UNIVERSITY OF GENOVA

Department of Earth, Environment and Life Sciences

Master's degree course in

Hydrography and Oceanography

Sea level rise evaluation by remotely sensed data and its impacts on urban areas

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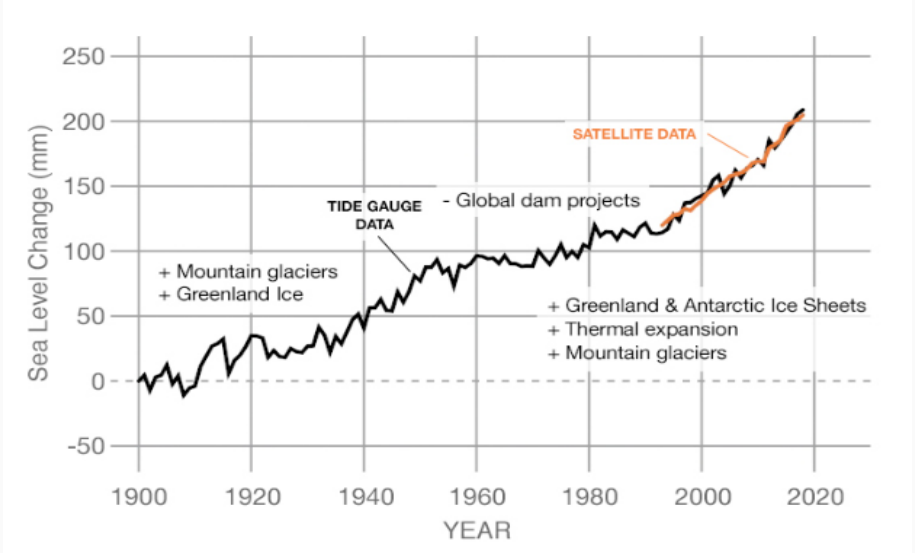
INTRODUCTION

Coastal change can be extremely slow or extremely rapid.

According to the fifth assessment report of the Intergovernmental Panel on Climate Change (IPCC), by 2100, the coastal cities will experience both sea-level rises (ranging from 0.28 m to 0.98 m) and much more intense storm surges.

Such storm flooding occasionally causes significant physical damage, loss of life, and economic losses. Examples of such incidents include Hurricane and Typhoon hazards.



The graph derived from coastal tide gauge and satellite data .

Geographical aspects of hazard

1.Factors related to changes in the volume

-Thermal expansion of seawater
-Growth or decay of land-based glaciers and ice sheets as Grenland
-Terrestrial storage,dam,river,depletion of groundwater

2.Factors are related to changes in the size and shape

-Isostatic adjustment of landmass, especially Glacial Isostatic Adjustment (GIA)
-Tectonic movement including ground subsidence/uplift associated with earthquakes
-Sediment inflow from land

3.Other factors causing local/temporal changes in sea level

-Changes in ocean currents
-Changes in atmospheric pressure
-Tides, tsunamis, storm surges, and waves
-Natural inter-annual variations, such as the Pacific Decadal Oscillation (PDO)

Factors related to changes in the volume of seawater contained in ocean basins

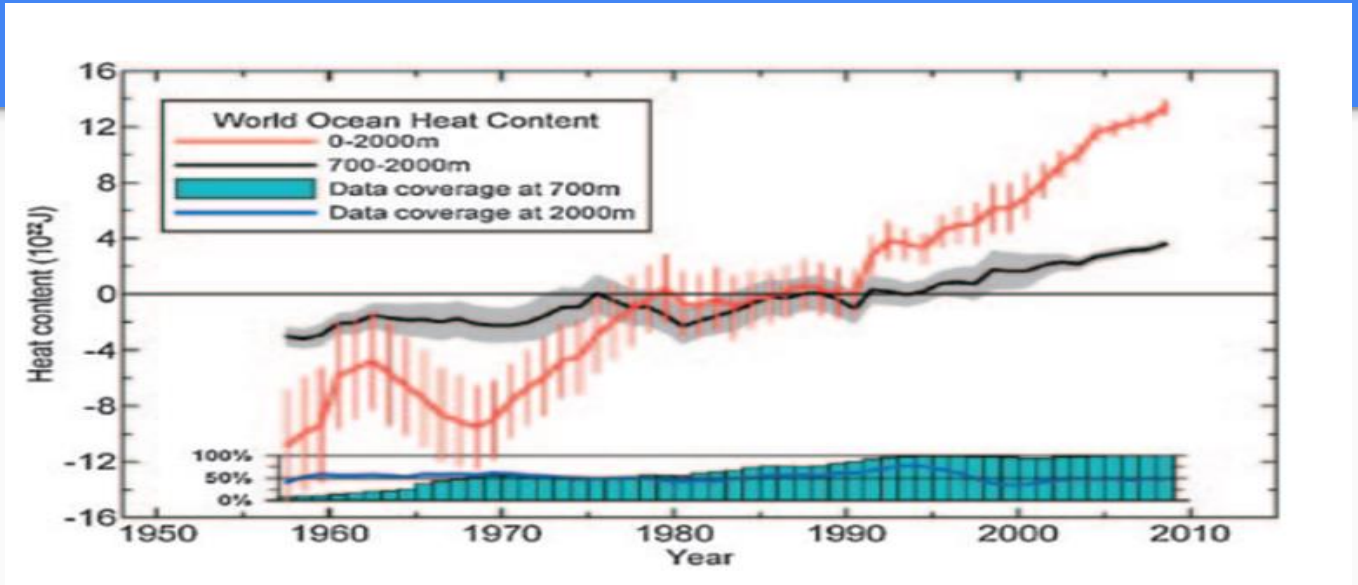
Most of the heat uptake of the ocean takes place through the surface mixed layer, where water temperature and density are nearly uniform due to the strong mixing of surface waters by the wind. Then the heat stored in the mixed layer is diffused to the deep layer through the thermocline. As the heat capacity of the ocean is about 1000 times larger than that of the atmosphere.

To estimate the thermal expansion of the ocean, we need to know the spatial distribution of the seawater temperature. Expendable bathythermographs (XBT) and mechanical bathythermographs (MBT) have been used by hydrographers to observe the vertical distribution of the temperature.

