University Of British Columbia

Tsunami Impact Assessment on Vancouver Island's West Coast

Alejandra Flores, Breagha Zakaib, Christy Chin

Geob 270

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Professor Sally Hermansen

TA: Mielle Michaux

ABSTRACT

As population increases in coastal regions, earthquake triggered tsunamis pose a greater threat than ever. This project shows the possible hazards and risks for a tsunami on the West Coast of Vancouver Island. Using evidence of the past 1964 earthquake that occured in Alaska and generated a tsunami that affected Vancouver Island, three maps analyzing different aspects of risk where created. Ucluelet, Tofino and Port Alberni were the towns that were selected for this project. The creation of two scenarios of 5 km storm surge and 10 km storm surge were selected to compare the hazards in each case. Airports, First Nation communities and major roads are going to be destroyed. Tsunamis in Vancouver Island are expected in the future posing a hazard to people and property in coastal areas.

DESCRIPTION OF PROJECT

The majority of the rock that makes up Vancouver Island was originated in the equator near the Pacific Ocean. It is part of a large terrane called Wrangellia. Vancouver island is situated in The North American plate, as the oceanic Juan de Fuca plate tries to slide under the less dense North American plate it becomes stuck. It has been stuck already for approximately three centuries building up stress and can be ready to go at any moment. This will cause the famous, overdue Megathrust Earthquake. Our infrastructure would be devastated and coastal communities from Vancouver Island will become victims of the massive tsunamis that the earthquake will generate.

The result of a Megathrust earthquake is presumed to produce a 20m tsunami wave on the west coast of Vancouver Island. Our project analyzes the areas within potential flood zones, affected transportation routes and communities, and the affected populations including First Nations. The potential of the natural disaster is inevitable and is creating high risks for many communities. Therefore, by assessing the affected factors, we can help mitigate the consequences of the tsunami.

METHODOLOGY

Acquiring Data: The data was taken from DataBC: Airports, Aboriginal Communities, coastline/shoreline. G:Drive UBC: Dems 25 metre,VanIsle Outline, Highways , CHASS Toronto: Population and Low Income Data, and the UBC data library: Census Dissemination Area Boundaries. Once collected and unzipped the Data was imported to Arcmap for analysis

Parsing Data: For this map NAD1983_BC_Enviromental_Albers was used as the projection. To make sure the data was reliable it was downloaded for the entire province, and checked with outside sources for location accuracy. For this map the 25m DEMS used needed to be “Mosaic to Raster” for further analysis. The data collected was then filtered for only Vancouver Island, eliminating the rest of the BC entities that existed. The highway layer consisted of road and boat highways, by clipping the roads to the VanIsle outline we removed the boat routes as they were not necessary.

Mining Data: All Layers were clipped to the Van Isle Outline first.The DEM layer was classified using different colours to represent different elevations. After re-assigning colours, the DEM was reclassified to 4 levels of elevation,(0,3,10,20). Once it was reclassified, the 20m elevation raster layer was converted to a polygon. For the flooded areas a buffer analysis was conducted, with ranges of 5 and 10 Kilometres, starting at the coastline, displaying the flooding that would occur. Once the buffer was complete, the Low elevation polygon and Buffer were intersected to show only the flooding and 20m of elevation on the same layer. After adding the Dissemination Area to the table of contents a Query for Tofino, Ucluelet and Port Alberni Da’s was conducted. Once Selected the three towns were exported to a new layer for further analysis. Tabular data from CHASS Toronto consisting of population and low income was collected. By using the unique identifier (DAIUD) the Tabular Data was joined with the Dissemination Area boundaries of Tofino, Ucluelet and Port Alberni. Once joined, symbology and classes were altered. We decided on 5 classes and Manual Breaks in even percentages, to display the data for each town. The highway after being added to the table of contents was “Selected by Location” to Flooding, to identify the roads in the flood zone. With outside information on the future road construction, and using the measure we identified the road work location for the development site. The Airports and Aboriginal Communities were added to the table of contents, followed by “select by location” for flooded area, to identify the affected communities and airports.

