Scaling Down the Global NEWS model to a Local Setting: Manila Bay Case Study

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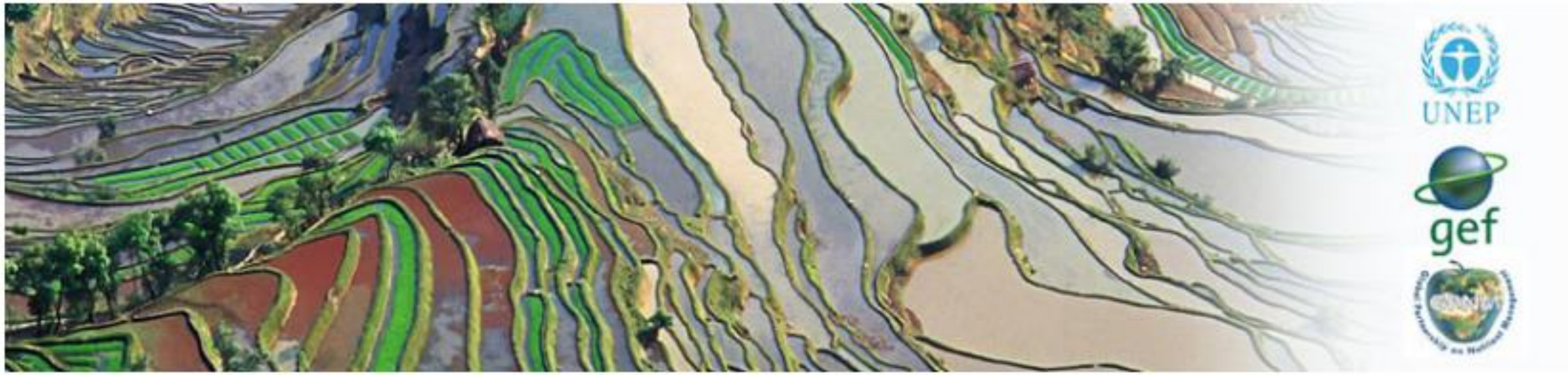
Component B4
Global foundations for reducing nutrient enrichment and oxygen depletion from land based pollution, in support of Global Nutrient Cycle (GNC Project)

Outline

- Background – Global Nutrient Cycle
- Introduction to Manila Bay, the study site
- Eutrophication in Manila Bay
- Manila Bay Nutrient Load Model
  - Inputs, brief overview of the components, scenario building, and results
  - Key findings and limitations
- Building a GUI for the model similar to the nutrient calculator toolbox

UNEP - GEF Global Nutrient Cycle Project



> Global foundations for reducing nutrient enrichment and oxygen depletion from land based pollution, in support of Global Nutrient Cycle

Project Details | Documents | Manila Bay | Chilika lake | Laguna de Bay

The project is designed "to provide the foundations (including partnerships, information, tools and policy mechanisms) for governments and other stakeholders to initiate comprehensive, effective and sustained programmes addressing nutrient over-enrichment and oxygen depletion from land based pollution of coastal waters in Large Marine Ecosystems".

It also aims to develop and apply quantitative modeling approaches: to estimate and map present day contributions of different watershed based nutrient sources to coastal nutrient loading and their effects; to indicate when nutrient over-enrichment problem areas are likely to occur; and to estimate the magnitude of expected effects of further nutrient loading on coastal systems under a range of scenarios.