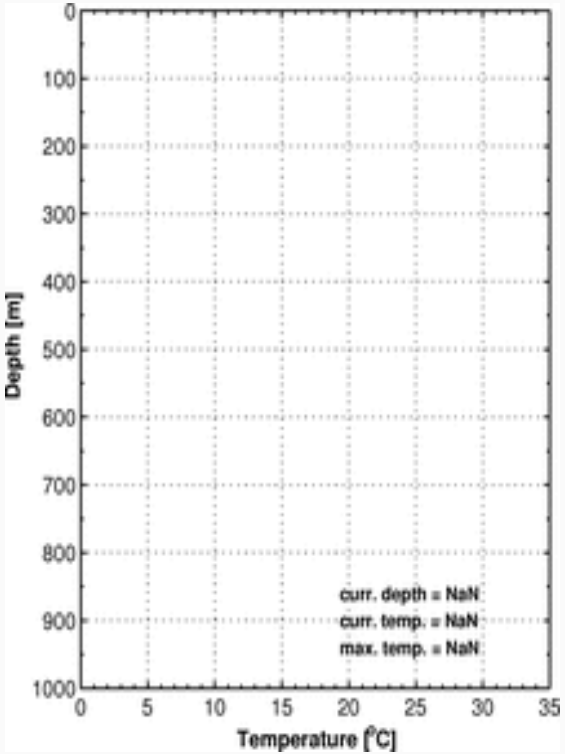
Time series for the World Ocean of ocean heat content

for the 0–2000 m (red) and 700–2000 m (black) layers based on pendatal (five years) running mean analyses.

Figure 3 shows a revised estimate for the ocean heat content (OHC) for two depth layers; 0–2000 m (red) and 700–2000 m (black).



the 700–2000 m layer is responsible for about one-third of the ocean warming of the 0–2000 m layer, indicating that major ocean warming has so far taken place in the relatively shallow ocean.



1. Example of XBT deployment using an auto-launcher (AL) mounted on the stern of a Merchant Vessel.
2.Example of real-time acquisition of a XBT temperature profile. The abrupt decrease in the temperature experienced by the XBT around 50 m is due to a feature called thermocline.

The most serious

Physical Impacts of gradual sea-level rise on coastal lowlands are :

1. inundation and displacement of wetlands and lowlands;
2. coastal erosion;
3. increased vulnerability to coastal storm damage and flooding;

4. salinization of surface water and groundwater

5.effects on coastal ecosystems such as salt marsh, mangroves

6.changes in sediment deposition along river channels

METHODS AND DATA ACQUISITION

REMOTE SENSING

OPEN DATA RESOURCES AND SOFTWARE

QUANTUM GIS

Remote Sensing

Examples :

- Cameras on satellites and airplanes taking images of large areas on the Earth's surface .

- Sonar systems on ships used to create images of the ocean floor without needing to travel to the bottom of the ocean.

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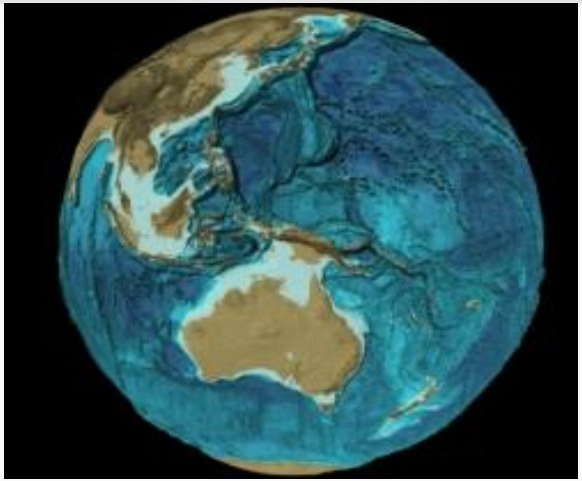
Bathymetry analysis by remote sensing

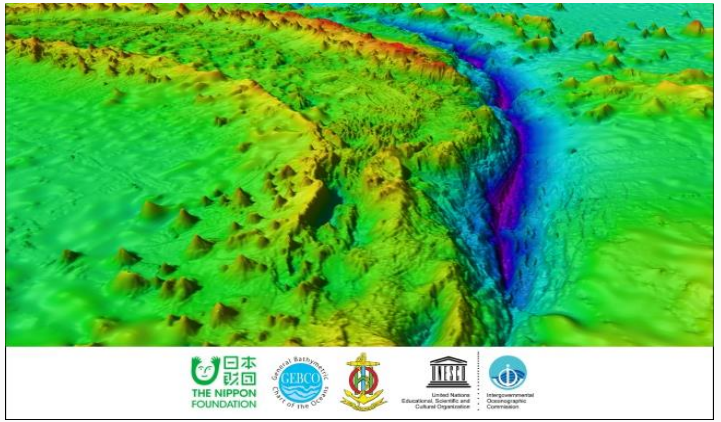


Bathymetry has been traditionally charted via shipboard echo sounding.

Remote sensing of bathymetry falls into two broad categories: non-imaging and imaging methods.

The detectable depth is usually limited to 20 m.

The accuracy of the retrieved bathymetry varies with water depth, with the accuracy substantially lower at a depth beyond 12 m.



Data source :**General Bathymetric Charts of the Oceans. Gridded Bathymetry**

POPULATION
DATA

There are many available resources. First and foremost the dataset needs to be chosen for the purpose of analysis. Population data can be filtered by country, region, year, gender, etc. Datasets are available in different types. Generally as a spreadsheet .csv or as a raster .tif file.

DATA RESOURCE

WorldPop produces different types of gridded population count datasets, depending on the methods used and end application. Datasets are available to download in .geotiff and ASCII XYZ format at a resolution of 3 and 30 arc-seconds (approximately 100 m and 1 km at the equator, respectively).

Probabilistic hazard map creation tool :

InaSAFE (plugin)

Flood modeling:
Flood modeling can be carried out by combining factors such as precipitation, geology and runoff characteristics, terrain, etc. to derive a model of an impending or current flood. Depends on data availability and the purpose of analysis.