Representing Data: When presenting the maps, scale was a major factor as each town is separated by several kilometres. To show the detail and analysis that had been conducted we chose to show each town at a large scale so the viewer could understand with a closer view. We also included an “Inset” to give the map reader a better sense of location, allowing them to visualize where on Vancouver Island the towns were. A legend to Identify the main features was included as some of the maps had several important entities which needed explanation. Landscape view was chosen for 3 of the 4 maps as it looked neater and presented the maps in a nicer way. Titles were appropriately chosen for the information being displayed, choosing relatively short and exact words that would be easy and appealing to the reader.

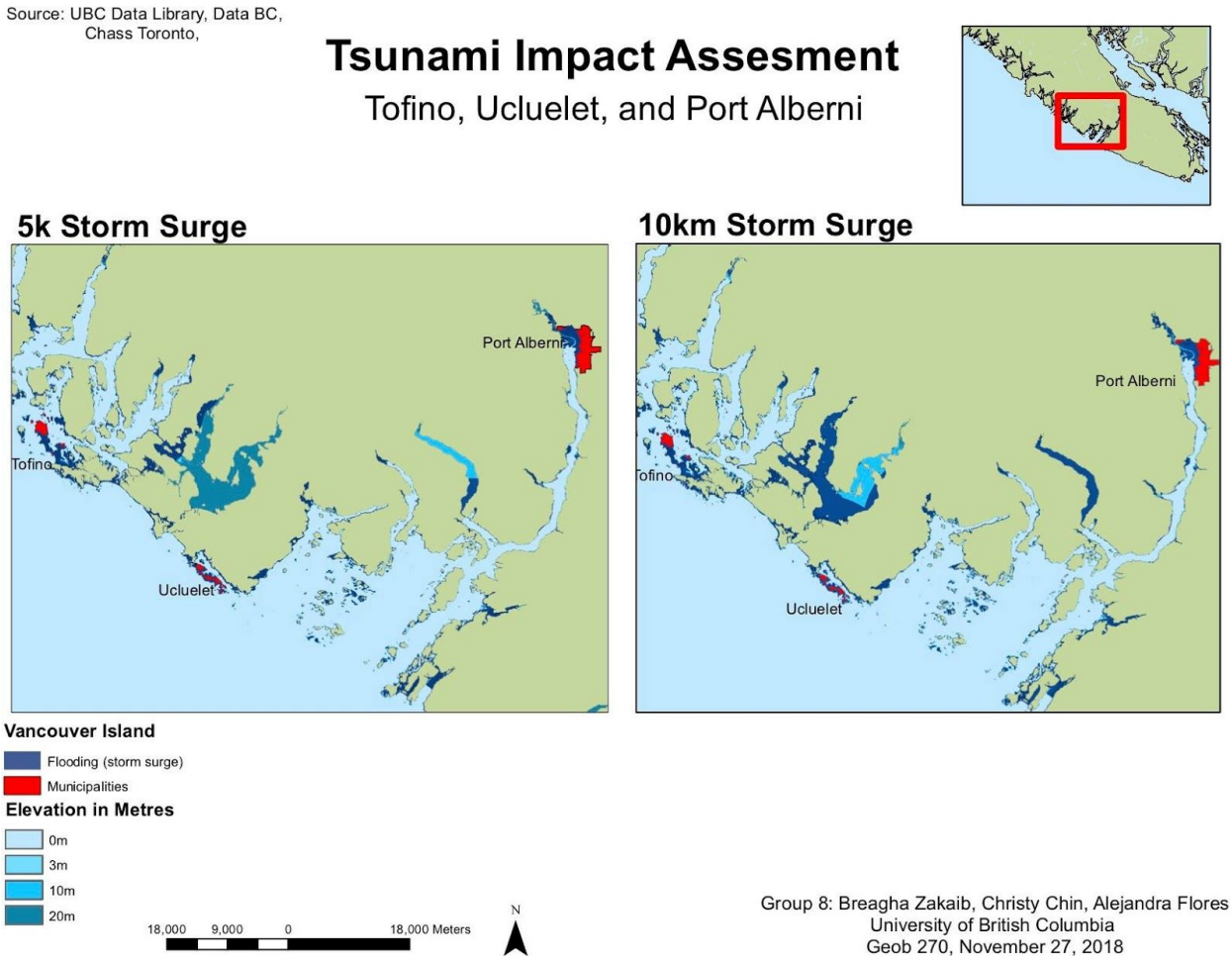
Layer/ Datafile name	Source	Uses	Entity/ Data Model	Attributes	Modifications
DEM 25M	G:Drive UBC data Library	To Reclassify elevation	Raster	Vancouver Island South	Mosaic to Raster, to Polygon. Clip to Vancouver Island Outline
Coastline	G:Drive UBC data Library	Buffer, outline island	Polyline	Vancouver Island Coastline	Buffer, Clip
Census Disseminati on area	Data Library UBC	Show Municipalities and Income	Polygons	Boundaries	Tabular Join, Symbology colour change: Natural Breaks (5 classes), Make features in percentages
Tabular Data	CHASS Toronto University	Tabular Join	Tabular Data	Low income and Population	Tabular join and relate with census dissemination area
Highways	Data BC	Project Highways	Polyline	Highways within British columbia	Clipped to Vancouver Island outline, Select by location, measured selected line from outside sources. Create new layer to project affected highway.
Van Isle Outline	G:Drive UBC	Outline Vancouver Island for Analysis	Polygon	Vancouver Island outline	Used as clip boundary
Airports	Data BC	Affected Airports	Points	Airports in BC	Clipped to Vancouver Island outline, Select by location, affected airports in flooding
Aboriginal Communiti es	Data BC	Affected communities	Points	Aboriginal Communiti es in BC	Clipped to Vancouver Island outline, Select by location, affected communities in flooding

