

Climate Change Effects on the Swinomish Indian Tribal Community

GIS in Water Resources Fall 2012

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Objective

Climate change is projected to impact the Swinomish Indian Tribal Community over the next century. In attempts to prepare for the impacts of climate change (increased temperatures, sea level rise, intensified weather events etc.), the Swinomish Indians completed an assessment of projected climate change effects and a plan of action to cope with the effects. One of the effects addressed in these assessments is the impact of climate change induced sea level rise and increased storm surge on the Reservation. The effects of sea level rise and storm surge were modeled using Global Information Systems (GIS) software and 2002 Light Detection And Ranging (LIDAR) data. My objective for this project was to see if I could recreate the results obtained from this portion of the Swinomish climate change assessment using ArcGIS and data available on the internet.

Introduction

Swinomish Reservation Location and Background

The Swinomish Indians are a federally recognized Native American Indian Tribe that occupies the Swinomish Indian Reservation on the Puget Sound in northwest Washington (see Figure 1). The Swinomish Reservation was established in 1855 by the Treaty of Point Elliott, and covers 10,350 acres of land [1]. Most of the perimeter of the Reservation is bound by water; to the east by the Swinomish Channel and to the west by Skagit and Kiket Bays.

Figure 1: Location of the Swinomish Indian Reservation.

The picture on the left shows the Swinomish Reservation as a black dot in reference to the state of Washington. The middle picture shows the Reservation in reference to Seattle. The picture on the right is a full extent view of the Reservation.



The Swinomish Indians are Coast Salish people and are descended from groups and bands originating from the Skagit and Samish River valleys, coastal areas surrounding nearby bays and waters, and numerous islands including Fidalgo, Camano, Whidbey and the San Juan Islands [2].

Much of the Swinomish culture is centered around their abundant saltwater and uplands resources including shellfish, marine mammals, cedar, camas, berries, and wild game [2]. In addition, the tribe has been particularly well known for cultural ties to salmon. Salmon is viewed as a sacred resource, and every year the Swinomish Indians hold ceremonies to bless fishermen and honor the return of the salmon (Figure 2). For this, the Swinomish Indians are commonly referred to as “The Salmon People” [3]. In the words of Larry Campbell, a Swinomish Elder, the Swinomish are “People of the Salmon and our way of life is sustained by our connection to the water and the lands where we have fished, gathered, and hunted since time immemorial”.

Figure 2: Picture depicting the Swinomish Tribe’s annual celebration of the return of the salmon



Climate Change in the Swinomish Reservation

As mentioned previously, the Swinomish Tribal Community depends heavily on their natural resources. This, in turn, makes the Swinomish community very sensitive to climate change as it impacts these resources. In fact, the Swinomish Indian Tribe has already had to adjust to impacts from climate change affecting their salmon resources. Two hundred years ago there was salmon in the Reservation’s rivers and bay areas 365 days a year. In the past 150 years climate change (among other factors) has led to depleted salmon populations throughout the Northwest [3]. This trend is expected to increase in the future. Adult salmon will die in water temperatures above 70 degrees, and it has been projected that by 2080, nearly half of the streams monitored in the Reservation will exceed average weekly temperatures of 70 degrees [3].

Another concern for the Swinomish Tribe stemming from climate change is the effects of sea level rise and storm surge resulting in inundation of land area, structures, and access routes. The Swinomish Reservation is bordered mostly by water bodies with only two roads connecting the Reservation to mainland Washington. These two roads are highway SR20 at the north end of the Reservation, and Reservation Road at the south end (highlighted in red on Figure 3). Inundation of either of these access routes could effectively isolate the Reservation from mainland Washington creating economic and logistical issues [4].

Figure 3: Roads (black) and bridges (red) on the Swinomish Reservation



In addition, climate change is expected to increase the risk of wildfires in the Reservation due to increased temperatures. Elevated health risks to the ill and elderly are also a projected impact of increased temperatures.

