Assessment and Planning for Nutrient Management - Manila Bay Case Study

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Manila Bay is a **marine pollution hotspot** in the **Seas of East Asia** (PEMSEA, 2004)

Major port and **source of livelihood** for many coastal communities

8000 km^2 or **42%** of the catchment area are agricultural with **48,182 mt** of **nitrogen N fertilizer** applied to 5621 km^2 of rice fields (BSWM, 2012)

The bay wide average of the near bottom dissolved oxygen reached **2.10 mg/l** in August 2011 (wet season) with DO levels reaching as low as **0.79 mg/l** (Sotto et al., 2014)

Increased nutrient (surface and bottom) and **chl-a levels** (surface) at and near the coast especially river mouths (Sotto et al., 2014)

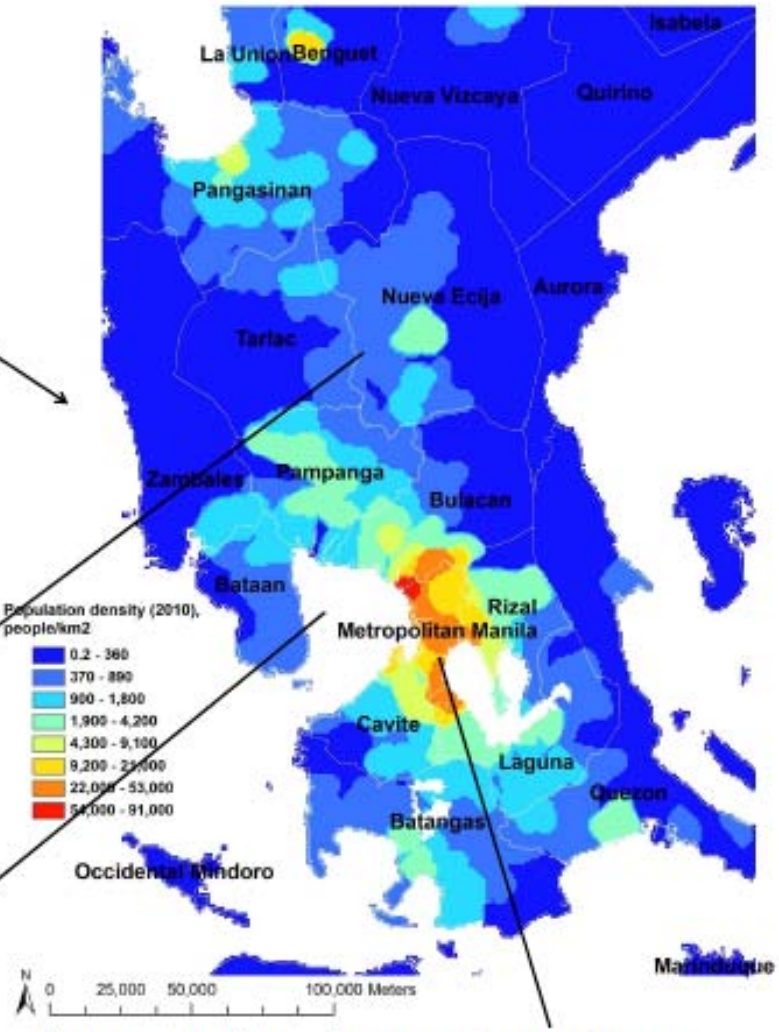
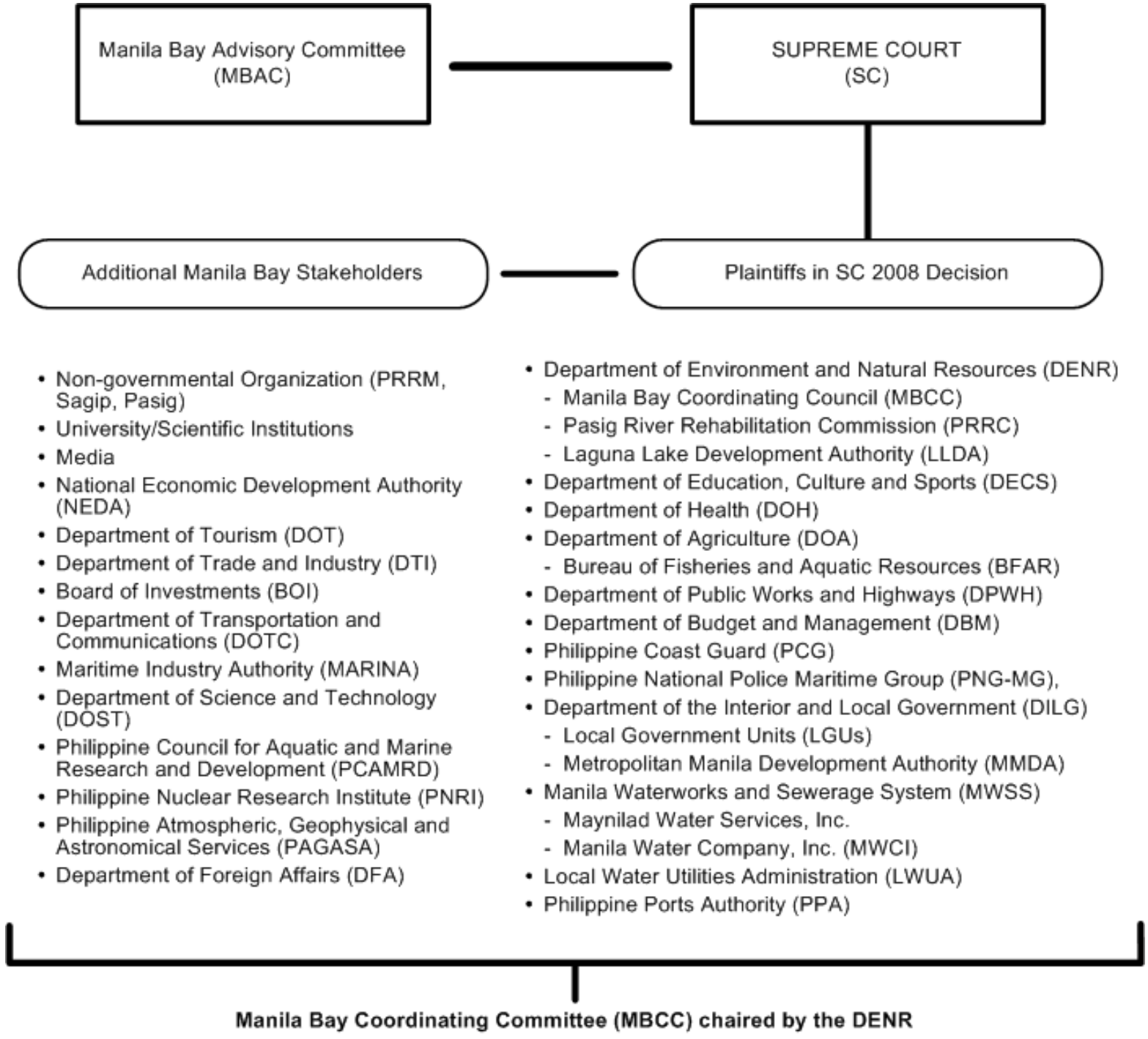
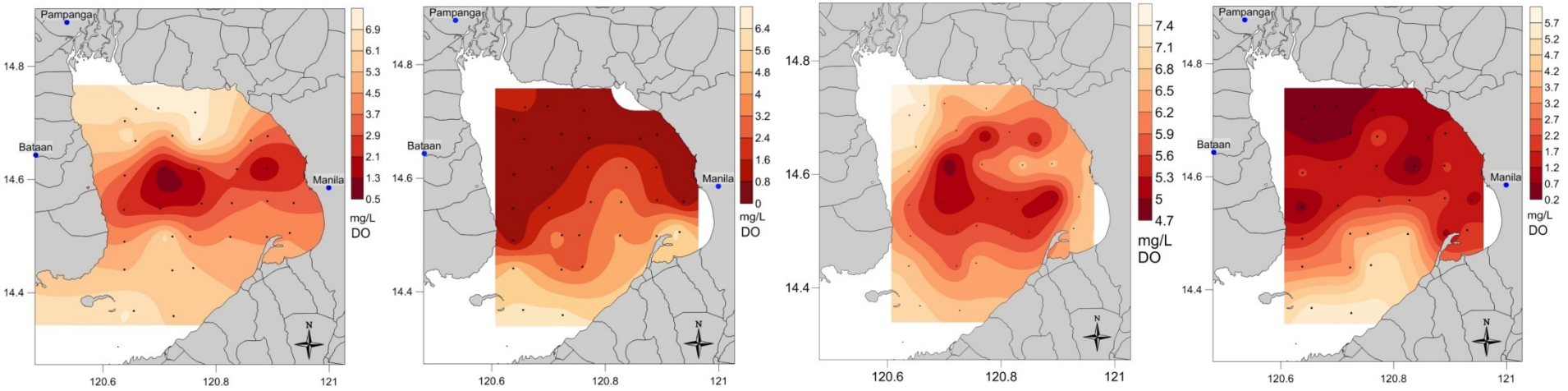


Figure 1. Population density in the Manila Bay watershed for 2010. Map separated into provinces.

