figure 1) to expand the area. There are also completely new offshore islands created using reclaimed land, such as the Pulau Punggol Barat and the Pulau Punggol Timor in the NorthEast shown above.

Question 3

How has topography of Singapore changed – where did the land go up, where did it go down, and why? Analyse three examples of local topographic change.

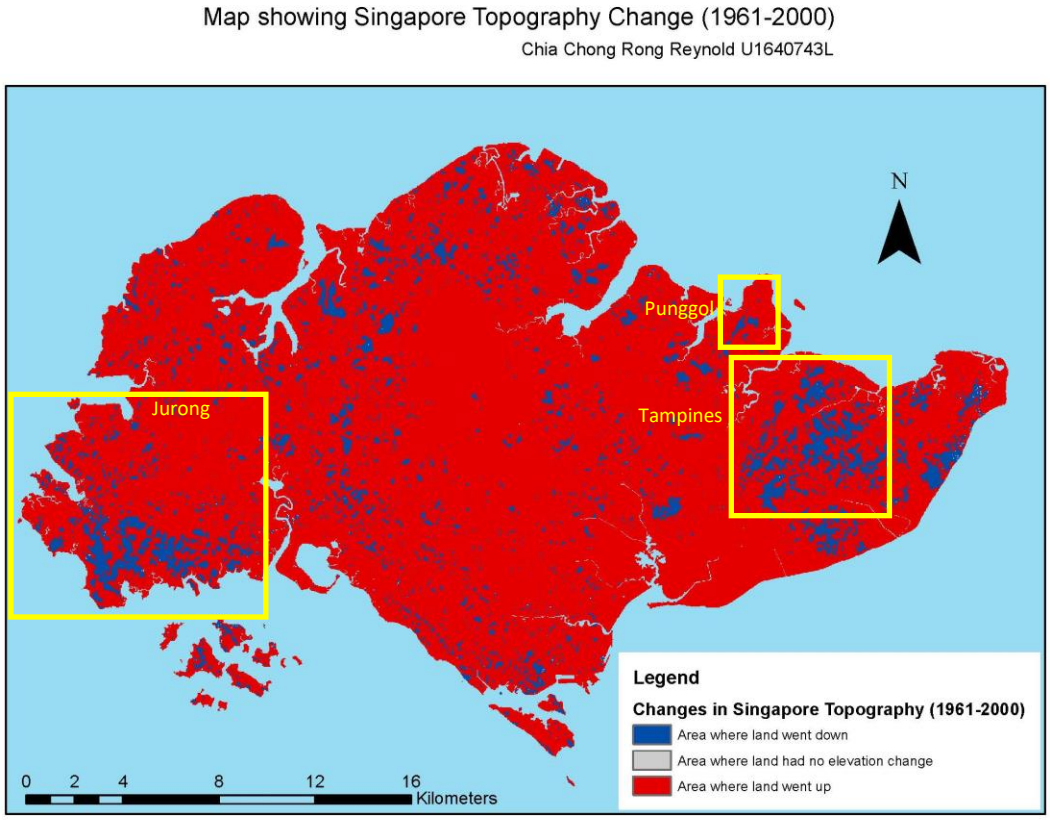

Figure 2. Map showing Singapore Topography Change (1961-2000)

Map shows change in elevation from 2000 to 1961, with respect to the spatial data given for 1961. In this case, it is assumed that all reclaimed land that was created from 1961 to 2000 results in a rise in elevation as the land was created in originally sea areas. Therefore, the above map only focuses the 1961 Singapore land area, and compares the elevations with the intersecting 2000 Singapore land area to see where did land rise or sink in Singapore from 1961 to 2000.

From the map, we can see that most of the Singapore land area has elevated (indicated by red color). There are some areas where land has decreased in elevation (indicated by blue color). There doesn't seem to be any point in Singapore where there is no elevation change.

Land area could have gone up due to the accumulation of sediment after building of dams, such as the Yishun Dam. Land area could have gone down as these land areas could have been used as material to reclaim land. There are 3 yellow boxes in Figure 2 above highlighting 3 areas of

Singapore for analysis. These 3 zones show areas where there have been decrease in elevation and their possible reasons. These 3 zones are further elaborated as follows:

1) **Jurong**

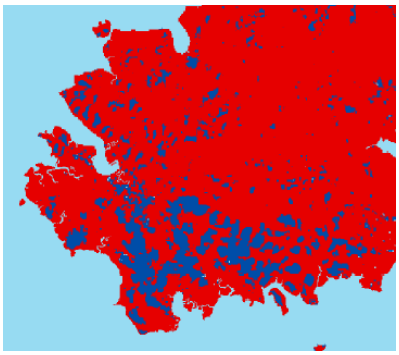

Figure 3. Zoomed in Jurong Area.