Swinomish Climate Change Initiative

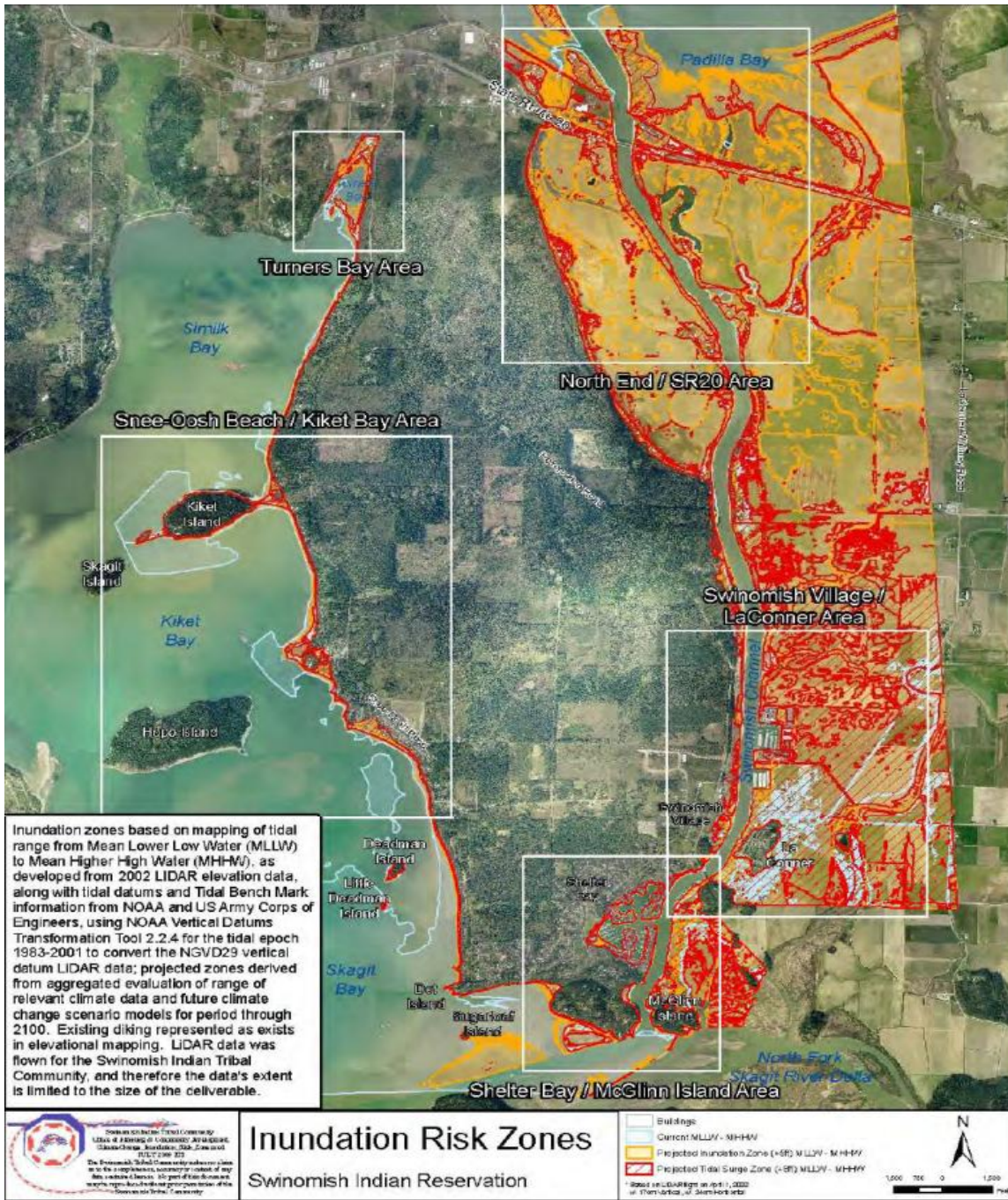
The Swinomish Indian Tribal Community understands the implications that climate change has on their community. In order to be prepared for these implications, the Swinomish Indians have worked with the University of Washington and surrounding communities to complete an assessment of the impacts of climate change on their Reservation. The findings of this assessment were published in a report in 2009 called the Swinomish Climate Change Initiative: Impact Assessment Technical Report. This report investigated the projected effects of sea level rise, temperature rise, and intensified weather events on the Swinomish Reservation.

A follow up report was constructed in 2010 documenting the Tribe's plan for coping with the climate change impacts investigated in their 2009 report. This report was titled the Swinomish Climate Change Initiative: Climate Adaptation Action Plan. This second report took the conclusions made in the first report and used that data to build a comprehensive plan of action to mitigate the negative effects climate change is projected to have on the region.

GIS and the Swinomish Indian Tribal Community

GIS was used in the Impact Assessment Technical Report prepared by the Swinomish Tribe in considering inundation risk from sea level rise and increased storm surge. Water elevations were estimated using a combination of 2002 LIDAR data, Tidal Datums, and Tidal Benchmarks [4]. Once elevation data was established for the region, GIS software was used to determine what areas of land would be inundated from a conservative projected sea level rise of 5 feet and a storm surge of 8 feet above the current sea level over the next century. A map of these results is shown below in Figure 4. The red on the map represents areas projected to be at risk of inundation from tidal surge and the yellow represents areas projected to be at risk of inundation from sea level rise. The scale bar at the bottom of the map represents a total distance of 3,000 feet.