DISCUSSION AND RESULTS

Tsunami Impact Assessment: Tofino, Ucluelet, and Port Alberni

The following maps compare the scenario of a 5km storm surge and 10km storm surge around Tofino, Ucluelet, and Port Alberni located on Vancouver Island (shown in Red). These estimations display the areas in which a storm surge may affect the area. According to Clague et al., (2000) large tsunamis occur once every hundreds of years, some of the tsunamis are caused by distant great earthquakes. Therefore, knowing this information we decided to create the different scenarios for tsunami hazards. A tsunami created by distant earthquakes might have less impact than a tsunami caused by the Cascadia subduction zone. We conducted some research on the impacts that the 1964 earthquake in Alaska had. That catastrophic hazard caused a great tsunami that killed over 130 people some of them where 2600 km apart the epicenter (Clague et al., 2000). Knowing this information we decided on doing the 10km buffer to show higher destruction risk. As it is observed in the maps below, flooding of towns is similar in the 5km and in the 10km storm surge due to the 20m elevation, however infrastructure had greater damage in the 10km storm surge.

Source: UBC Data Library, Data BC, Chass Toronto,



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Tsunami Impact Assessment: Affect Roads, Aboriginal Communities and Airports

The following three maps of Tofino, Port Alberni, and Ucluelet show the main transportation routes and communities that will be affected by the Tsunami. The First Nations communities on the coast can expect their houses to be damaged, but they also have longhouses for celebrating potlatches as well as Cedar Totem Poles and cultural infrastructure that will be damaged. As mentioned in the first map, the shaded blue areas are within the potential risk of storm surges.

Tofino

The flooded zones will affect the highway that spans across Tofino and the Tofino - Long Beach Airport (YAZ). As shown below, the airport is located along the shoreline within the flooding zones and most of Highway 4 would be flooded, prohibiting evacuation by civilians. The transportation routes are critical for entering and exiting Tofino, as there is only one road. However, when the tsunami hits, these transportation methods would not be accessible. This may lead to isolation of the affected community.

