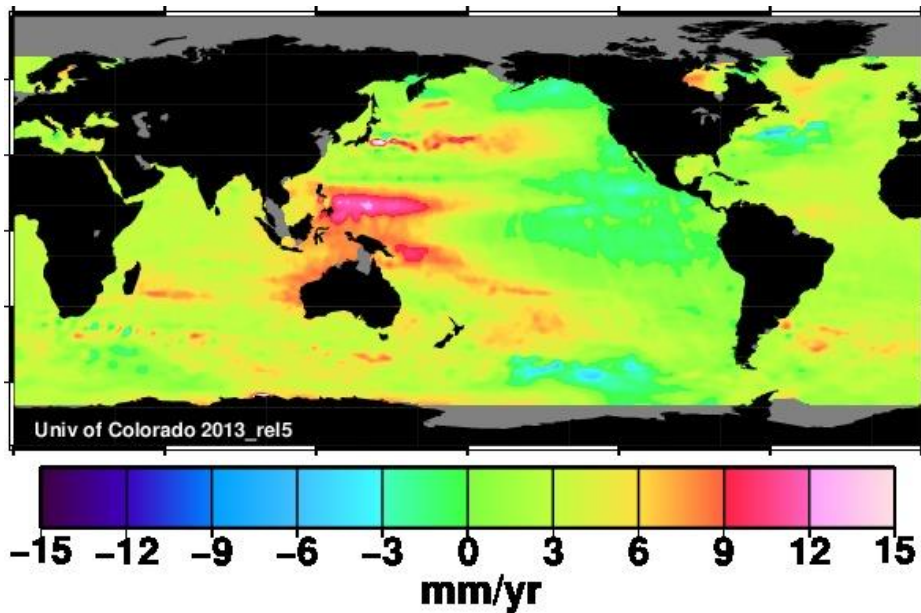


Relative sea level rise and coastal erosion as considerations in planning for reclamation

Fernando Siringan
MSI and NAST



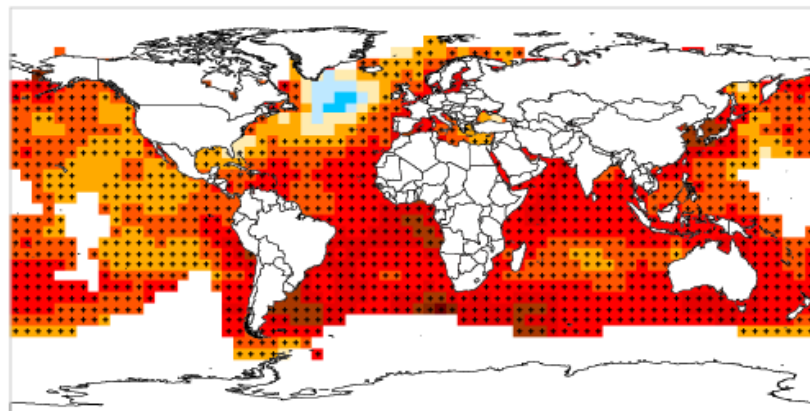
Sea Level Rise 1993-2013 (Source: University of Colorado)

Why is sea level rising at a fast rate in the region of the Philippines?

Because this is the area where sea surface temperature is also warming rapidly .

Because of the intensification of trade winds

Figure 2. Change in Sea Surface Temperature, 1901–2012



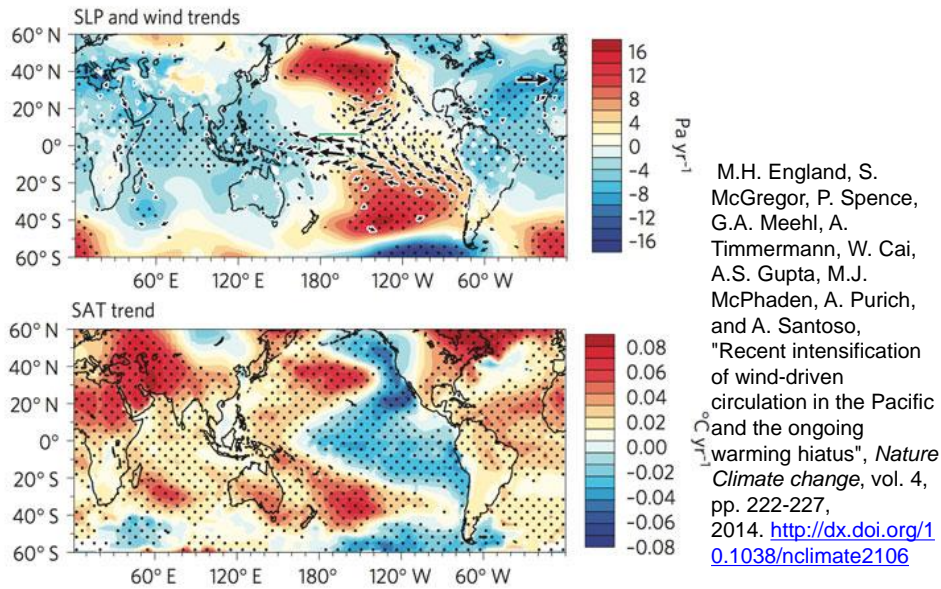
Change in sea surface temperature (°F):