There seems to be a large concentration of land area which decreased in elevation at in the West of Singapore, in the Jurong Area, which is indicated by blue. One reason for this is probably to use the land materials to embark on the land reclamation projects to extend Jurong Port *(Pui, 1987)*. The land materials are also being used to extend the Jurong Industrial Estate to build marine-oriented industries and other related industries in the Tuas area *(Chia, Habibullah, & Chou, 1988)*.

2) **Tampines**

Figure 4. Zoomed in Tampines Area.

There seems to be a large concentration of land area which decreased in elevation at in the East of Singapore, in the Tampines area which is indicated by blue. Land materials might have been removed from this area to reclaim land in Loyang *(Pui, 1987)* and in the nearby Changi area *(Chia, Habibullah, & Chou, 1988)*, where the Changi Airport was built. Land material might also have been used to create the East Coast Parkway and East Coast Park *(Chia, Habibullah, & Chou, 1988)*.

3) **Punggol**

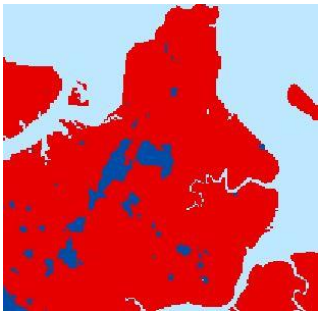

Figure 5. Zoomed in Punggol Area

There seems to be some land area which decreased in elevation at in the North East area, around the Punggol area, which is indicated by blue. One possible reason for this was to use the land materials to build beaches in the nearby Coney Island and Pulau Seletar (Chia, Habibullah, & Chou, 1988). Coney Island was enlarged by about 36 ha between 1974 and 1976, and Pulau Seletar was enlarged by about 18 ha between 1975 and 1976 (Chia, Habibullah, & Chou, 1988).

Question 4

Quantify the elevation change – what is the mean change, and the net volume change? What is the change for each of the 5 regons in Singapore (as defined in the 2014 URA Master Plan)?

The mean elevation change is **+8.59 m** (3 s.f.).

The net volume change is **+4.63 km^3** (3 s.f.).

Central region

Elevation change: **+10.8m** (3 s.f.)

Volume change: **+1.04 km^3** (3 s.f.)

East Region

Elevation change: **+5.80m** (3 s.f.)

Volume change: **+0.366 km^3** (3 s.f.)

North Region

Elevation change: **+9.82m** (3 s.f.)

Volume change**: +1.25 km^3** (3 s.f.)

North-East Region

Elevation change: **+8.49m** (3 s.f.)

Volume change: **+0.514 km^3** (3 s.f.)

West region

Elevation change: **+7.45m** (3 s.f.)

Volume change: **+1.20 km^3** (3 s.f.)

Question 5

<u>In the area west of the Jurong River, what is the volume of material removed (presumably to build Jurong Island)?</u>

Volume of material removed = **<u>0.0661 km^3</u>** (3 s.f.)