Population density in Metro Manila: **19,000 km^2** and **only 20%** have sewerage services (NSO, 2010; Manila Third Sewerage Services, 2012)


Manila Bay Advisory Committee (MBAC)
SUPREME COURT (SC)
Additional Manila Bay Stakeholders
Plaintiffs in SC 2008 Decision
• Non-governmental Organization (PRRM, Sagip, Pasig)
• University/Scientific Institutions
• Media
• National Economic Development Authority (NEDA)
• Department of Tourism (DOT)
• Department of Trade and Industry (DTI)
• Board of Investments (BOI)
• Department of Transportation and Communications (DOTC)
• Maritime Industry Authority (MARINA)
• Department of Science and Technology (DOST)
• Philippine Council for Aquatic and Marine Research and Development (PCAMRD)
• Philippine Nuclear Research Institute (PNRI)
• Philippine Atmospheric, Geophysical and Astronomical Services (PAGASA)
• Department of Foreign Affairs (DFA)
• Department of Environment and Natural Resources (DENR)
- Manila Bay Coordinating Council (MBCC)
- Pasig River Rehabilitation Commission (PRRC)
- Laguna Lake Development Authority (LLDA)
• Department of Education, Culture and Sports (DECS)
• Department of Health (DOH)
• Department of Agriculture (DOA)
- Bureau of Fisheries and Aquatic Resources (BFAR)
• Department of Public Works and Highways (DPWH)
• Department of Budget and Management (DBM)
• Philippine Coast Guard (PCG)
• Philippine National Police Maritime Group (PNG-MG),
• Department of the Interior and Local Government (DILG)
- Local Government Units (LGUs)
- Metropolitan Manila Development Authority (MMDA)
• Manila Waterworks and Sewerage System (MWSS)
- Maynilad Water Services, Inc.
- Manila Water Company, Inc. (MWCI)
• Local Water Utilities Administration (LWUA)
• Philippine Ports Authority (PPA)
Manila Bay Coordinating Committee (MBCC) chaired by the DENR

Extent of hypoxia in Manila Bay during the Northeast and Southwest Monsoon Seasons



Feb 2010 Jul 2010 Feb 2011 Aug 2011

	Feb 2010	Jul 2010	Feb 2011	Aug 2011
Range (bay wide)	0.79 – 7.25 mg L^{-1}	0.21 – 6.35 mg/L	4.76 – 7.40 mg/L	0.28 – 5.55 mg L^{-1}
Average (bay wide)	avg. 4.49 mg L^{-1}	**2.15 mg L^{-1}**	6.08 mg L^{-1}	**1.99 mg L^{-1}**
Range (midsection)	0.79 – 3.76 mg L^{-1}			
Average (midsection)	**2.50 mg L^{-1}**			

Global Foundations for Reducing Nutrient Enrichment and Oxygen Depletion from Land Based Pollution, in Support of Global Nutrient Cycle

- *Component B4. Development of regional models of coastal effects under different physical regimes using regional data.*
  - *Nutrient Load Estimates for Manila Bay*

Moree et al. (2013)