Figure 4: Inundation risk zones within the Swinomish Indian Reservation



Project Goal

The map in the previous section that was presented as part of the Impact Assessment Technical Report was created by GIS professionals and used a very high resolution (1m or greater) elevation map. My goal for this GIS project was to see if I could produce similar results as the Impact Assessment Technical Report with limited experience in GIS using elevation and other data easily accessible online.

Methods

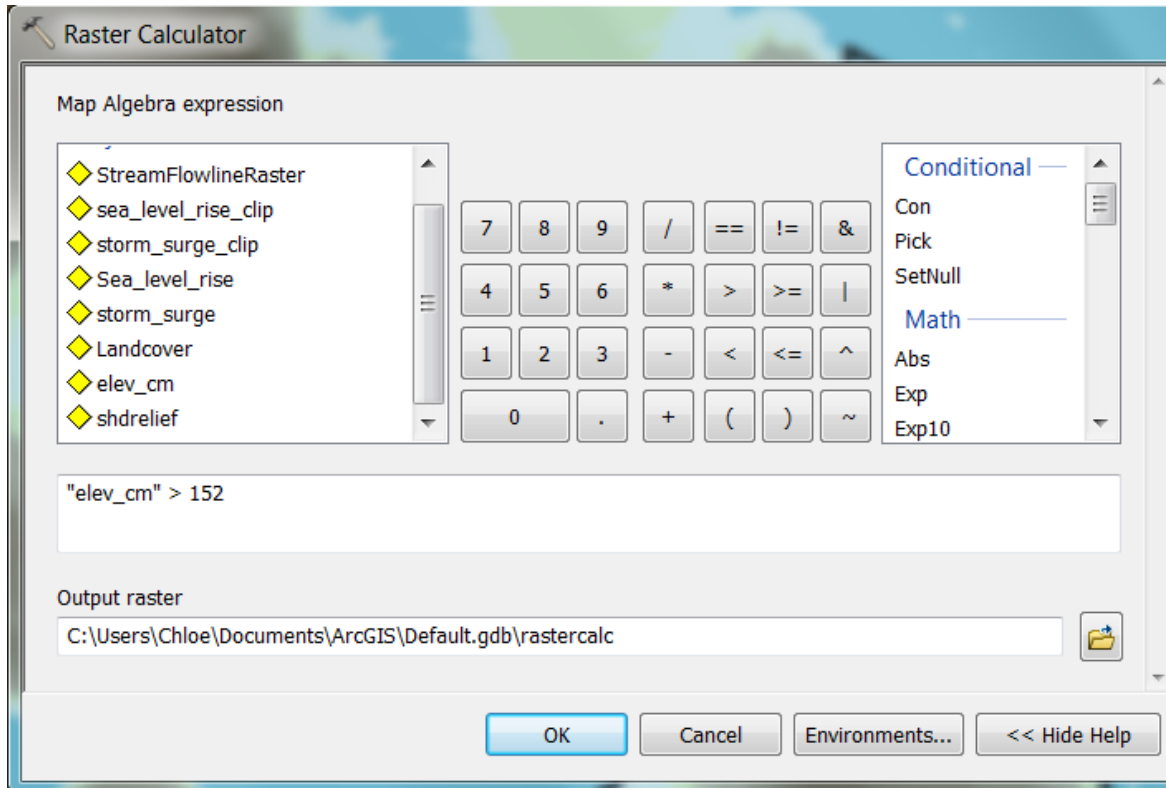
Data Acquisition

For this project two datasets were downloaded from free online databases: land cover data and a 30 meter resolution digital elevation model (DEM). The land cover data was downloaded from the USGS National Map Viewer [5] and the DEM was downloaded from the USGS National Hydrography Dataset (NHD) [6].

Sea Level Rise and Storm Surge Inundation Risk Calculations

To determine the areas at risk for sea level rise and storm surge inundation, two raster calculations were performed on the DEM of the Swinomish Reservation. Keeping consistent with the Impact Assessment Technical Report, the inundation risk area for sea level rise was modeled as the portion of the DEM that was less than 5 feet above sea level (assuming a value of zero in the DEM corresponding to sea level). Similarly the inundation risk area for storm surge was modeled as the portion of the DEM that was less than 8 feet above sea level. An image of the raster calculation performed for the sea level inundation risk area is shown below in Figure 5 where the number '152' corresponds to the centimeter equivalent of 5 feet (as centimeters are the units of the DEM).

