Investigating the Effects of Varying Projections of Sea Level rise on San Francisco County Humboldt State University Geospatial Analysis

GSP 270 By: Logan Salcuni and Zach Porteous

Abstract

Geospatial Analysis (GIS) has become a key tool in communicating and visualizing the effect of damage, growth, and potential to an area. GIS has changed the way that communication is effective with the ability to describe an issue and display projections over a map that outline and highlight the area that is under discussion. Climate change has become an overwhelming issue for forests, oceans, and cities. The best supported scientific evidence describes that the global surface temperature is increasing due to anthropogenic disturbances. Our study investigates the effect that global surface temperature increase might have based on the most recent analysis from the National Oceanic and Atmospheric Administration (NOAA). Sea level rise poses a great threat to large cities along the coast and could result in erosion of cliff-side areas and flooding of others. Based on the worst-case scenario (WCS) data given by NOAA, we projected a 4m sea level rise onto a map of San Francisco. Catastrophic damage was anticipated and observed from the model. Our model however does not take into account the physical properties of water i.e thermal expansion and the shifts in tide severity and changes of weather patterns that could promote flooding.

Introduction

1.1 Climate Change

Global Climate change poses an increasing threat to humans all over the globe. Due to anthropogenic disturbances such as fossil fuel consumption we will profoundly change global weather patterns. Global surface temperature has increased by ~0.2 degrees Celsius in the past 30 years (Hansen et al. 2006). The increase in global temperature is the most serious impact from climate change. It is one of the most difficult things to assess and model due to limitations in understanding the physical properties and dynamics of ice sheets and glaciers being not sufficiently understood. Our geospatial analysis will target and visualize various levels of sea level rise one of which is a worst case scenario predicted by the National Oceanic and Atmospheric Association (NOAA), the National Ocean Service (NOS), and the Center for Operational Oceanagraphic Products and Services (COOPS) put out in 2017 of 10 to 12 feet.

1.2 Model Site

We were curious as to what San Francisco would look like under 10 to 12 feet of water because we both grew up very close to it. San Francisco has a population of 789,172 (2010 census) and is projected to be rising. It receives more than 16 million visitors and $9,380,000,000 annually from local visitors and international tourists. It is well known for its industrial and manufacturing economy as well as being a beacon of technological innovation. International trade enters San Francisco seaports and the city has many surrounding attractions near the coastline. Our projections of sea level rise highlight the dangers that will arise if the global climate is allowed to warm significantly without mitigation.

1.3 Sea level rise

The threat of sea level rise is a combination of glacial melt occurring at the poles and thermal expansion occurring throughout major oceans of the world. Thermal expansion is the tendency of matter to change in shape, area, and volume in response to temperature (Britannia.com). With global surface temperatures increasing, it is directly correlated with an increase in seawater temperature. Increases in ocean temperatures cause ecological disturbances as well as more severe changes in weather patterns. Due to the effects of sea level rise along with changing weather patterns we can expect drastic and harmful changes to human inhabited areas.

1.4 Issues with analysis

Our analysis will be inherently flawed because of its lack of inclusion of many factors that can affect sea level rise. Since it will be purely based on the elevation of San Francisco, factors such as erosion, regional ocean currents, local subsidence and tidal fluctuations will not be considered.

Methods

After we downloaded the appropriate layers we needed to reproject them all into the same spatial reference system. I chose WGS 1984 for the datum and the UTM zone 10 projected coordinate system because of my familiarity with it. The SRS that was used in the city's layers were already in WGS 1984 but had an additional tag of DD in parenthesis that I was not familiar with so I thought that it was appropriate to change the projected coordinate system. Using the clip tool we extracted the part of the DEM that was within San Francisco's boundary.