Nutrient Load Model

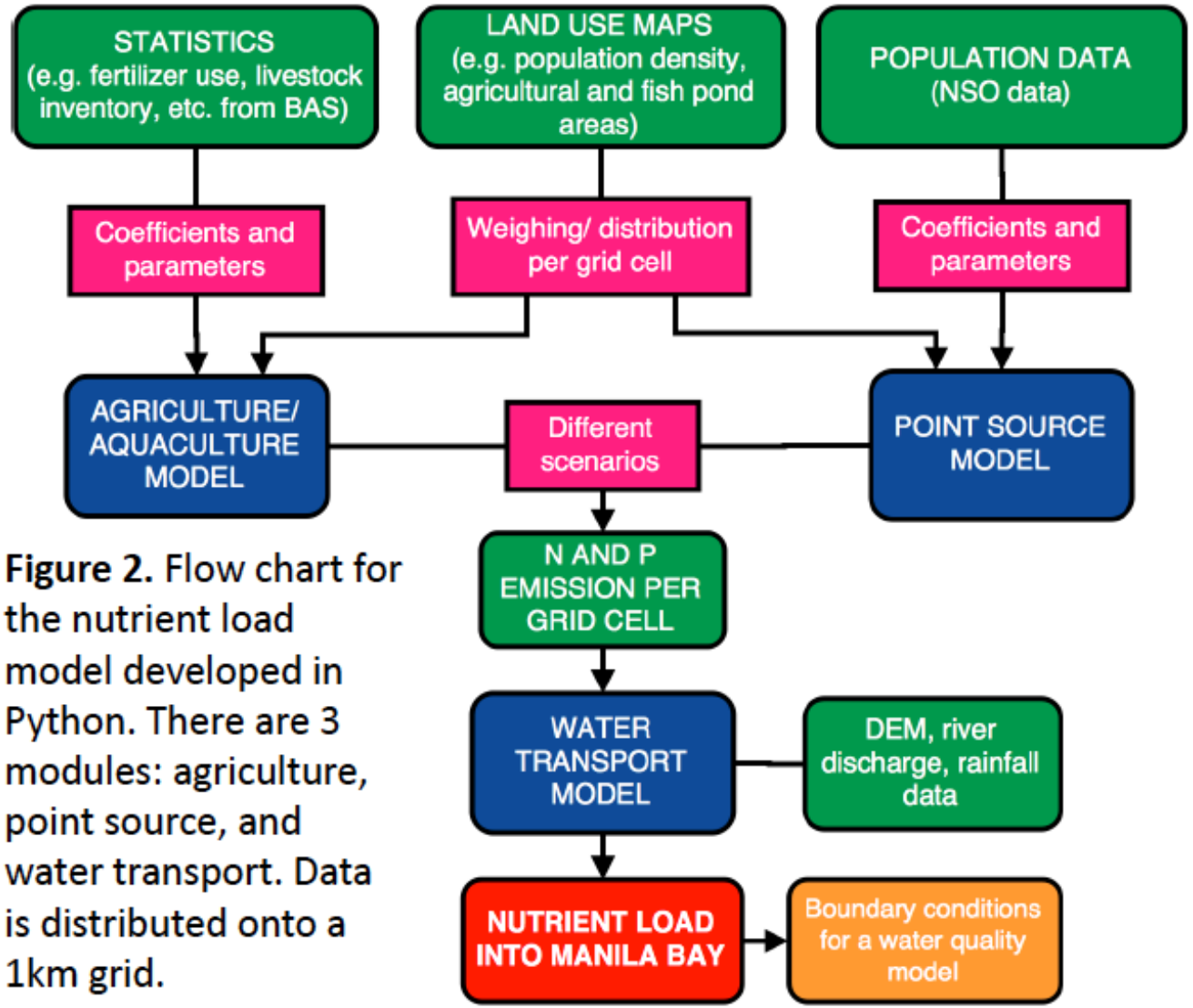


Figure 2. Flow chart for the nutrient load model developed in Python. There are 3 modules: agriculture, point source, and water transport. Data is distributed onto a 1km grid.