Single-event versus multiple-event hazards:
Hazard data used in InaSAFE can represent either single-event or multiple-event.

InaSAFE concepts.

Introduction of Study areas

NEW YORK CITY

New York City is most densely populated city in United States. Also known as largest metropolitan area in the world by urban area. Situated in world's largest harbor area. The city's land had been altered substantially by human action.
The total areas of the city is 783 .8km^2

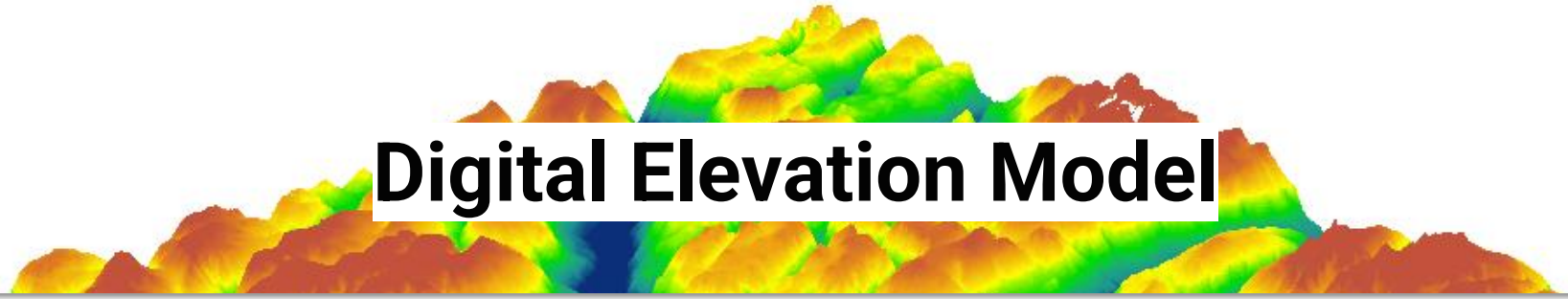
The city of Iloilo is highly urbanized area in Philippines, Panay island. Also most important city as a cultural heritage. The city is regional hub for tourism, education and economy. The city area is 70.3 km^2.

ILOILO CITY

Economic difference between countries.

Country	MEDIAN AGE	UNEMPLOYMENT PERC	GDP
USA	35 years	3,6 %	20.94 trillion $
PHLP	25years	5,8 %	361.5 billion $

One of the most common indicators is GDP, which stands for gross domestic product. It has become widely used as a reference point for the health of national and global economies.There are differences in electricity and internet access, average life expectancy, etc.