Our main analysis was identical to the one we used in Lab 9. Using the select by attributes tool on the DEM we created generalized base rasters at sea level, 2, 3, 4, 5, and 10 meters of sea level rise. We then used the raster calculator to subtract those layers of rise from the sea level raster to get the specific inundation layers for each level. After creating an inundation map we then multiplied the sea level rise rasters by the parcel layer to get the number of pixels that were affected in each specific zoning class. There were five classes for zoning in this layer: mixed use, public, industrial, commercial, and residential. We then took the number of pixels and changed them to hectares using the cell size of the DEM and a conversion. To add some additional context I took snapshots of the 3D view of San Francisco from Google Maps and drew a rough line of where the water would be at the worst case scenario position posited by NOAA of 10 to 12 feet (approximately 4 meters).

The digital elevation model we used was obtained from USGS the generalized parcel layer of San Francisco was from that counties geospatial data portal. We also used a San Francisco county boundary layer from the counties data portal to clip to. Originally we were going to include the county of San Mateo in our analysis but we experienced some problems with the viability of their parcel layer; there were many parts of that layer that had no data available because it was only for planning purposes.

Results

A four meter increase in sea level will cause catastrophic damage to the city of San Francisco (Figure 1). The worst inundation occurred primarily on the east facing locations throughout the city of San Francisco. Large areas within Commercial and Mixed use zoning areas would be dramatically impacted. Treasure Island would be totally submerged and accounts for a large area of public land containing many sports fields and small portions of residential areas. Areas that experience five meters of sea level rise will also experience dramatic impacts (Figure 2). Impacts to Commercial zoning areas would be even more extreme under a higher level of sea rise. Public land would experience large impacts as well as residential areas becoming inaccessible and uninhabitable. Commercial zoning areas under ten meters of sea level rise would be dramatically in danger (189 hectares Table 1). Under the unrealistic rise of ten meters mixed use land would be dramatically impacted (511 hectares).