Figure 5: Sea level rise inundation risk raster calculation



Data Management

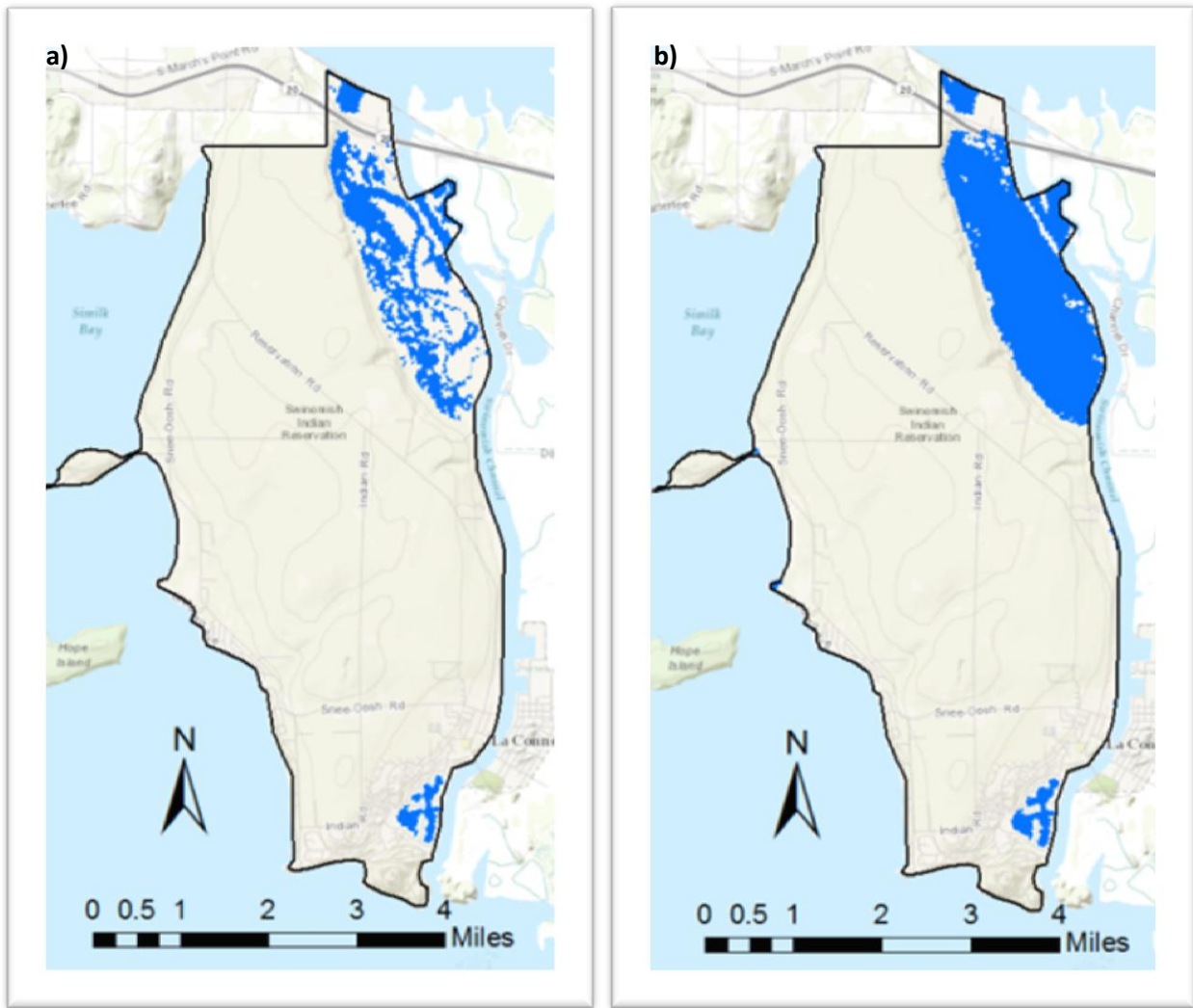
In order to keep the maps of sea level rise and storm surge inundation risk areas uncluttered, a polygon was drawn outlining the land border of the Swinomish Reservation and both inundation risk area rasters were clipped to only occupy the land area of the Reservation. Similarly, the land cover vector data was also clipped to the Reservation polygon. Clipping data to the Reservation polygon allows for a more user friendly map by showing only the area of interest and removing extraneous data that might be confusing.