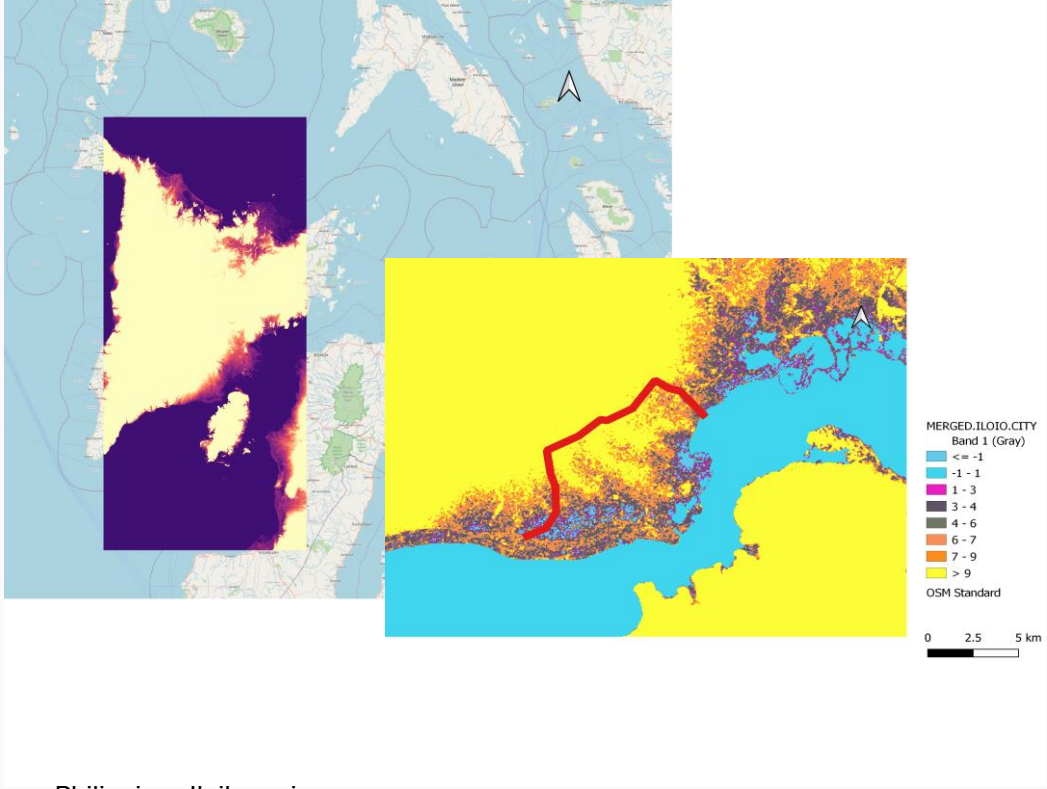


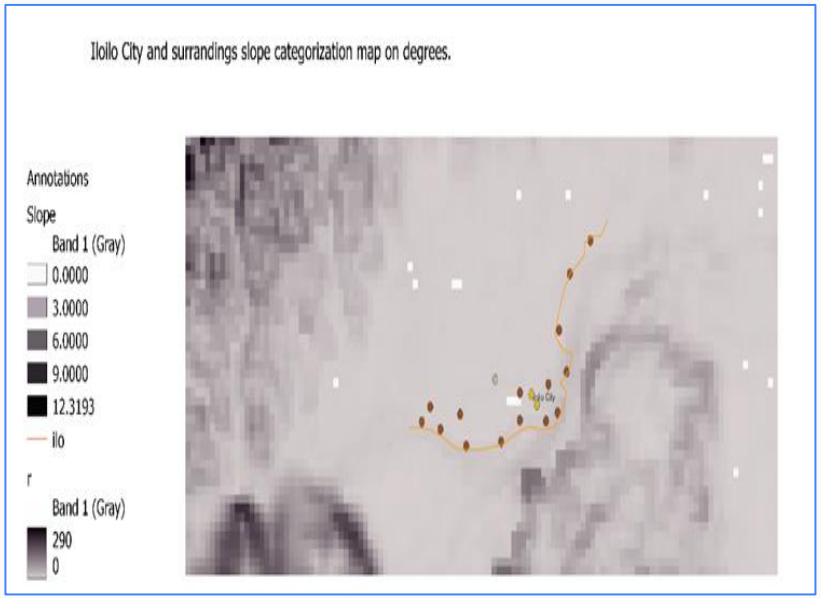
Digital Elevation Model

DEMs, standing for Digital Elevation Models, are digital representations of the Earth topographic surface.

DEMs are raster files with elevation data for each raster cell. They come in a variety of file formats.

The main difference between the two models lies in the fact that the DEM generally takes into account all persistent objects on the ground (vegetation, buildings, and other artifacts)—while the DTM shows the development of the topographic surface.