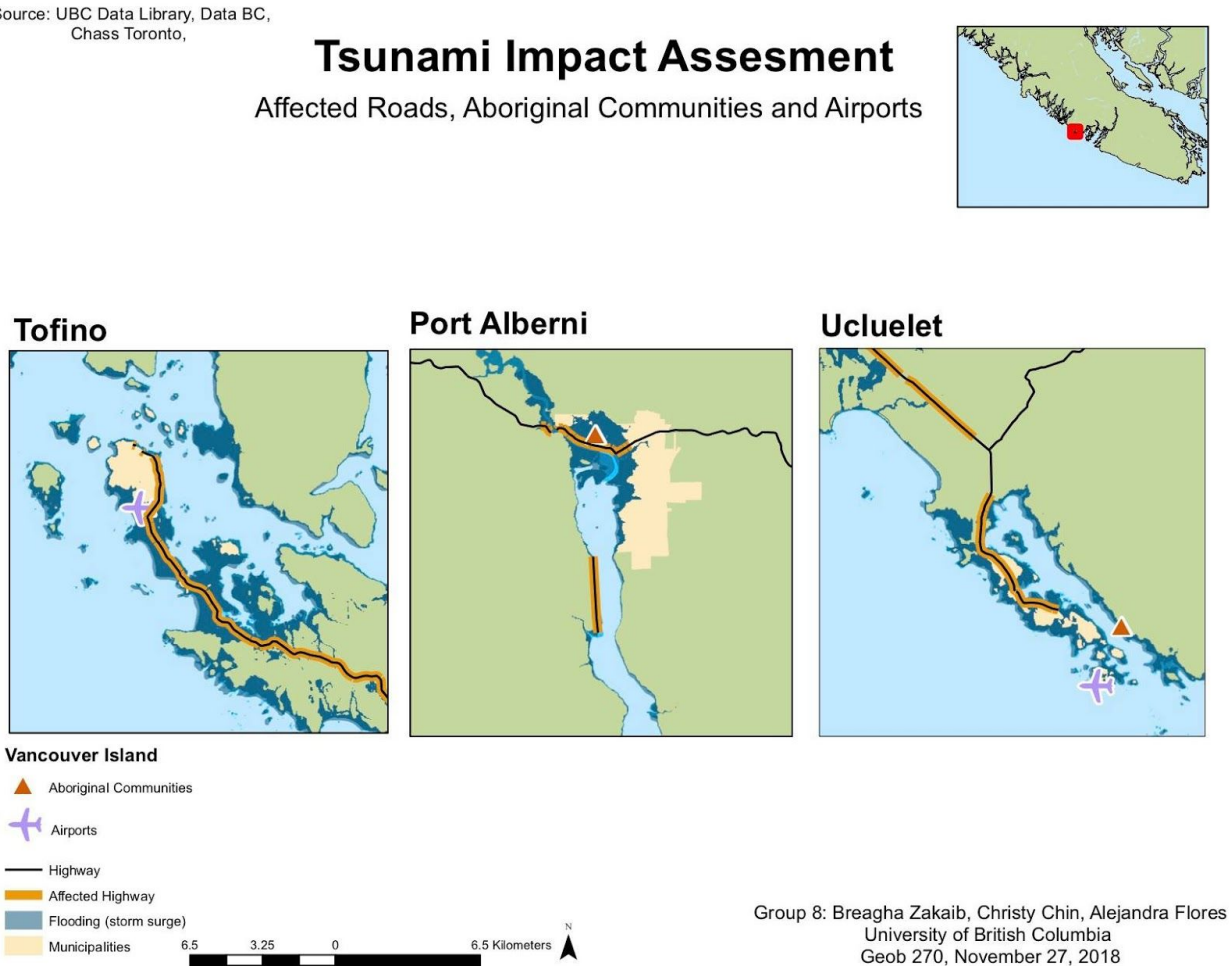
Port Alberni

Although Port Alberni is inland, inundation occurs within this zones when a tsunami rapidly runs through the Alberni Inlet (Neil et al., 2015). Port Alberni is located at the end of Alberni Inlet, resulting in a stronger storm surge that cuts further into the land. As shown below, the main highway (Highway 4) and most of the town is flooded. Additionally, there is a aboriginal community within Port Alberni, Ahahswinis 1, within the potential risk zone. According to Statistics Canada, the 2016 Census shows that the Ahahswinis 1 population is decreasing. The age of the remaining population are mostly ranges between 15-64 (Statistics Canada, n.d.).

Ucluelet

Similar to Tofino, Ucluelet is also located on the very west edge of Vancouver Island. The transportation routes are within the storm surge zones as well as the aboriginal community, Ucluelet First Nations. The Ucluelet First Nations affected by the tsunami are within the Ittatsoo Reserve 1 with a population of around 200 people (Statistics Canada, n.d). The destruction of transportational methods will cause the community of Ucluelet to be more vulnerable to the tsunami as evacuation could be potentially impossible. .