Results

Storm Surge and Sea Level Rise Inundation Risk Areas

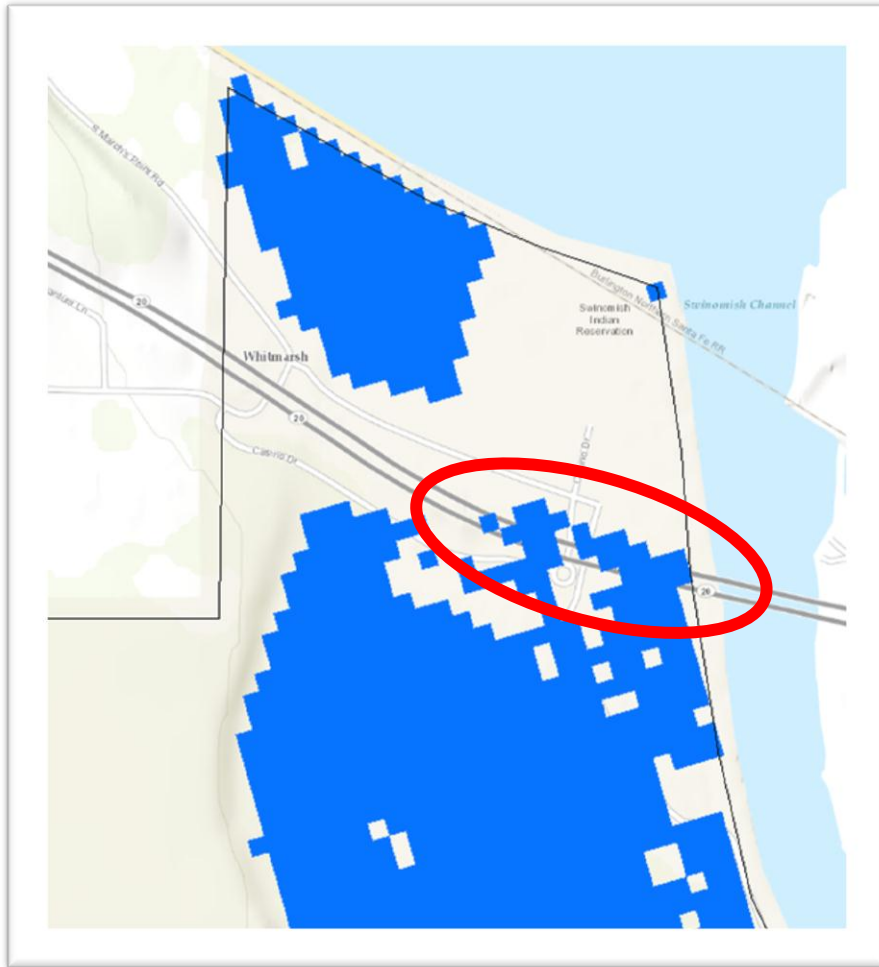
The areas determined to be at risk for inundation from sea level rise and storm surge are shown below in Figures 6a and 6b, respectively. The images clearly show that the northeastern portion of the Swinomish Reservation is at highest risk for inundation from both storm surge and sea level rise. A portion of the southeast part of the Reservation is also at risk for both sea level rise and storm surge inundation. In the case of storm surge, there are also a few areas along the coast that are at risk for inundation.

Figure 6: a) Inundation risk area from sea level rise b) Inundation risk area from storm surge. The darker color blue indicates inundation risk.



One particular issue with the storm surge inundation risk is shown in Figure 7 (a zoomed in portion of Figure 6b). The area circled in red indicates an area where the storm surge inundation risk zone overlaps one of the two main access routes to the Reservation. As mentioned in the climate change section of this the paper, this is an issue as inactivation of this access route could cause huge transportation issues to and from the Reservation.

Figure 7: Storm surge inundation risk area overlapping highway SR20



Inundation Risk Areas In Relation to Land Cover

In order to have a more interesting interpretation of the Swinomish Reservation area at risk for inundation, a map of land cover was used to determine what types of land use are at risk of inundation. Figure 8 shows a map and key of land cover in the Swinomish Reservation and Figures 9a and 9b show the sea level and storm surge inundation risk zones on top of the land cover map, with blue indicating the inundation risk zones.