Philippines,Iloilo region

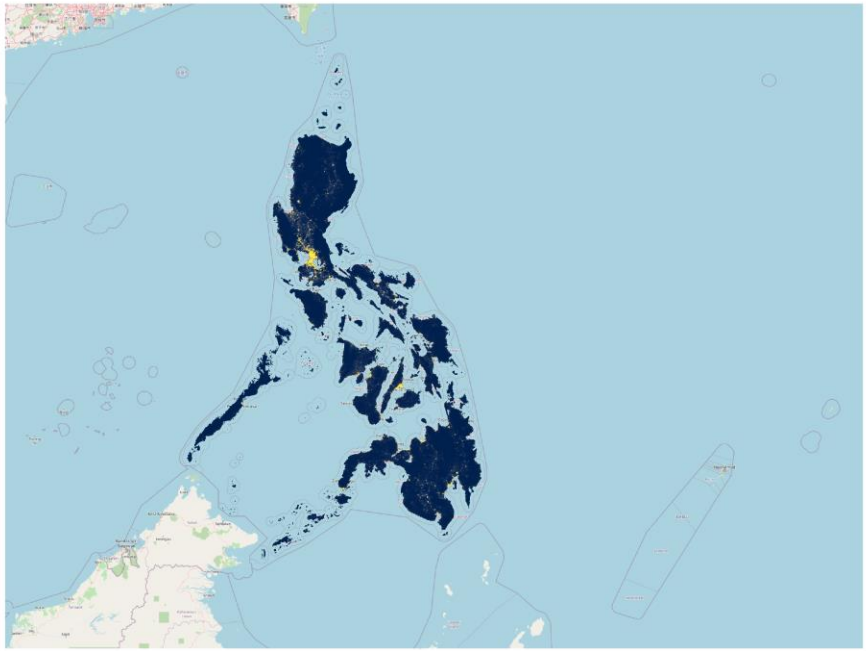
DEM

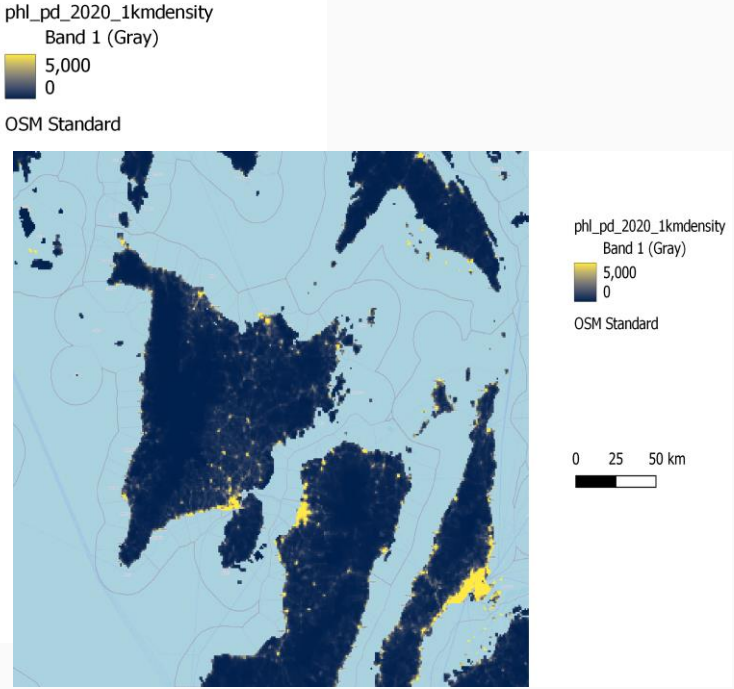
Slope map analysis

Values obtained: Slope percent : 0-21%

Slope degree:0-1.25°

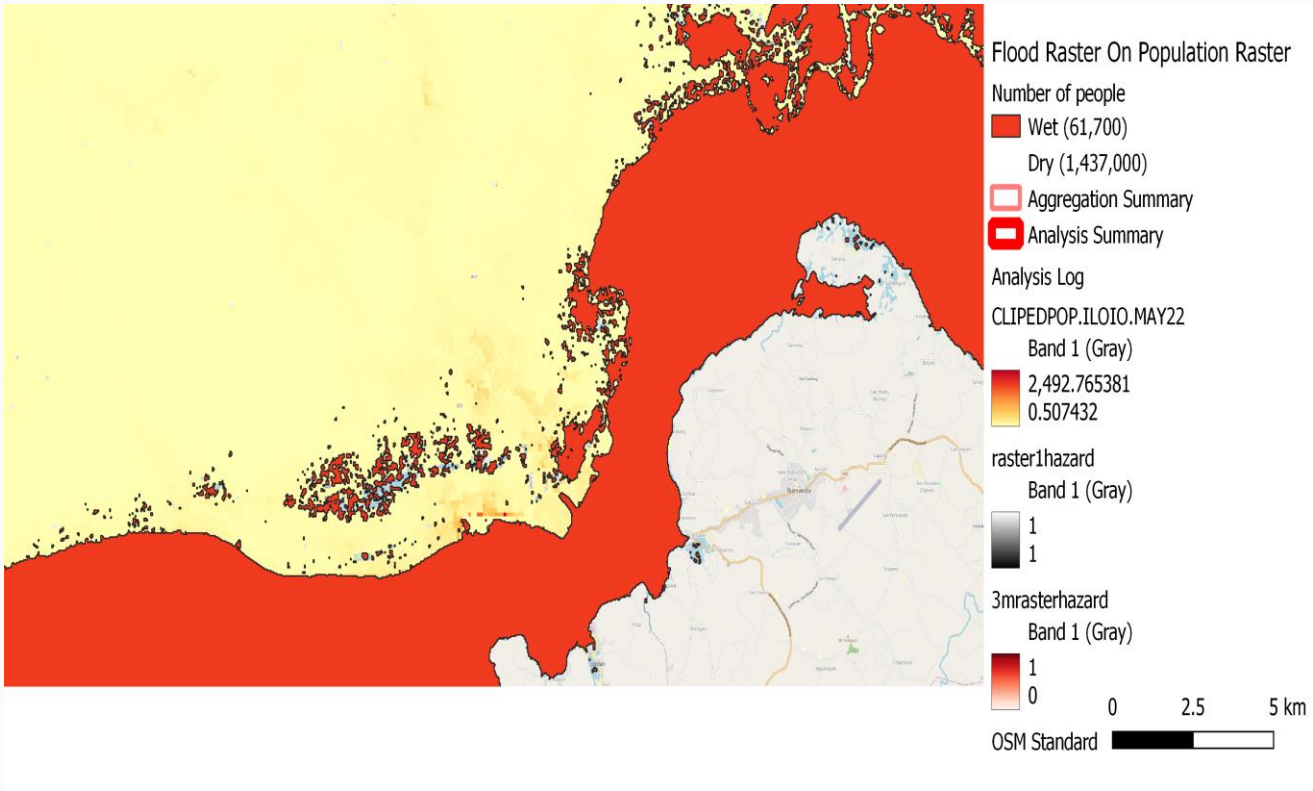
Slope degree	Terminology	Iloilo City
0.0-0.5	Level	0.02
0.5-2.0	Nearly Level	1.25



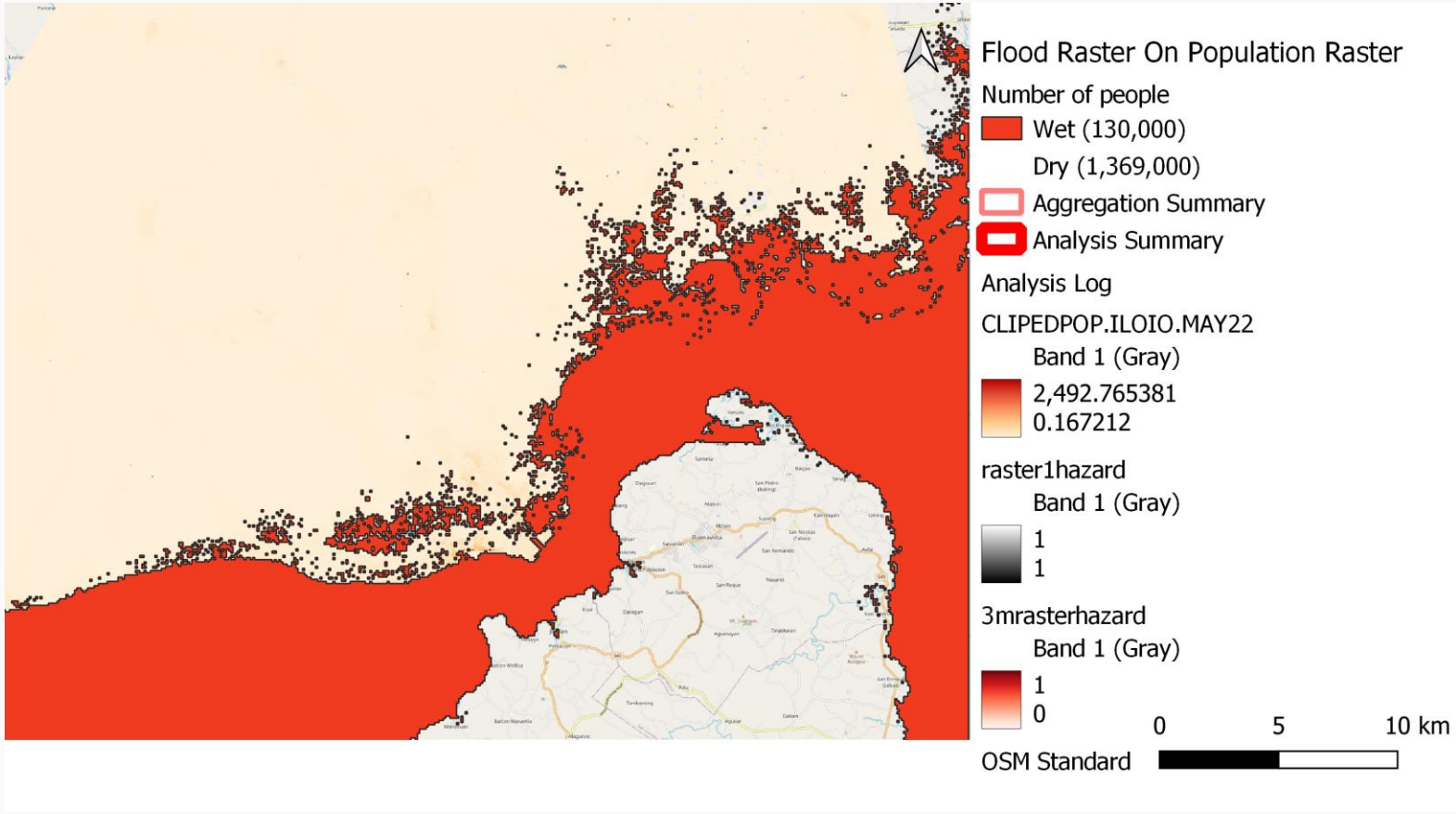


Philippines, Population data
Most populated cities are :Quezon, Manila(42,857), Davao, Cebu, Antipolo, Pasay, Iloilo, San Joze Del Monte and others.