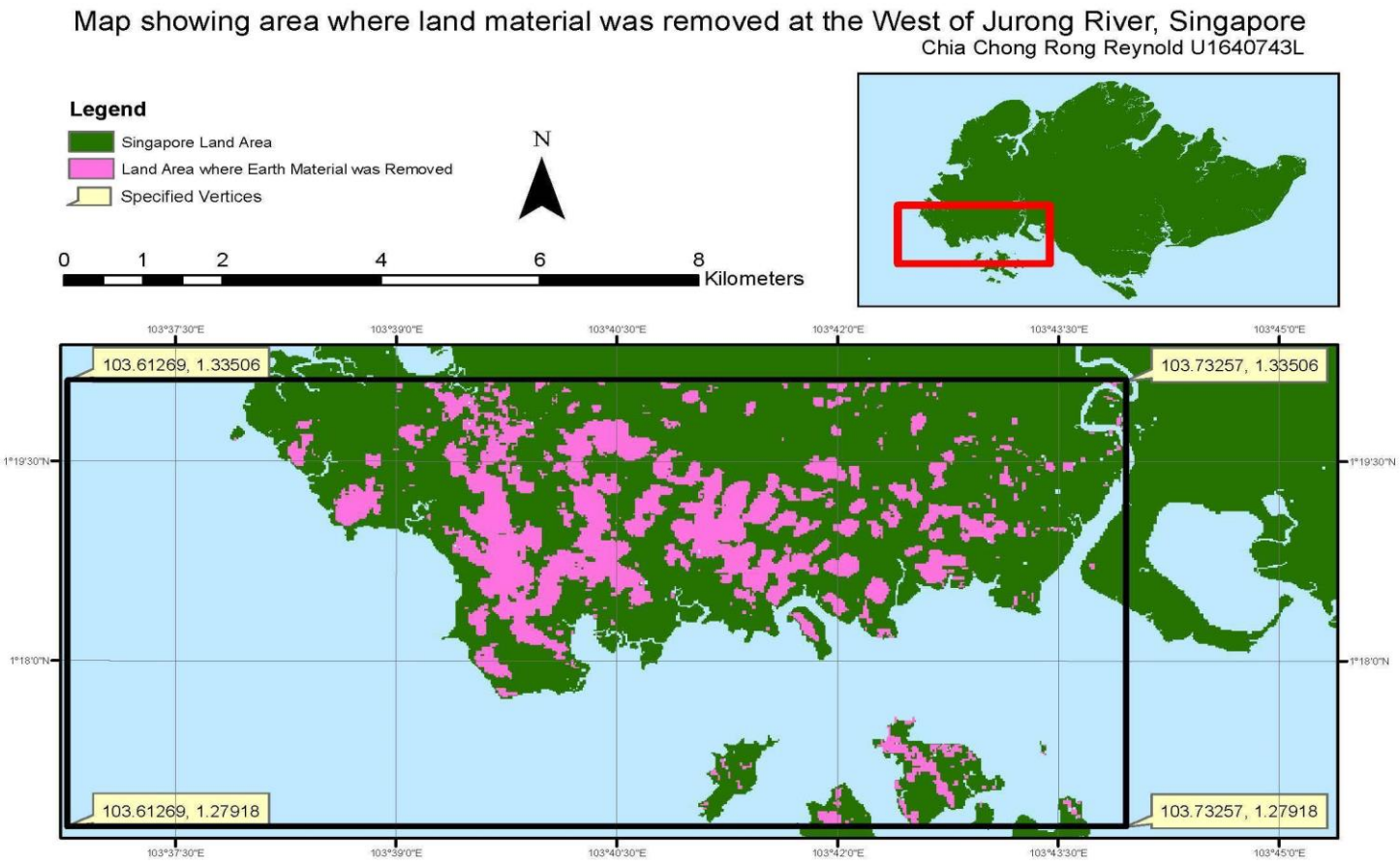

Figure 6. Map of West of Jurong River, Singapore.

Question 6

If Singapore were to reclaim more land, what should the minimum elevation of the reclaimed land be, in your opinion? Justify your answer.

The minimum elevation of reclaimed land should be above sea level. As sea level is continuously rising due to climate change, the elevation of reclaimed land should be increased accordingly. According to a study done by Meteorological Services Singapore, the highest possible sea level rise is 1.0 to 2.0m by 2100, taking into account rate of climate change (Matthew, et al., 2015). Changes in sea level due to high and low tides also have to be considered. Assuming that change in sea levels due to tides remains relatively the same from now till 2100, it is possible that sea levels can rise by an additional 1.0 to 2.0 meters due to tides (National Environment Agency, 2017). Therefore, considering all these factors, minimum elevation of reclaimed land should be **5m** above sea level if land is to be reclaimed by 2100, to avoid sea level rise by climate change and tidal changes, and to ensure safety of the people.

Question 7

Given this, how much more land area could Singapore reclaim? Assume that the ocean around Singapore is on average 10 meters deep.

Reclaimed land should be at least 5m above sea level as explained in question 6. However, in order to reclaim this land, there shouldn't be too much land materials taken away from the original Singapore land volume. After removing land volume from the Singapore original land, the elevation of remaining land should still be above 5m as well. Therefore, the volume of land above 5 meters in the current Singapore should be calculated, as this is the volume of land that can be used to reclaimed more land so that the original land area does not dip below 5 meters above sea level.

From the calculations, the land area which Singapore could reclaim is **653 km^2** (3 s.f.).

References

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