Figure 8: Land cover in the Swinomish Reservation

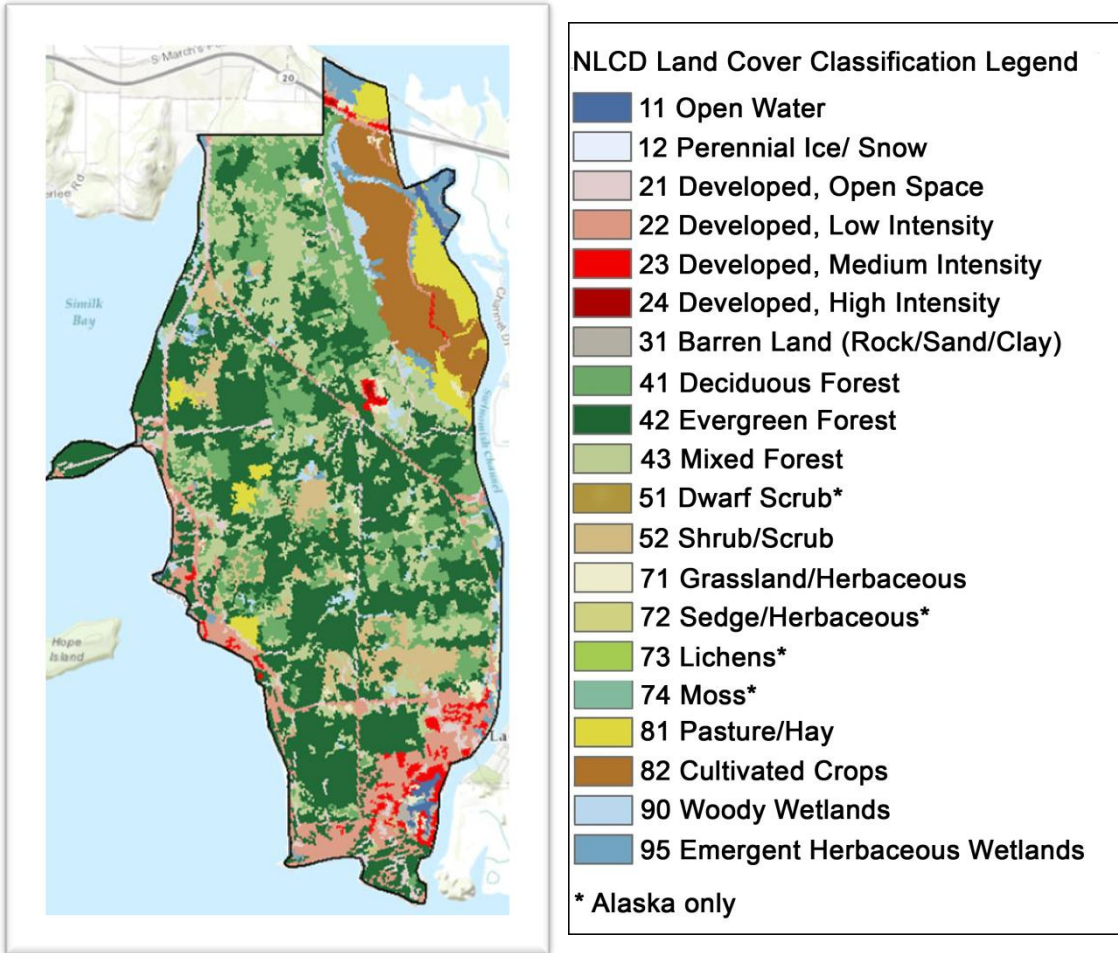
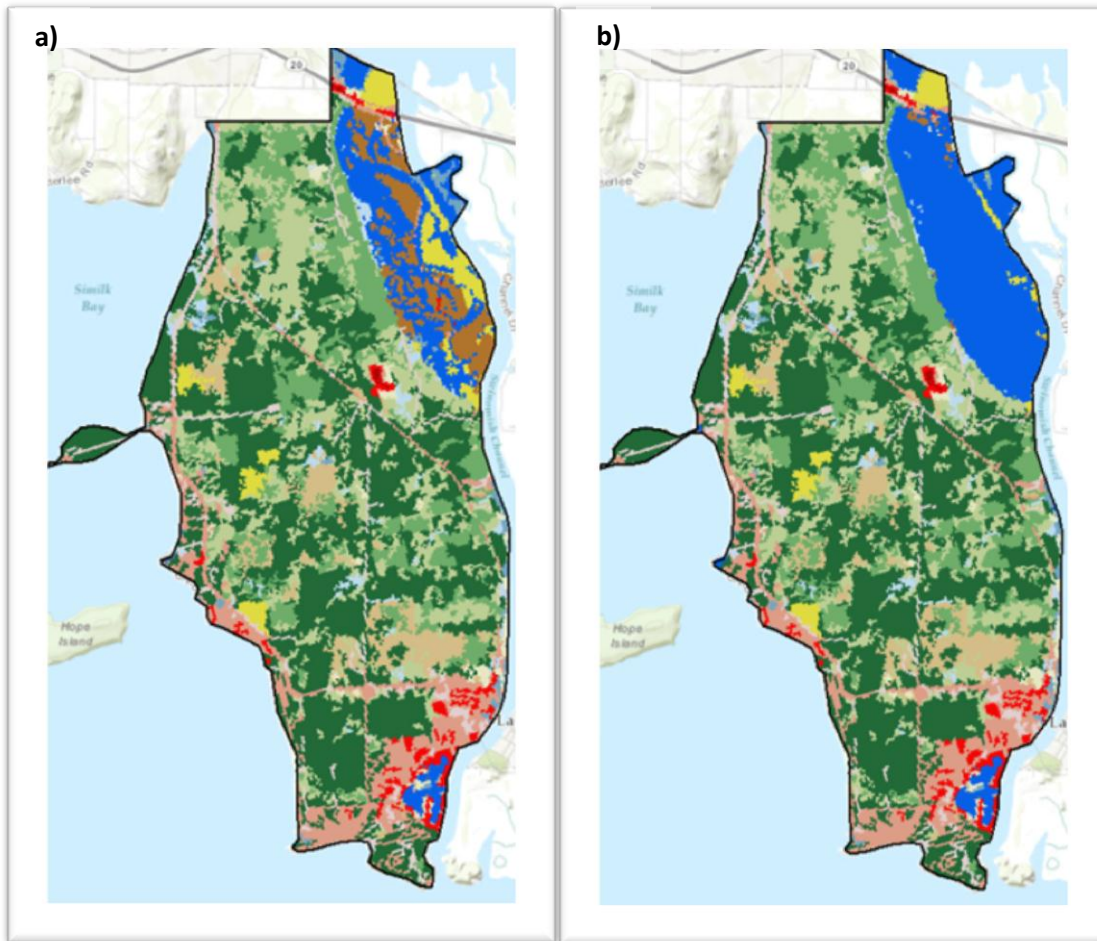