Source: UBC Data Library, Data BC, Chass Toronto,



Low Income of Affected Neighbourhoods

According to the Government of Canada website a person is considered to have low income status if they make 60% less than the average annual income, which is approximately 35,000 dollars a year. Living in a low income household might be one factor that increases risk of injuries. The purpose of the following maps is to demonstrate the percentage of low income houses in the three different towns. As we believe that housing quality is associated with rates of low risk in case of a hazardous event.

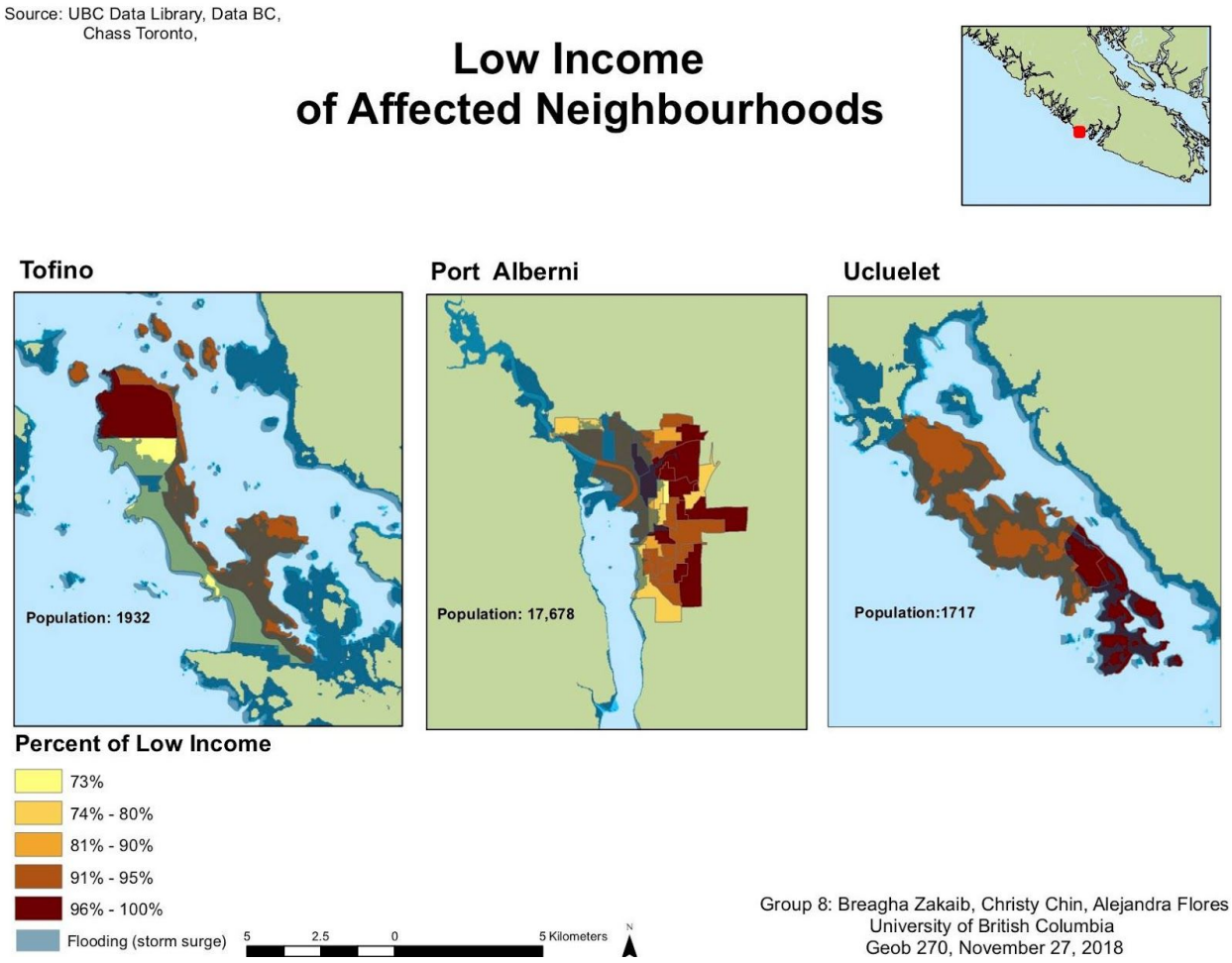
Hurricane Harvey hit eight countries in its destructive path. Of those countries people lying within the low income category suffered the worst, as infrastructure and buildings in low income neighbourhoods were poorly maintained and of much lesser quality, making them highly more susceptible to damage. Not only is building damage a worry but so is economic recovery, when Hurricane Harvey hit, only 17% of homeowners could afford flood insurance. (Krause and