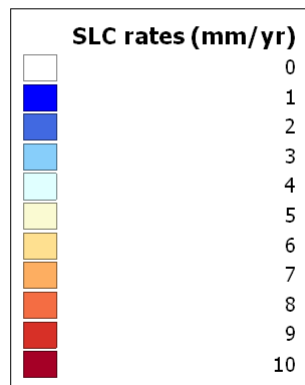
+ = statistically significant trend

<http://www.epa.gov/climatechange/science/indicators/oceans/sea-surface-temp.html>

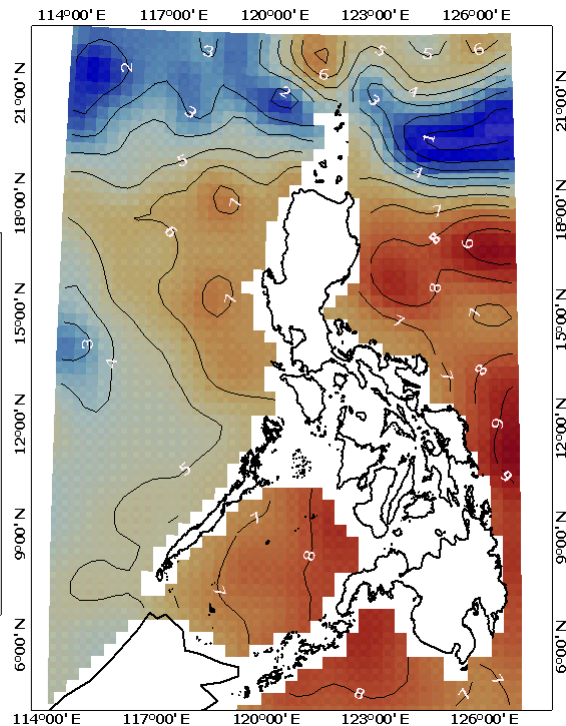
1992 – 2011 changes in (a) sea level pressure and trade wind intensity and (b) sea surface temperature

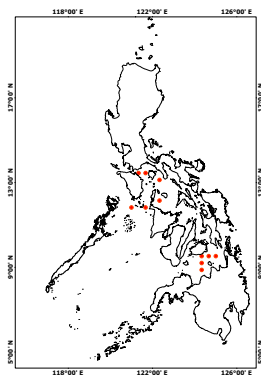


Sea level is rising close to 1 cm/y all around the country.



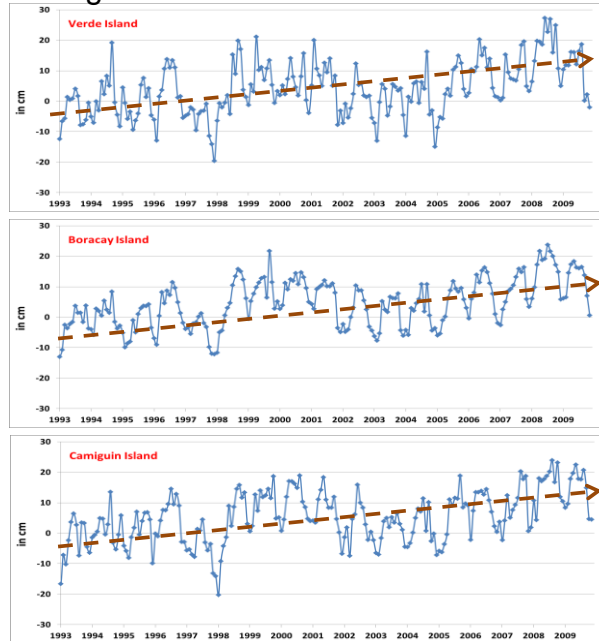
Sea level change (mm/yr): 1993-2009





AVISO monthly sea surface heights for Verde, Boracay, and Camiguin islands (1993 -2009)