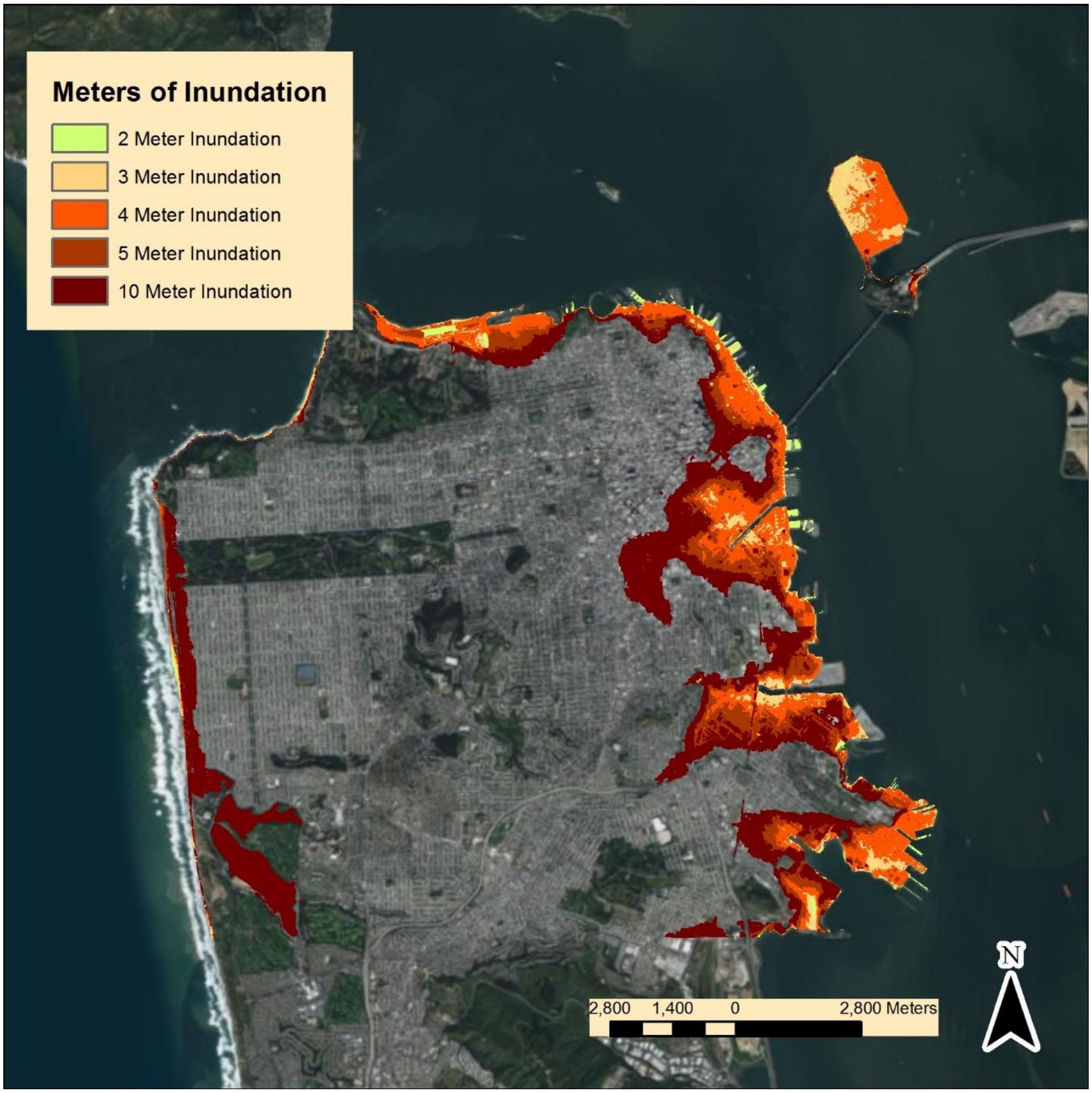

Figure 1: *Inundation Map of San Francisco*

Figure 2: *Rough sea level rise line at 4 meters rise of downtown SF*

Figure 3: Rough Line of sea level at 4 meters rise near AT&T park and UCSF Medical Center