Reeves 2017) This means the houses without sufficient coverage dealt with the incident for much longer and on their own. After Hurricane Katrina in 2005, strict building requirements were established in preparation for another likely storm. These building standards were costly, which stopped people from rebuilding or moving home at all.(White 2015) As damaging as the disaster is itself, it's the recovery process that can be some of the most difficult obstacles to overcome. By highlighting the percentage of low income in each of the three communities on Vancouver Island we hope to express the worry and potential outcomes in the occurrence of a major tsunami for poorer families.

By clipping the flooding to the DA areas we were able to calculate the percentage of land affected. The percent of municipality flooding was the same at 5km and 10km.
The equation used to calculate the percent of municipality:

(Shape area of flooded clip total / DA shape area total) x 100

Tofino: 7455382.02 / 10498793.507 = 0.7101 X100= 71% of area is flooded
Port Alberni: 6705873.590 / 20220452.23 = 0.331 X100 = 33% of area flooded
Ucluelet: 4244358.28 / 6449190.629 =0.655 X100=65% of area flooded



MegaQuake (10km Surge) Damage: Impact to Existing Roads and Future Construction Site

Highway 4 is a crucial means of transportation for people entering and exiting the area. Along the highway, the yellow highlights represent the areas that will be affected by the flooding if a major earthquake is to occur. Highway 4 is already dangerous and safer development and planning is currently happening. The 38 million dollar construction process is underway and expected to be finished in 2020. The B.C. Government website states that the road work is essential for the future of the region as it is a major road for transporting goods, inviting tourists and connecting towns (Ministry of Transportation, 2018). The 'new highway' is being built near Kennedy Lake, approximately 14 km northeast of the Tofino/Ucluelet Highway 4 junction (Ministry of Transportation, 2018). However, the construction area (red) is within the estimated storm surge zone. Although there are plans for rock slope stabilization, it could still be a hazard along the highway during the tsunami. Highway 4 is built on different elevations varying from the coastline to mountains. Some potential reasons to slope failures are logging of old growth (weakens the soil), blasting bedrock along the new highway, and the water from the storm surge.

MegaQuake (10km Surge) Damage

Impact to Existing Roads and Future Construction Site

Source: UBC Data Library, Data BC, Chass Toronto,

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ERROR AND UNCERTAINTY

Buffer does not fully show exact areas that may be affected

Although we have chosen to use a 5km and 10km buffer along the coastline, other geographical factors are not accounted for such as land/soil type and higher elevation. Typically speaking, the 20m tsunami could flood most of the west coast of Vancouver Island.

Strength of tsunami

Although we calculated for a 9.0 earthquake and a wave height of 20m, results could vary, causing more or less damage to the areas and analysis than we have predicted. As we are limited to the amount of data available, there is room for error as we can not pick the best possible numbers and models.

Other natural disasters/ man made disasters that may be triggered during the tsunami

We have only accounted for the directly affected areas due to the tsunami. Other natural disasters such as landslides have not been fully taken into account due to the many possibilities of physical and human geographies. Tofino and Ucluelet are also major tourist hotspots in the summer months. Along with local housing, businesses and hotels/resorts are likely to be wiped out, as much of the development is on the shore.

Age of data collection

The census dissemination areas is collected from 2016. Changes within the past two years are not included in our analysis. Housing, income, and population could have changed as the area is becoming more well known.

Raster cell size: affects resolution

A DEM of 25m was used for our maps, however the resolution and accuracy would not only be better but could potentially change the analysis, if a smaller cell size was used. We have limitations on the data available, and our analysis was conducted to the best of its ability, but not the best quality. Without up to date, 1mx1m resolution accuracy and precision are bound to be off.