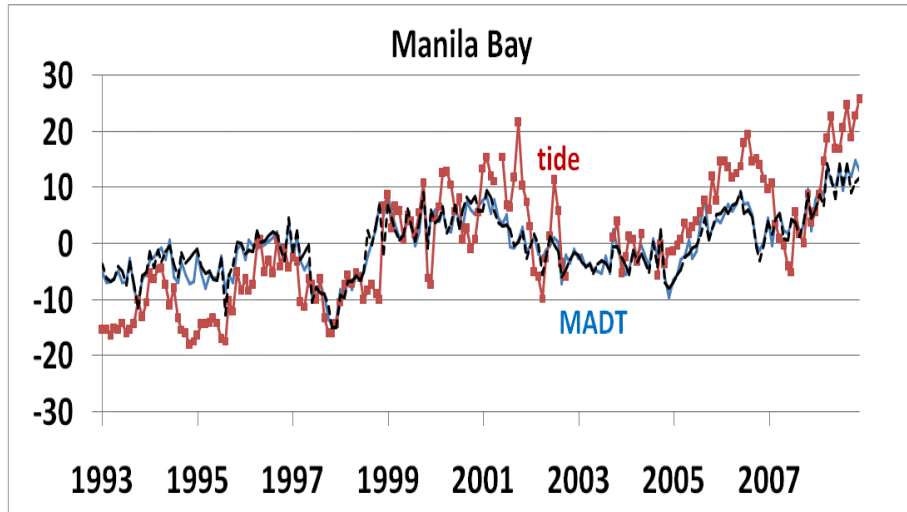
ENSO and PDO cycles are embedded in the signal of an overall rise of sea level



In addition to global warming, sea level rise can also be caused by . . .

- natural compaction
- dewatering of wetlands
- excessive groundwater withdrawal
- build-up over soft sediments
- local fault movement
- subsidence due to regional tectonism
- liquefaction due to an earthquake
- deflation after a large volcanic eruption

Tide gauge data vs SSH (MADT and MSLA)



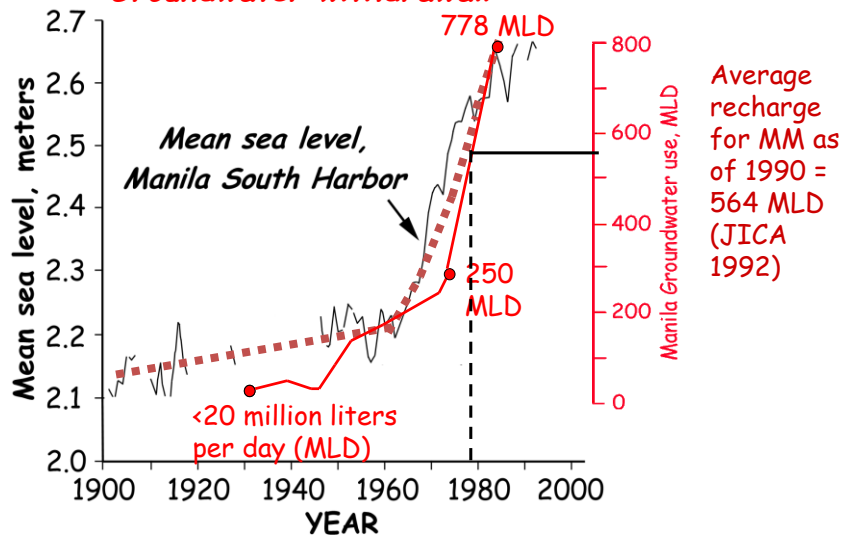
At Manila's South Harbor mean sea level rose at about 2 millimeters per year from 1902 to the early 1960's. . .