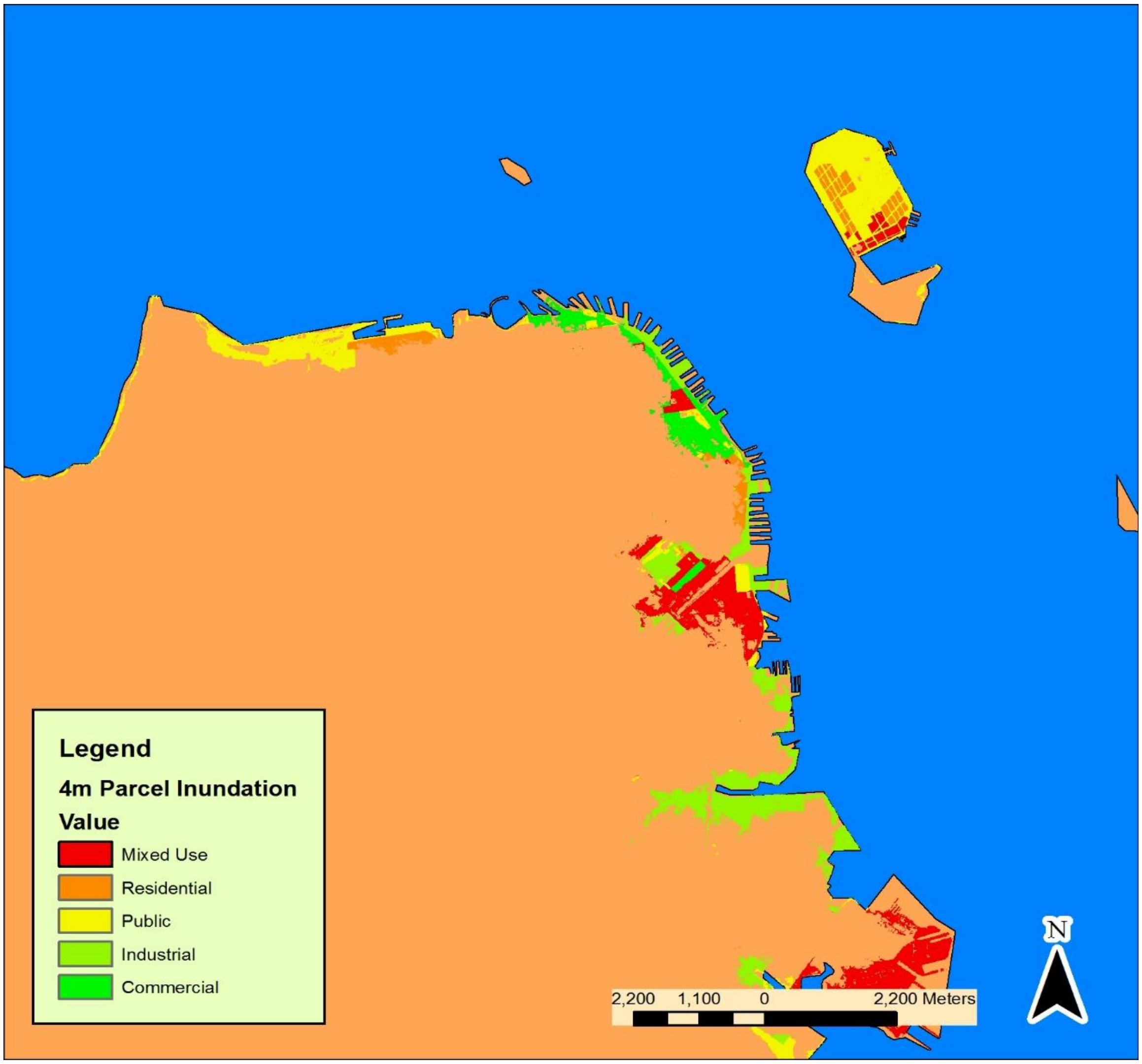

Figure 4: Parcel Inundation at 4 meters

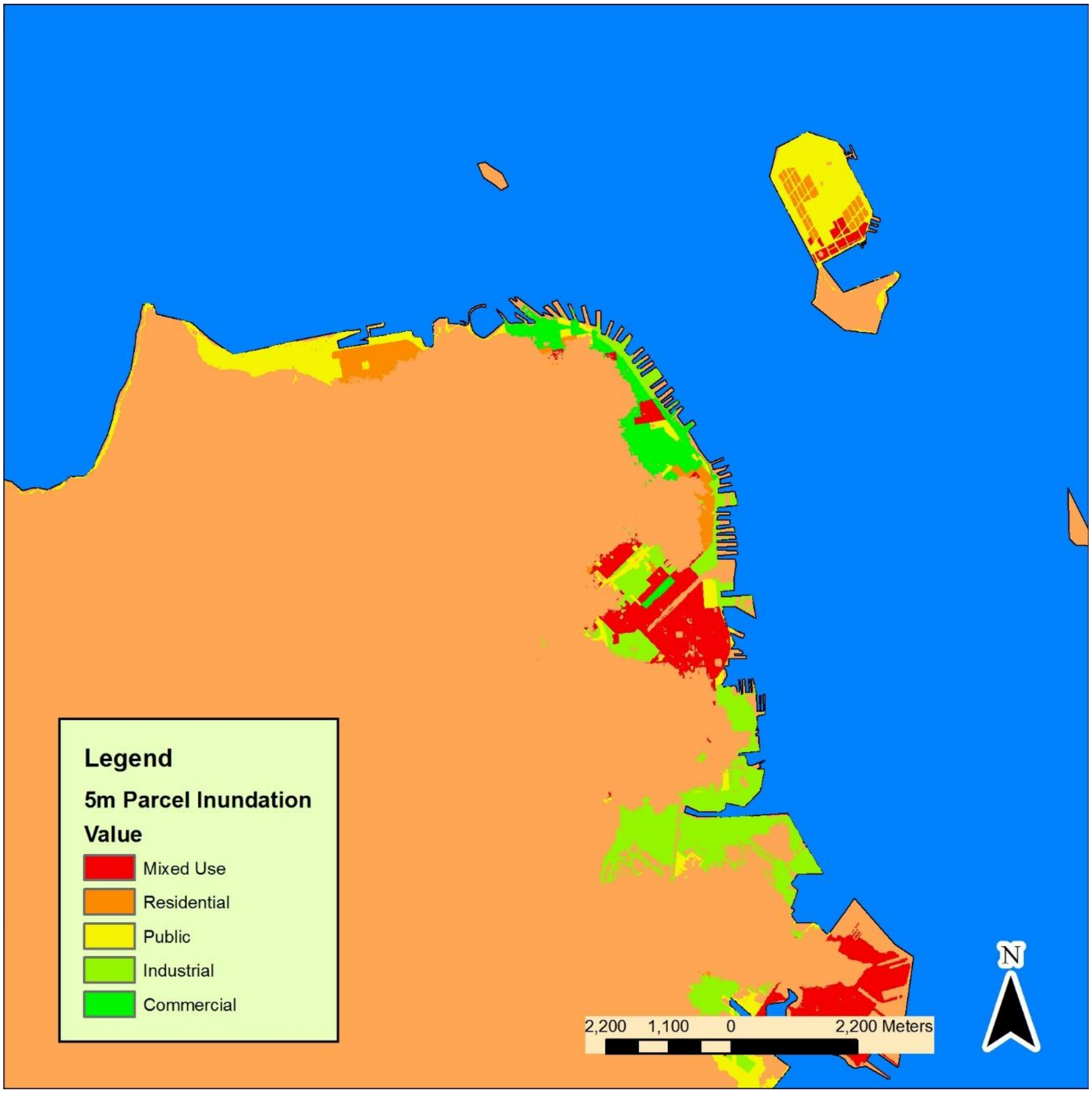

Figure 5: Parcel Inundation at 5 Meters

Table 1. Area of Inundation in Hectares of land affected based on projections of sea level rise in San Francisco. Sea level rise is in meters (m)

	Mixed use	Residential	Public	Industrial	Commercial
10m Inundation	511	244	734	662	189
5m Inundation	324	95	351	358	112
4m Inundation	249	56	279	201	79
3m Inundation	54	14	108	59	18

Conclusion:

Since the projection of sea rise that we cited from NOAA is based on estimations for the year 2100 it is prudent to focus on mitigation goals that are long term and focus on the reduction of greenhouse gas emissions. This is more ideal then trying to create physical barriers because it eliminates the source of the problem. Fortunately California is leading the way with AB 32 a law which seeks to reduce California's GHG emissions to 1990 levels by 2020 corresponding to a 15% reduction in emissions as opposed to "business as usual". The next milestone for AB 32 is to achieve 80% of the emissions from 1990 in 2050 (ARB 2018).

Another form of climate change mitigation that is happening in California is the participation of mayors (one of which is SF's mayor) in the United States Conference of Mayors Climate Protection Agreement which stipulates that signatories must strive to "meet or beat the Kyoto Protocol targets in their own communities, through actions ranging from anti-sprawl land-use policies to urban forest restoration projects to public information campaigns" and participate through lobbying local and regional governments to spur action on climate change (usmayors.org). this Agreement was spurred on by President Bush' refusal to sign the Kyoto Agreement. There are many avenues of climate change mitigation through local government action and as long as there is a substantial constituency in the United States committed to reducing their emissions, action on climate change will never cease.

References

Hansen, James, et al. "Global temperature change." *Proceedings of the National Academy of Sciences* 103.39 (2006): 14288-14293.

"Thermal Expansion" *Encyclopedia Britannica*, 2018. https://www.britannica.com /science/thermal-expansion.

Sweet V. Williams et. al., "*Global And Regional Sea Level Rise Scenarios for the United States*," NOAA, COOPS, NOS, January 2017. Received from USA Today, Accessed April 29, 2018. https://www.usatoday.com/story/weather/2017/04/27/water-water-everywhere-your-neighborhood-underwater-2100/100987622/

"Mayors Climate Protection Center." *United States Conference of Mayors*, 23 Aug. 2017, www.usmayors.org/mayors-climate-protection-center/.

"Homepage | California Air Resources Board." *History*, ww2.arb.ca.gov/homepage.