Treatment of population data

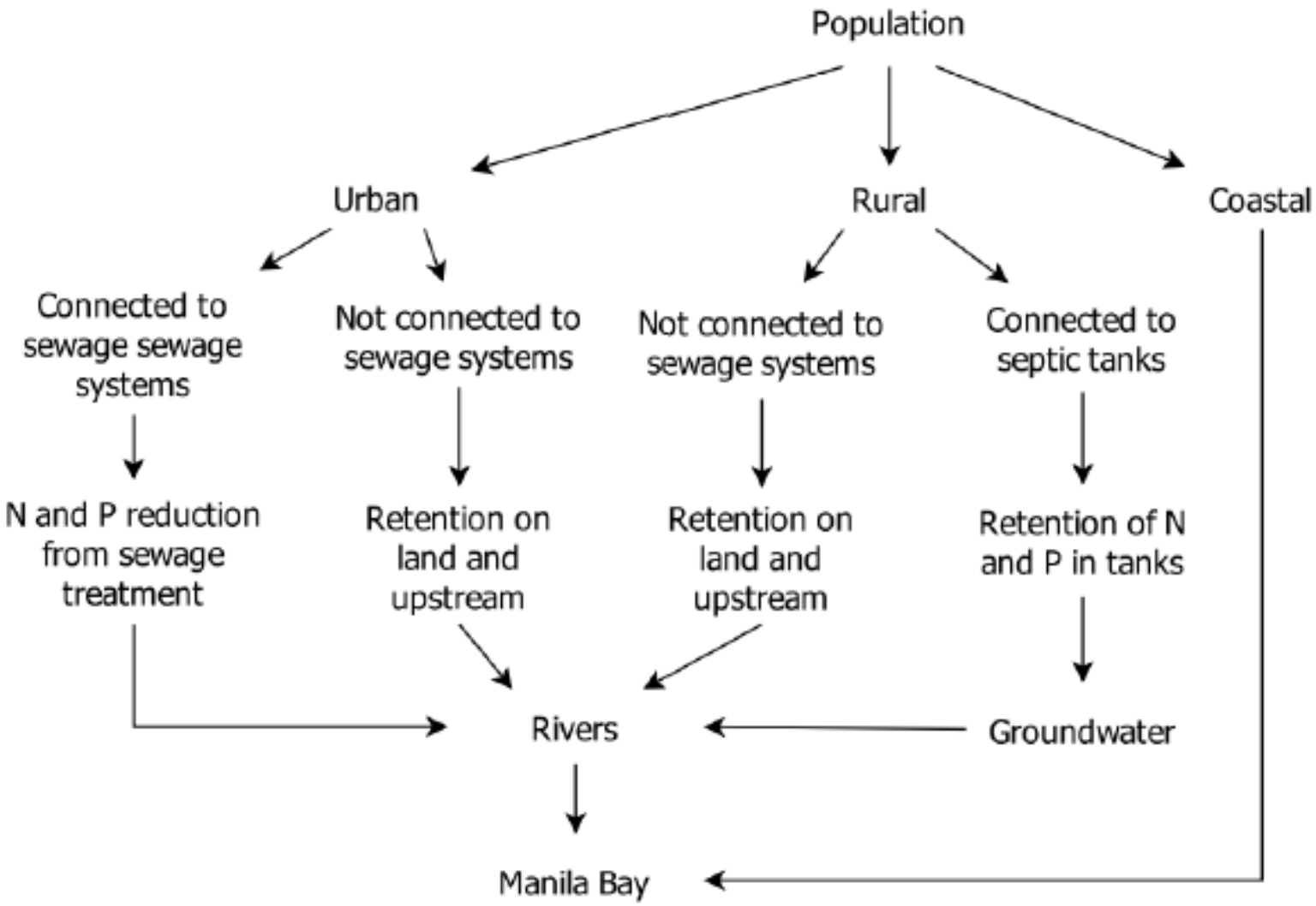


Figure 3. Schematic diagram of the treatment of population data in the point source model

Preliminary calculation scheme for **agriculture** in Manila Bay or country-wide

Regional
Fertilizer use

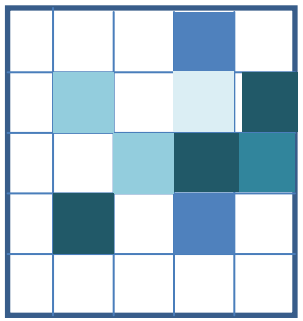
Provincial
Land use

Animal category
Excretion rates

Provincial
Quarterly
Livestock

Provincial
Quart. crop production

Quarterly N/P input



Export coefficient or water transport model

Emissions and loads

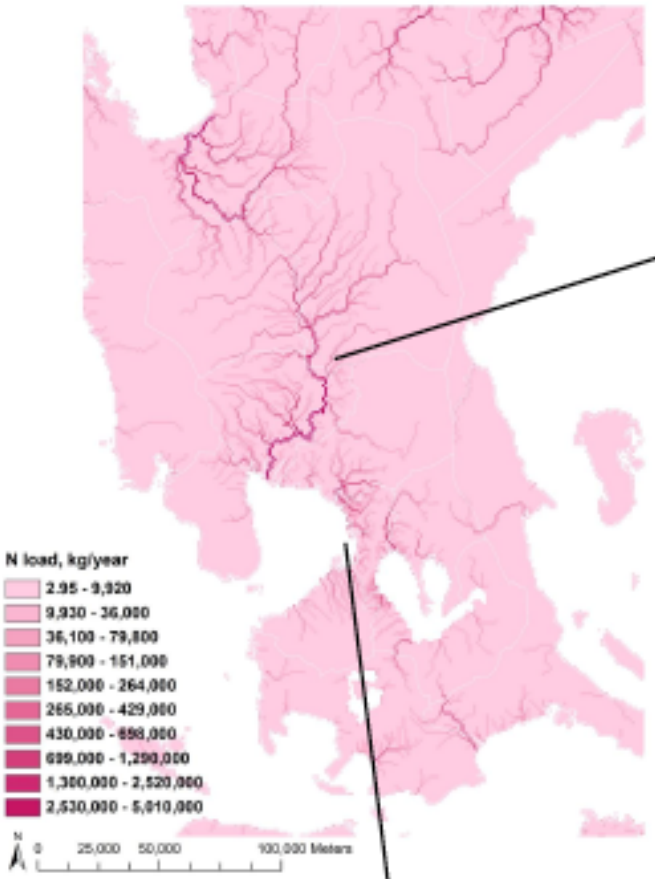


Figure 6. Total N load from domestic and agricultural sources in the Manila Bay watershed (2010)

One of the major rivers in the Manila Bay Watershed, the Pampanga River, drains a majority of the agricultural areas in the watershed bringing in as much as **1.47 million kg of N** and **395 thousand kg of P load to the bay per year**

Pasig river passes through most of the densely populated urban areas in Metro Manila bringing in as much as **3.61 million kg N** and **340 thousand kg P load into the bay per year.**