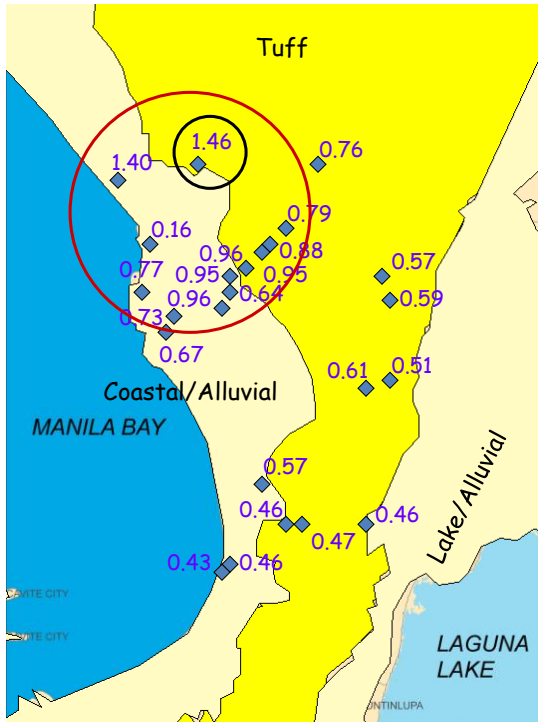
.. then started rising ten times as fast. **WHY?**

Groundwater withdrawal!