InaSAFE hazard / Exposure impact analysis. Flood probability of 1 m.



Flood hazard probability impact analysis, 3m of inundation. Iloilo City.

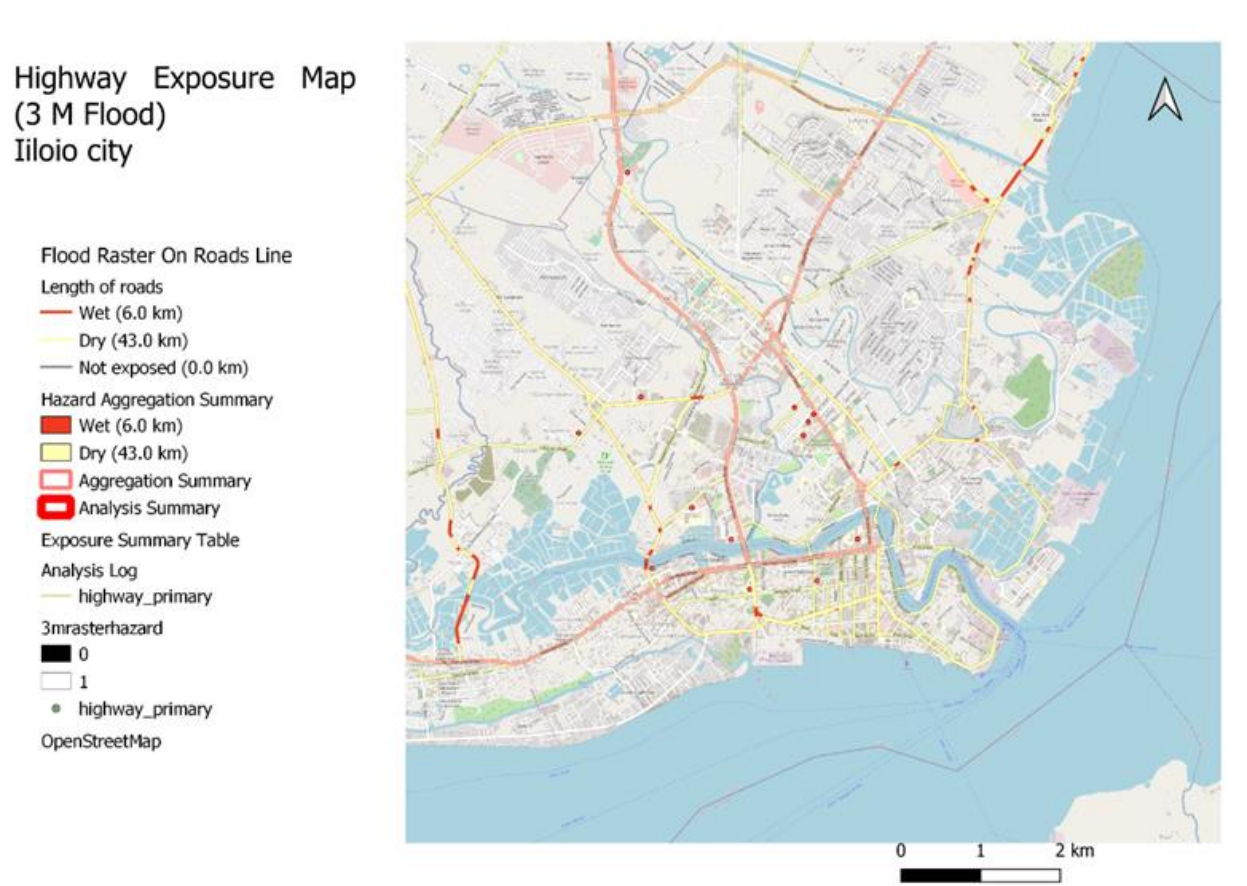


InaSAFE plugin reports

Flood scenario from 1-5 meters and 10 meters of extreme sea-level rise hazard on population of Iloilo city data

Iloilo City population	1m	3m	5m	10m
Affected	61700	130000	305000	649000
Displaced	620	1300	3100	6500
Infant	60	120	290	6100
Child	110	230	530	1200
Youth	170	350	820	1800
Adult	410	850	2100	4300
Elderly	50	100	240	500

Flood scenario on city features : Roads. Highway - Primary.



Minimum needs for analysis :

1. Hazard layer
2. Exposure layer

The hazard layers are previously created inundation models. They are in raster format.
Exposure data for roads could be downloaded from Quick OSM plugin.

Estimated length of roads affected per hazard zone are:

Total exposed: 49,500 m.(49 km)

Not affected:43,600 m.(43 km)

Affected:6,000 m.(6 km)

NYC AND SURROUNDINGS

New York City is highly affected by climate change. The city's coasts are low-lying and some of them are even in landfills. That is the main aspect, for most vulnerable people.

Considering the historical data, several catastrophic events

occurred within the present and the past centuries.

Recent events like Hurricanes a most known.