Figure 9: a) Sea level rise inundation risk area b) Storm surge inundation risk area

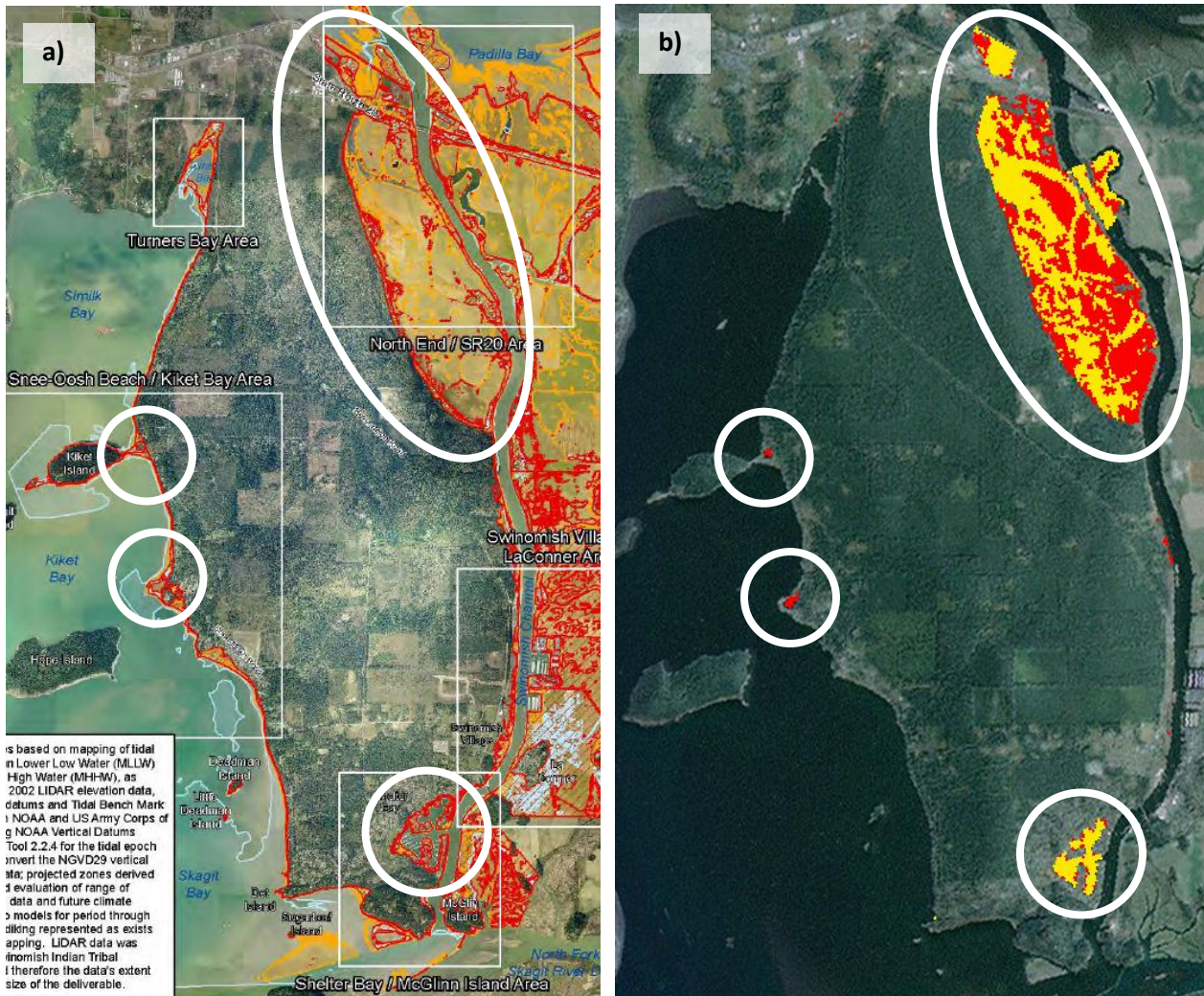


Interpretation of figures 8 and 9 show that the area in the northeast region of the Reservation that is at risk of inundation is the Reservation's main pasture and crop lands. In addition, the area in the southeast region of the Reservation that is at risk of inundation is the most developed section of the Reservation. Both of these areas are very important to the economy of the Swinomish Reservation and could have drastic effects on the population if inundated.

Comparison to GIS Image from Swinomish Impact Assessment Technical Report

My next goal in GIS was to attempt to make a direct comparison between my inundation risk zones map and the inundation risk zone map presented in the Impact Assessment Technical Report (shown in Figure 4). To make the two maps as similar as possible, I changed the coloration of my sea level rise and storm surge inundation risk zones, overlaid the two risk zones, and chose an imagery base map similar to the base map used in the Impact Technical Report. The results are shown in Figure 10a and 10b.

Figure 10: a) Inundation risk zone map from the Impact Assessment Technical Report b) Inundation risk zone map from my GIS project



The white circles in Figure 10 show the areas of similarity between the two images. The yellow in both images represents the inundation risk zones from sea level rise and the red represents the inundation risk zones from storm surge. The Impact Assessment Technical Report extended their analyses of inundation risk beyond the border of the Swinomish Reservation into mainland Washington, and that is why there exist large areas of inundation risk on the right side of Figure 10a and not in my analyses (Figure 10b). However, for areas within the Swinomish Reservation it is clear that my analysis of inundation risk areas matches reasonably well with the inundation risk areas found in the Impact Assessment Technical Report.

Conclusions

The data used in completing the Impact Assessment Technical Report was much higher resolution and more up to date than the data I was able to easily download from USGS. However, even with the discrepancies in data used for analyses, I was able to generate comparable results of inundation risk zones in the Swinomish Reservation. Not only did my inundation risk zones map show similar locations of inundation risk, but I was also able to use a land cover base map to draw similar conclusions about what types of land use are at high risk of inundation.

The Impact Assessment Technical Report specifically mentions the inundation risk for highway SR20 as well as the Reservation's main agricultural lands (shown in my map as pasture/hay and cultivated crop lands). Both of these conclusions were also made from my inundation risk map when overlaid on a land cover map for the region. In addition, the Impact Assessment Technical Report mentioned how approximately 180 structures were at risk of inundation [4]. It is reasonable to expect that the majority of these structures are present in the highly developed areas that my analyses also showed as at risk for inundation.

Although my results are not as precise as the results presented in the Impact Assessment Technical Report it is valuable to show that an individual with limited knowledge of ArcGIS using data available free of charge online can come to similar conclusions as those presented in a professional report. This is a tribute to the user friendly nature of ArcGIS, and the quality and availability of data online. This project shows that a limited knowledge of ArcGIS and where to access data online is suitable for being able to find answers geographic questions.

Acknowledgements

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