1770 MLD in 2004 (CEST 2004)

989 MLD in 1990 (JICA 1992)

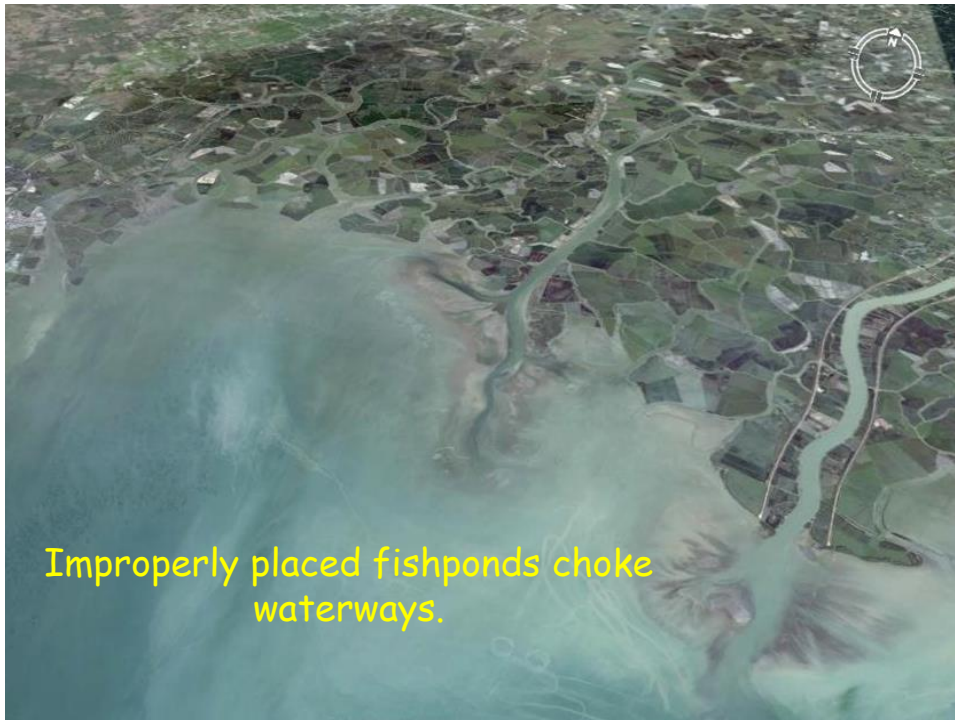




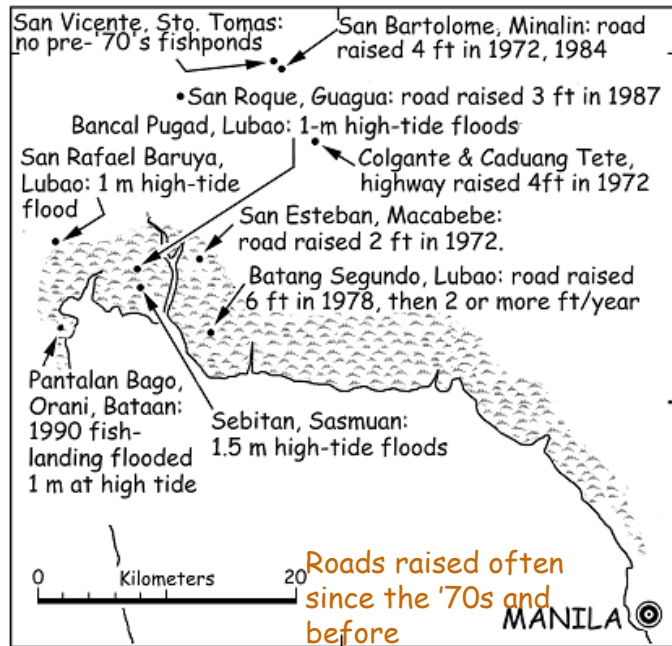
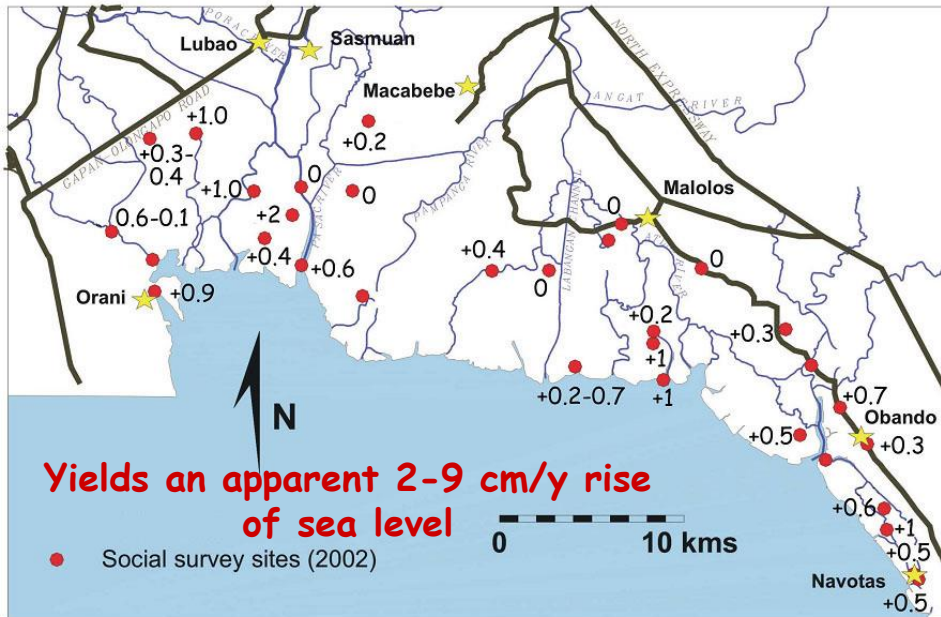
Magnitude of subsidence
(in meters) from 1978 to
2000 from re-leveling
data (Jacob 2004)

Maximum rate - 6.1 cm/y

Change in height of
maximum high tide, from
1991 to 2002 based on
social survey range from
0.5 - 1.0 m (4.5 - 9.1 cm/y)



Increase in highest tide, 1991-2002 (meters)