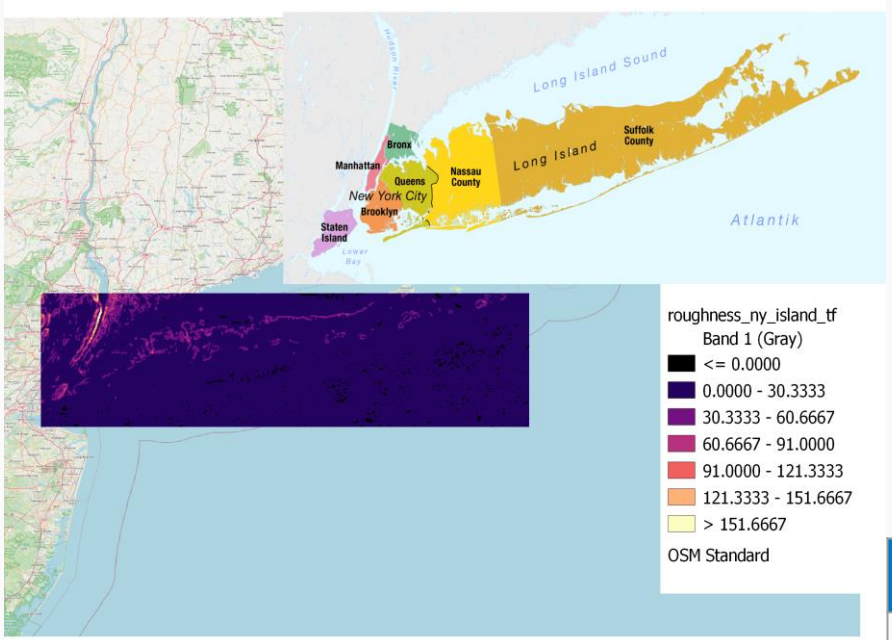
New York was severely affected by Hurricane Sandy on October 29–30, 2012,

particularly in urban areas, its suburbs, and Long Island.

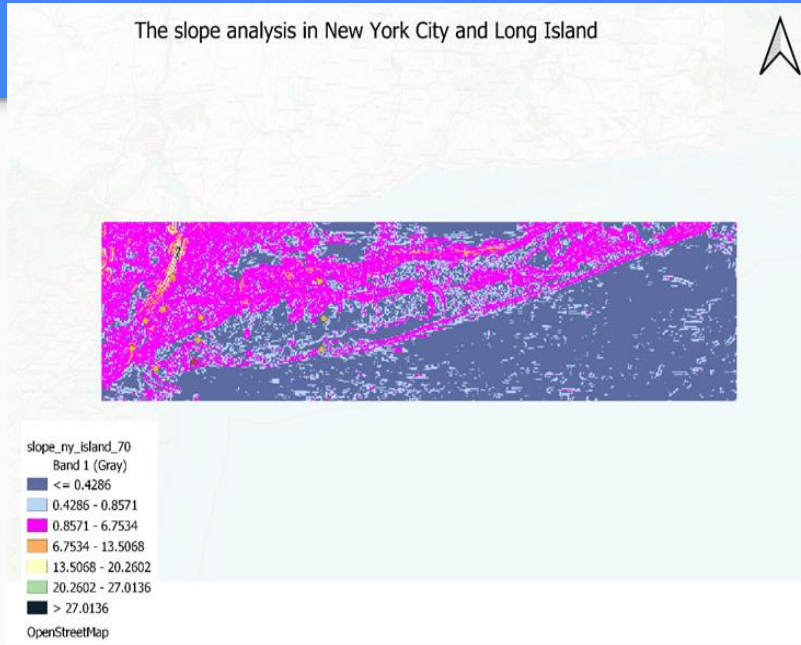
Sandy's impacts included the flooding of the New York City Subway system,

many suburban communities, and all road tunnels flooded entering Manhattan except the Lincoln Tunnel. Large parts of the city and surrounding areas lost electricity for several days. With the loss of power and floods hospitals are damaged and evacuated.

Producing Roughness and Slope map of NYC



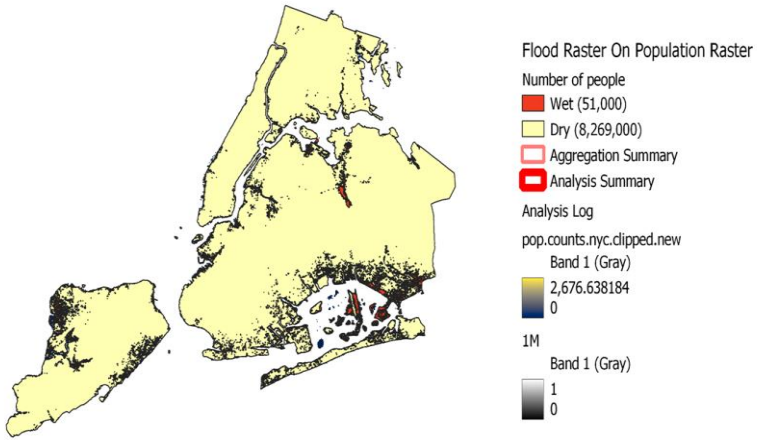
Roughness map of NYC AND lONG ISLAND

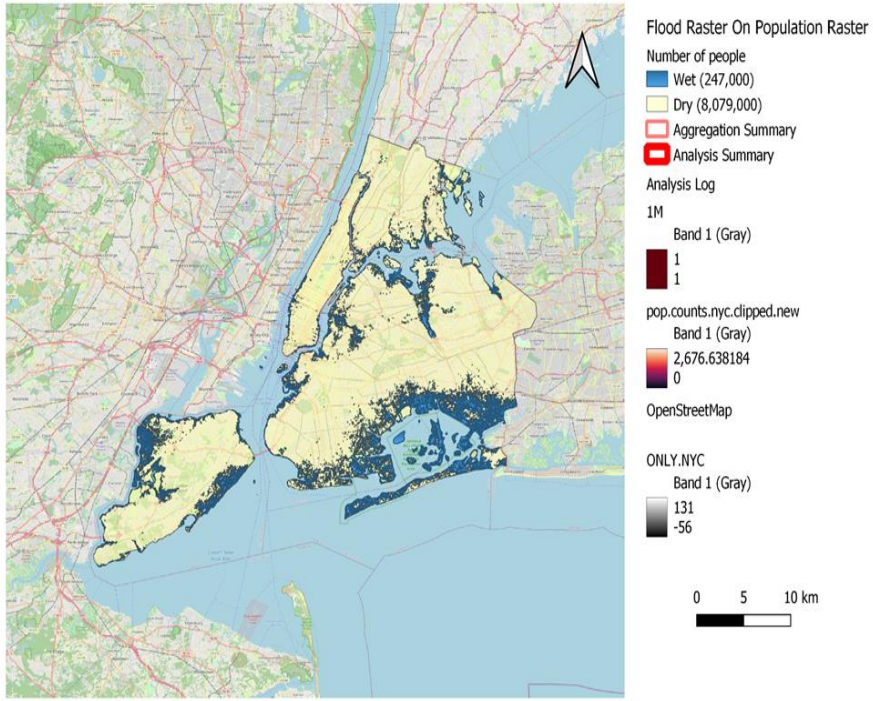


Slope %	Terminology	Long Island western part	Long Island Center	NYC
0.0-0.5	Level			
0.5-2.0	Nearly level	0.74	0.6	
2.0-5.0	Very gentle slope	2.60	2.9	3
5.0-9.0	Gentle slope	-	8.26	5
9.0-15.0	Moderate slope	-	-	10
15.0-30.0	Strong slope	-	-	26