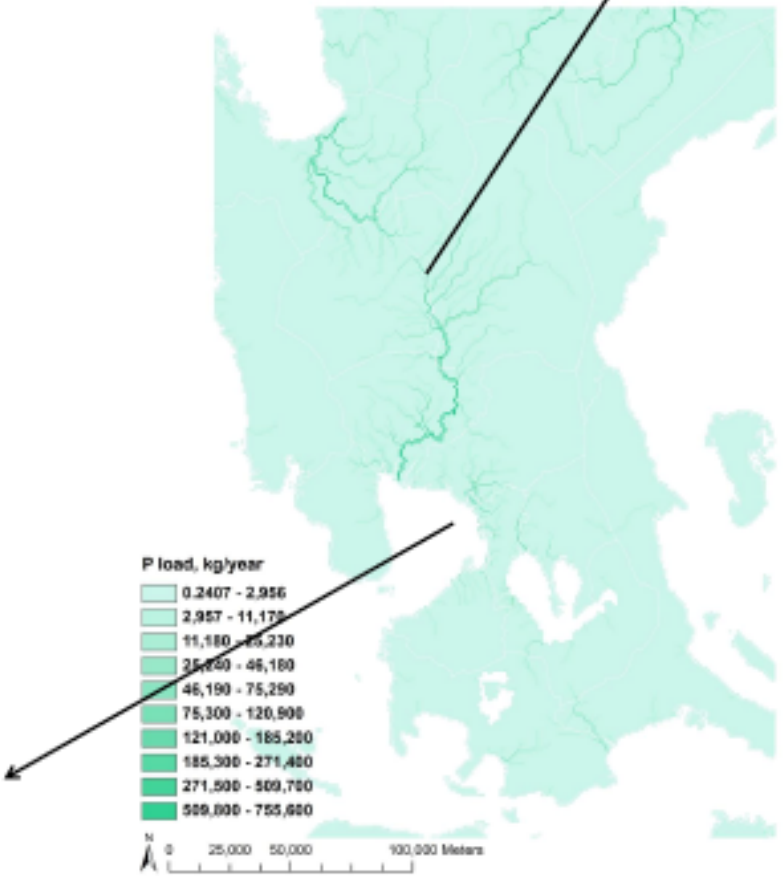
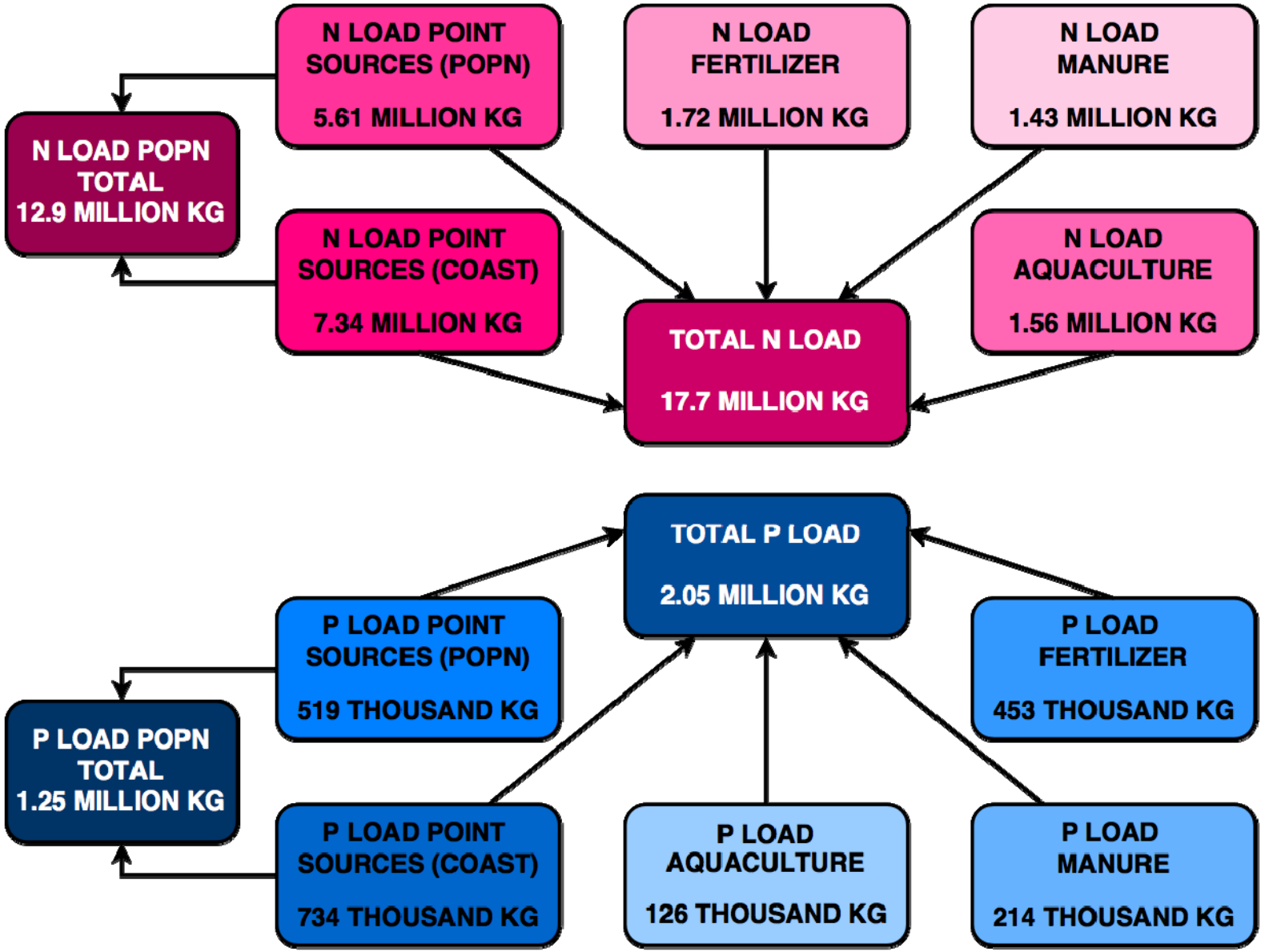