Choosing between dissemination areas or census tracts

‘Low Income of Affected Neighbourhoods’ uses dissemination areas data. Dissemination Areas covers a smaller boundary which allows for variation in statistics of smaller and less populated towns, as well as a more accurate representation. However, census tracts cover a larger area which allows for a wider range of data values. Census tracts typically stays stable over time, meaning less change in values over the 5 year periods.

FURTHER RESEARCH/RECOMMENDATIONS

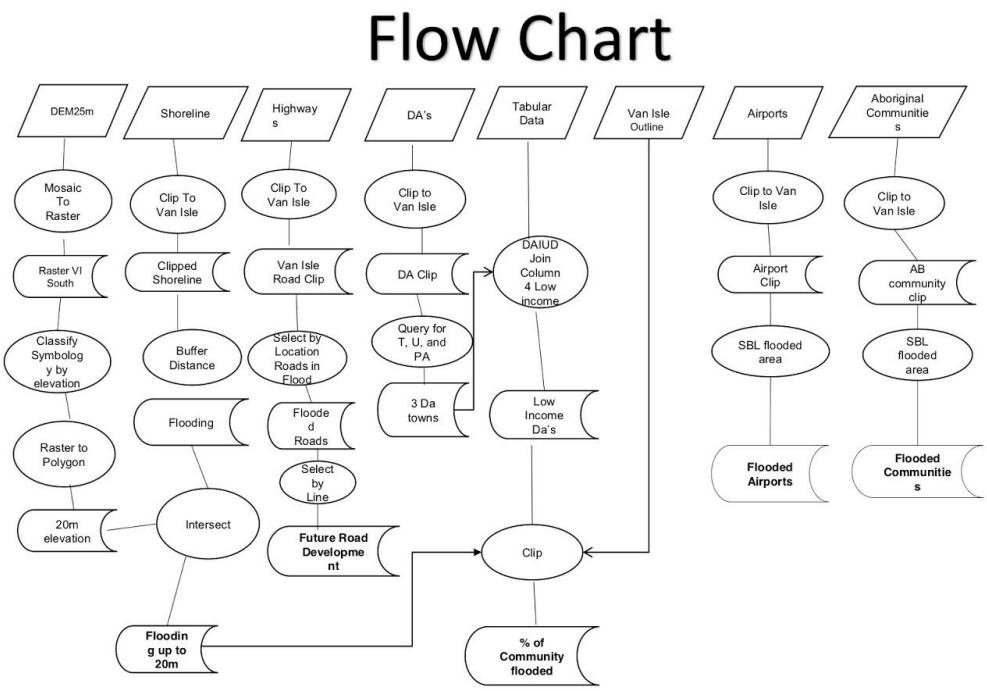
There are several areas of possible research expansion such as relocation sites for people and first nations communities and key infrastructure which would be hotels, hospitals, and airports. One of the biggest risks when a catastrophic event occurs is trying to get people out of the danger zone once the hazard has occurred since warning for tsunamis are relatively short. Relocation of civilians and new construction of airports and hospitals in safe areas, is a key to re planning and recovery. However, relocation of people would also be beneficial since there is certain time of recovery approximately 10 months according Ingram et al., 2006 after a tsunami has impacted a town.

When a natural disaster occurs it is hardly just the impact of the storm which devastates the communities, it's the destruction of landscape, buildings and ruin of resources. A likely landslide, pipe leak and electrical fire are all potential hazards apart from the Tsunami. Within the area there are drinking water wells and groundwater aquifers. Further analysis could be how water sources from flooding or landslides etc are affected, unable to be accessed or used in the time of panic.

The west coast of Vancouver Island is a raw and rugged landscape, home to some of the biggest trees in the province. The dense forest holds many ecosystems full of Deer, Wolves, Bears, Cougars, Eagles, Herron, Seals, Salmon etc. The impact of a massive tsunami on the wildlife in the area could be devastating. Further research and investigation of habitats in the potentially hazardous area could be another analysis project.

A recommendation for Canadians living in BC would be to encourage drills promoted by government and plans of emergency in case any hazardous event happens. It is a responsibility to inform and educate people in a susceptible community of possible natural disasters.

APPENDICES



Data sources: As well as G:Drive from UBC

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