Worsening floods in Pampanga even before '91 Pinatubo eruption

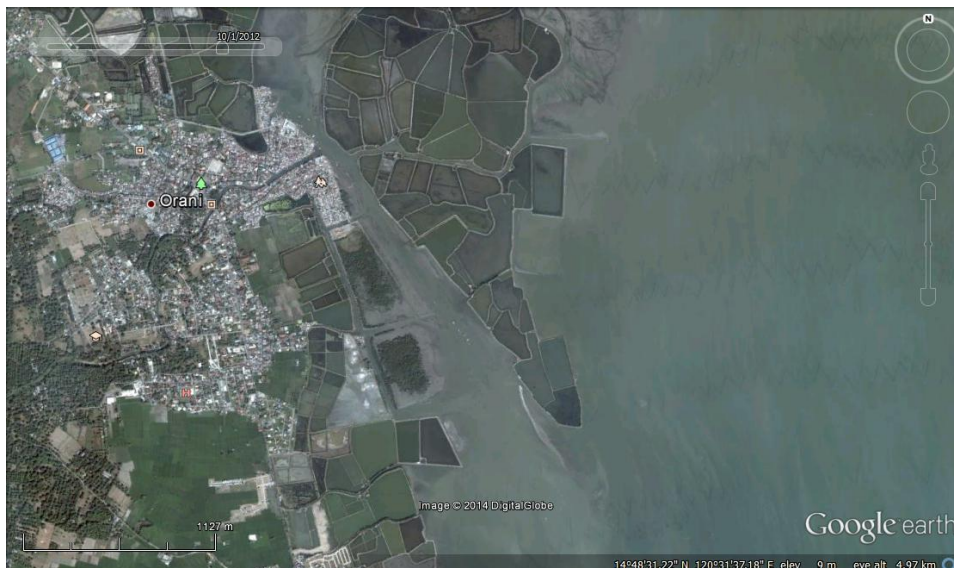


Slowly buried house,
Bgy. Binaungan,
Obando, Bulacan



Photo by J. Ong

At high tide, floor of Pantalan Bago fish landing in Orani Bataan built in 1990 is flooded in seawater up to 1 meter deep.





Sediments in mangroves are typically soft.



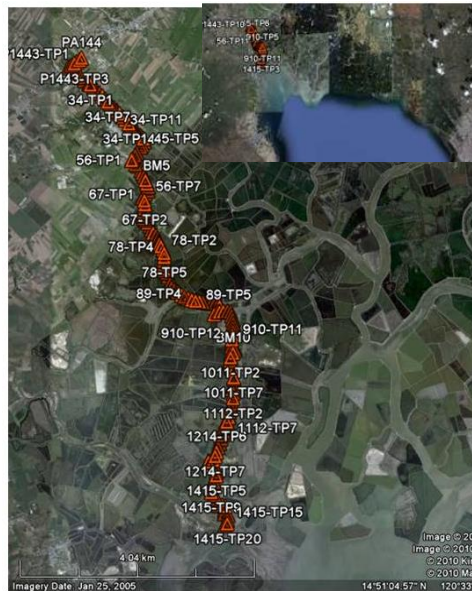
San Rafael Baruya, Lubao, Pampanga to Hermosa, Bataan

Survey period:

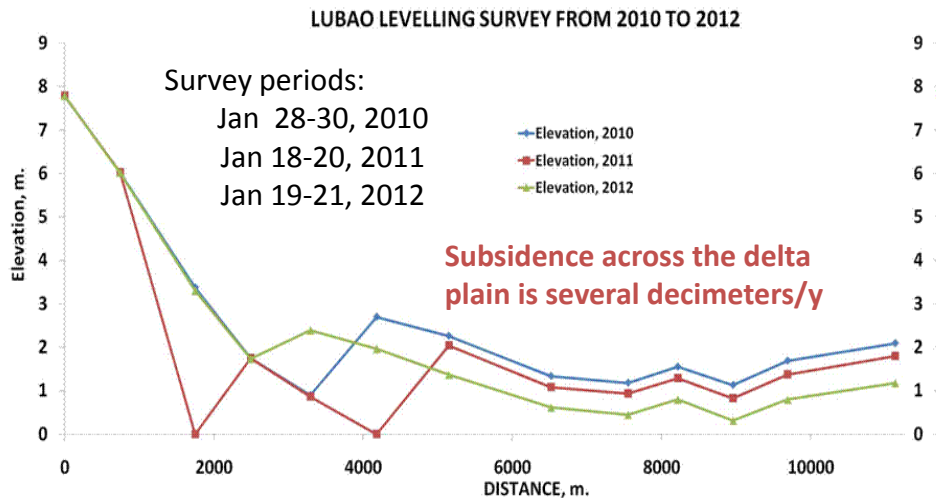
Jan 28-30, 2010

Jan 18-20, 2011

Jan 19-21, 2012



San Rafael Baruya, Lubao, Pampanga to Hermosa, Bataan

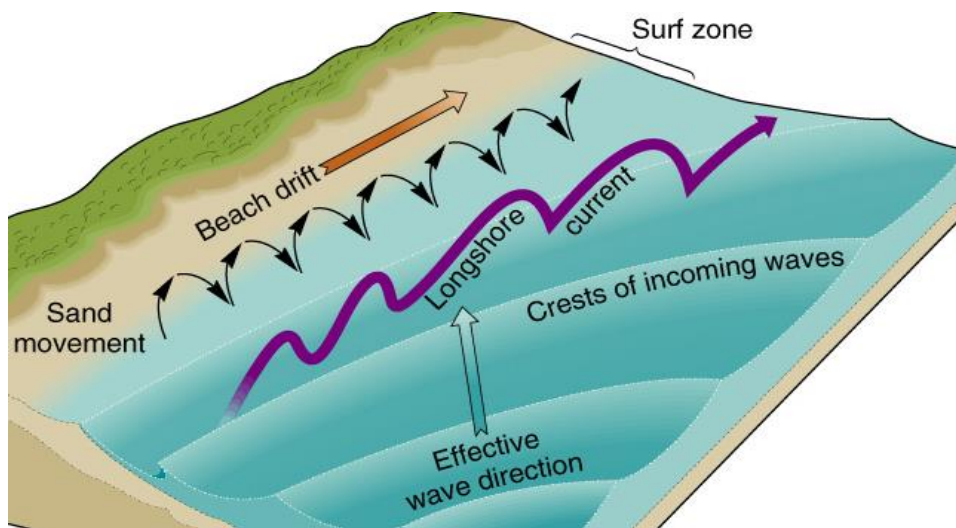


How much will it cost to raise a house by 1 meter every 10 years?

How much will it cost to raise a road by 1 meter every 5 years?

Can the government afford to maintain a 50 km highway which is situated in an area that is sinking unevenly and at rates of a few to several centimeters/year?

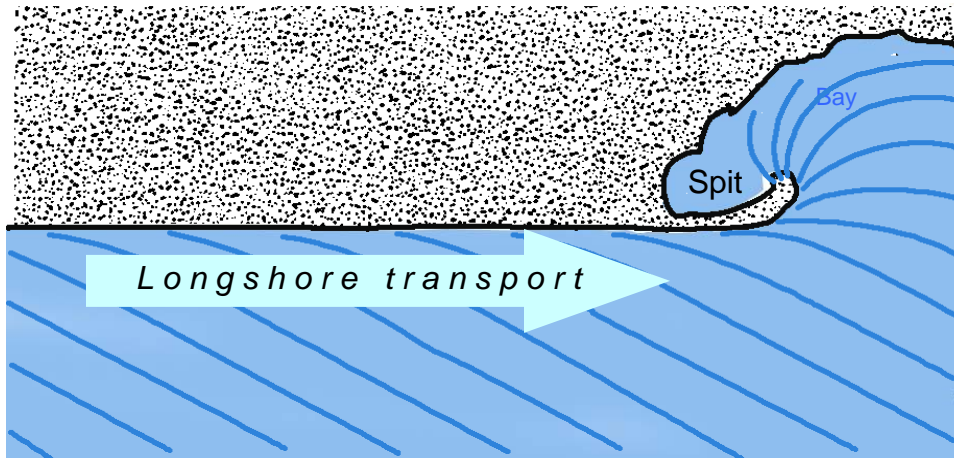
What will happen to the floodplain behind a raised reclaimed land?



Longshore current - is a wave induced current that flows parallel and close to the shoreline

- causes redistribution of sediments along the coast.

Longshore transport and spits

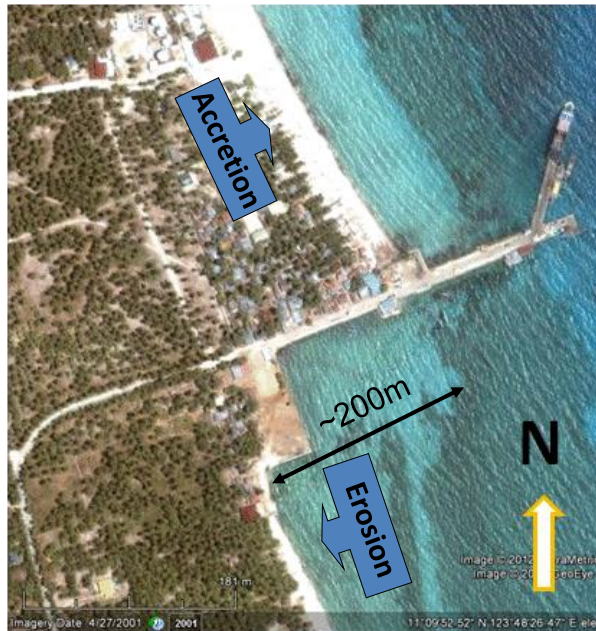


Sediments are trapped by the pier structure and some are veered offshore and deposited in deeper waters.

Dredging is needed to keep the pier open to barges.

Santa Fe Port, Santa Fe, Bantayan Is. Cebu

April 27, 2001
Google Earth image



Seawalls reflect the wave energy scouring the seafloor and transporting the sand farther offshore