NYC flood probability and its impact on population , InaSAFE Report maps

1 m sea-level rise event , inundation layer on population layer





NYC/1M SLR/POPULATION EXPOSURE MAP

1 m and 3 meters of sea-level rise flood event probability scenario on population exposure results :

NYC population	**1 m SLR**	**3 m SLR**
Affected	51000	247000
Displaced	350	2400
Infant	10	160
Children	30	350
Youth	60	600
Adult	280	1600
Elderly	10	130
Minimum needs	**1 m SLR**	**3 m SLR**
rise/kg/weekly	1100	6600
Drinking water/l/weekly	6100	40900
clean water	23000	156000
family kits	30	390
hygiene packs	70	810

RESULTS

affected-1889000

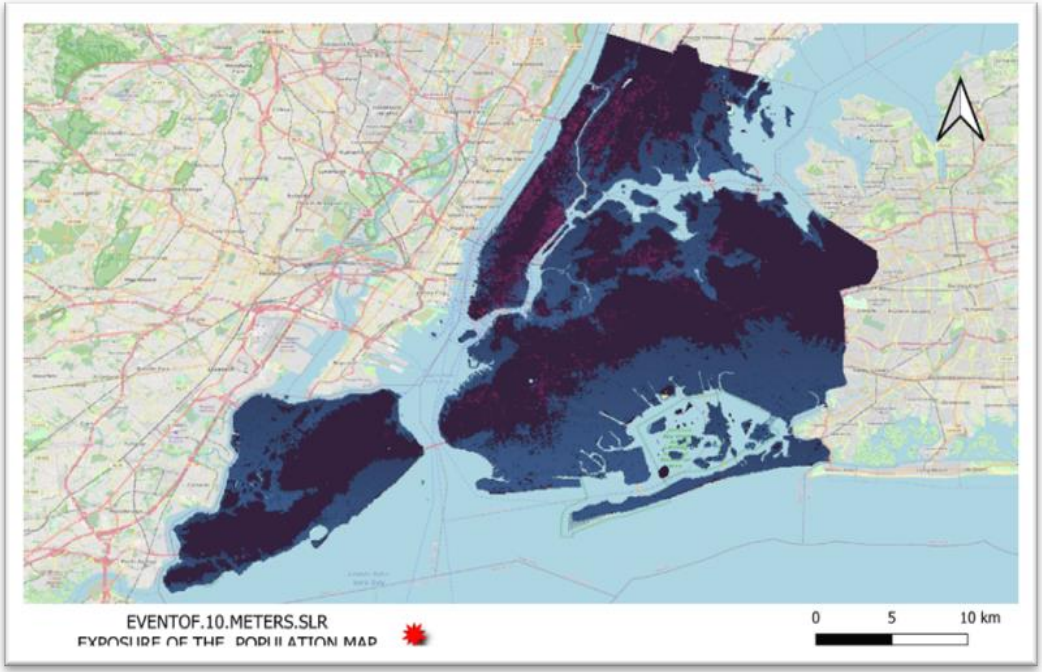
displaced-18900

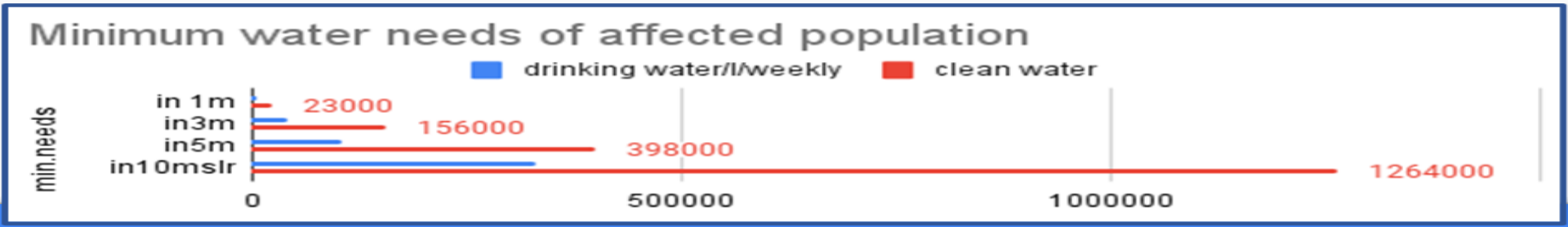
infant-1700

Child-3300

youth-5100

adult-12500





Probable sea-level rise caused hazard events and minimum needs of displaced population increase.

Results and conclusions

The total area of NYC is 10 times bigger than Iloilo city.

The New York City area have been proposed to prevent another flood surge from being as destructive as Hurricane Sandy. One proposed barrier, the New York Harbor Storm-Surge Barrier would be located offshore and consist of multiple systems of barriers.

The Philippine Climate Change Adaptation Project (which aims to develop the resiliency and test adaptation strategies and the National Framework Strategy on Climate Change (envisioned to develop the adaptation capacity of communities).The simple analysis could be guide and idea for taking action about climate change and its impacts. Adaptation measures can range from physical structures such as sea walls where they still are cost-effective to the development/revision of land use plans with the usage of risk maps as the basis.

Population	**NYC 1 m SLR**	**ILOILO 1 m SLR**
Affected	51000	61700
Displaced	350	620
Infants	10	60
Children	30	110
Youth	60	170
Adults	280	410
Elderly	10	50

Special Thanks to :
Dr.Ilaria Ferrando
Prof.Bianca Federici

Thank you for your attention.