Figure 7. Total P load from domestic and agricultural sources in the Manila Bay watershed (2010)

Nutrient load coming from domestic sources appears to be greater than the agriculture sector



How much N and P could be going into the bay?

Scenarios	Total N load (kg/yr)	Total P load (kg/yr)
Baseline (2010)	4.67E+07	4.54E+06
Scenario 1 (2050)	1.64E+08 (250%)	1.62E+07 (257%)
Scenario 2 (2050) (partial 1^{o} and 2^{o} treatment, no 3^{o} treatment)	2.66E+08 (469%)	2.47E+07 (444%)
Scenario 3 (2050) (10% primary, 10% secondary, 70% tertiary treatment)	1.22E+08 (161%)	9.62E+06 (112%)
Scenario 4 (2050) (70% primary, 10% secondary, 10% tertiary treatment)	1.67E+08 (288%)	1.36E+07 (232%)
Scenario 5 (2050) (Population growth rate halfed, conditions same as scenario 1)	9.83E+07 (110%)	9.66E+06 (113%)
Scenario 6 (2050) (Population growth rate halfed, conditions same as scenario 2)	1.58E+08 (238%)	1.46E+07 (222%)
Scenario 7 (2050) (Population growth rate halfed, conditions same as scenario 3)	7.29E+07 (56%)	5.75E+06 (27%)

What if?

"What if?" scenarios were tested using 2010 baseline values projected to year 2050 with different sewage treatment settings

118% N **88% P**
If we don't do anything by 2050 and the population keeps increasing at current rates

273% N **188% P**
If we connect everyone to sewage pipes but do not improve treatment

79% N **35% P**
If everyone is connected and 70% tertiary treatment is achieved

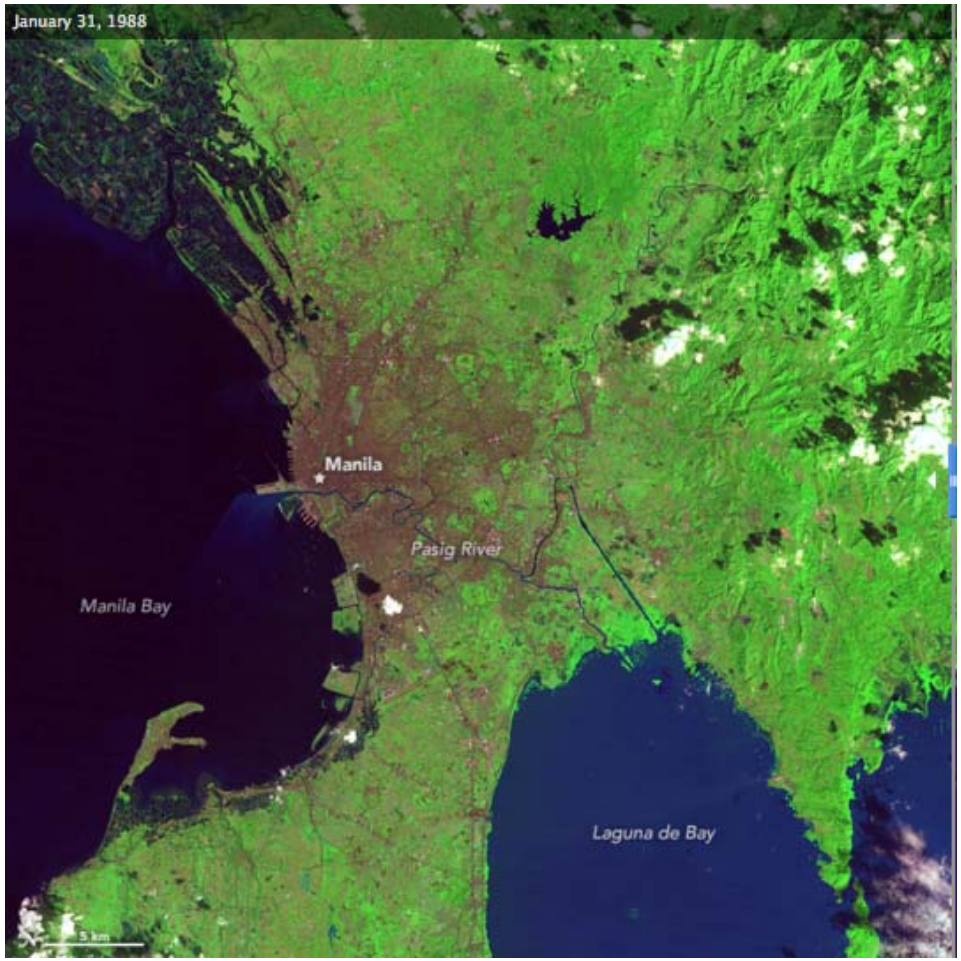
55% N **41% P**
If the population growth rate is reduced to half and baseline sewage scenarios are maintained

Summary of Preliminary Results of Nutrient Load Model

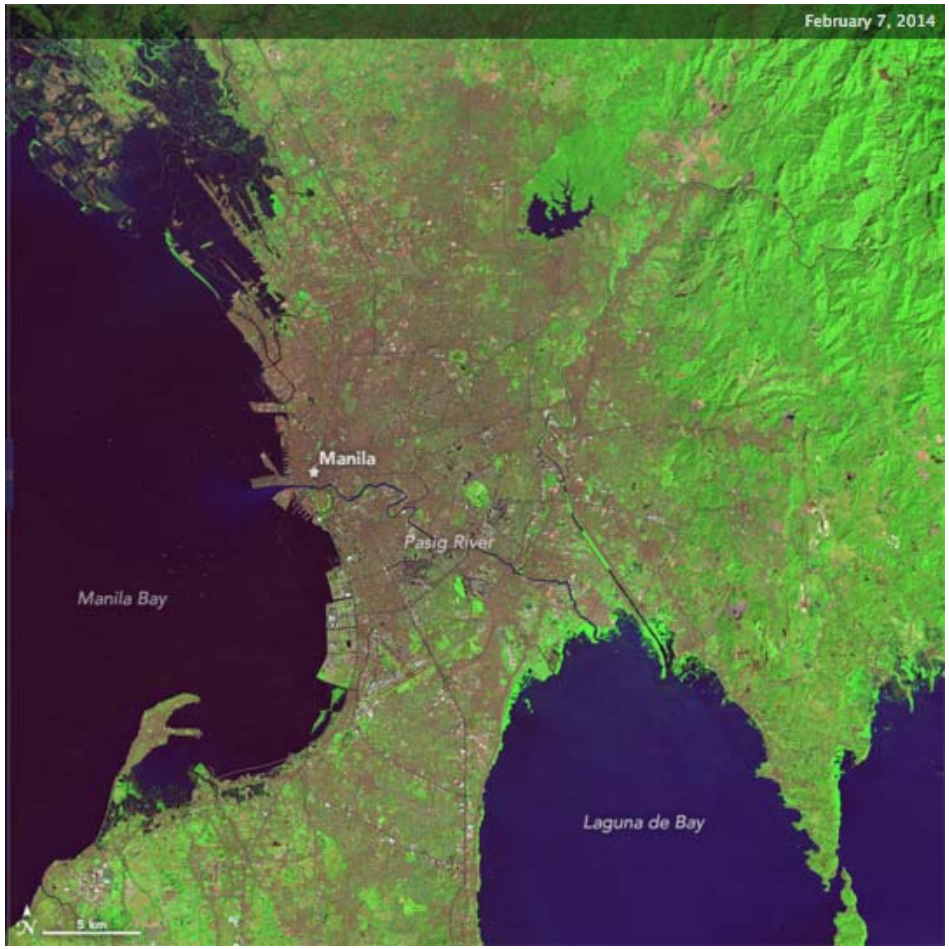
- Domestic waste seems to be a more significant source of N & P into Manila Bay compared to agriculture.
- With continued high population growth (driven principally by migration into Metro Manila), nutrient loading from the domestic sector will continue to increase even with improvements in sewage treatment

Metro Manila

1988



2014



Rural areas (mainly farmland and forest) appear light green. Urban areas are gray.
Source: http://earthobservatory.nasa.gov/IOTD/view.php?id=86780&src=fb

Policy Recommendations

- Improve data gathering and access (e.g., nutrients, discharge rates of rivers and point sources, time series observations, data encoding protocols).
- Encourage or legislate the sale and use of phosphate-free detergents. This could significantly decrease the phosphorus load into the bay, without need for substantial government or private sector investments.
- Review, adopt and enforce nutrient water quality standards for point discharges and water quality criteria for receiving waters.
- Government support towards the development of and investments in growth areas outside Metro Manila will help decongest a densely populated megacity and reduce nutrient inputs into Manila Bay.

Acknowledgment

- UNEP-GEF
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- PEMSEA
- Marine Environment & Resources Foundation
- Metropolitan Waterworks & Sewerage System
- Bureau of Soils and Water Management
- PBL Netherlands Environmental Assessment Agency