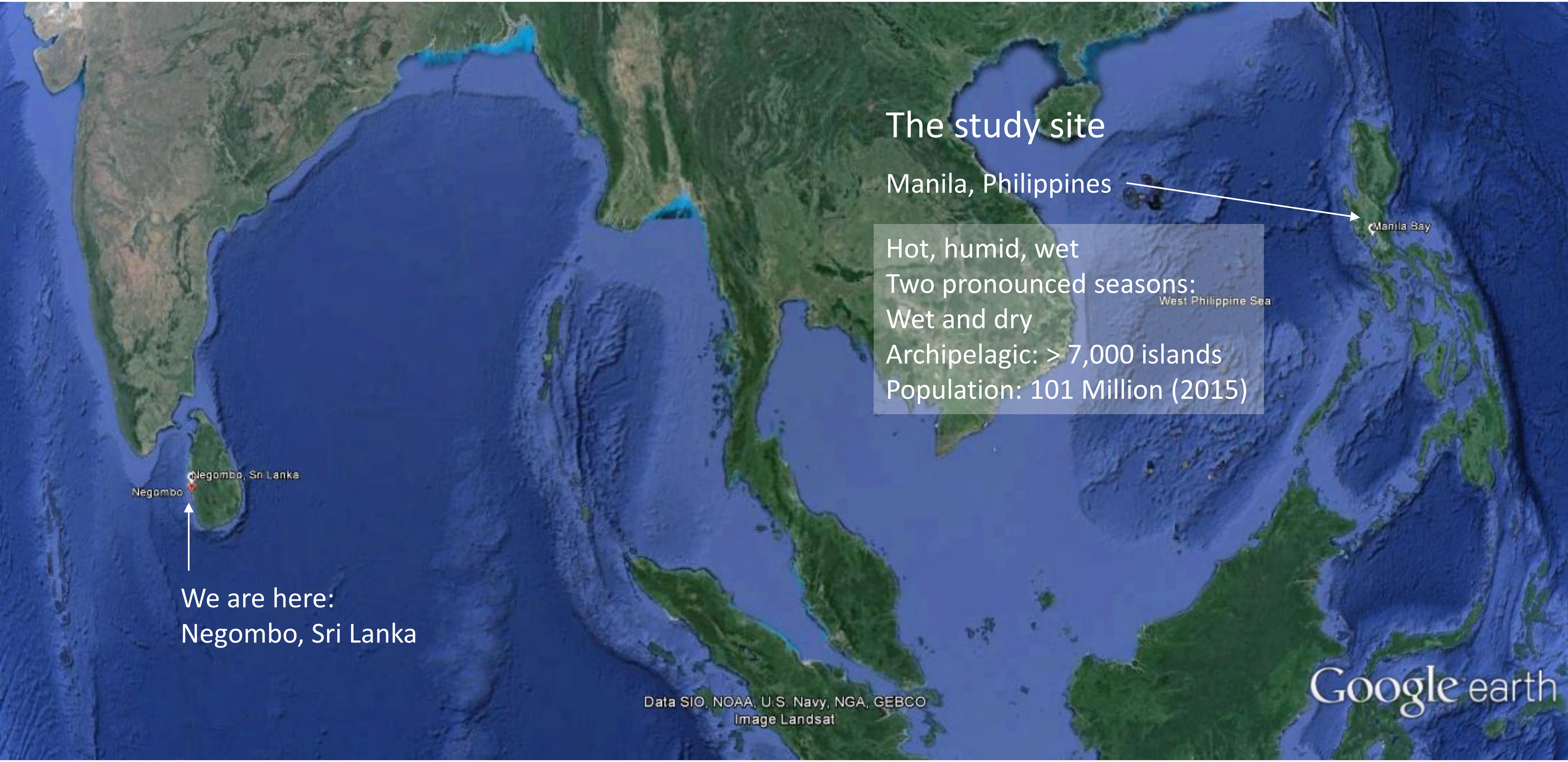
Nutrient over enrichment
Oxygen depletion
From Land Based pollution

Modelling approaches
-watershed based nutrient sources
-effects

Smaller study areas:
Manila Bay
Chilika Lake
Laguna de Bay

Scaling down the global work to regional and basin level scales

- Apply similar principles and methodologies to basin level scales
  - Coarse to fine resolution
  - Apply tool to a specific watershed
- Collaboration with University of Utrecht (Dr. Lex Bouwman and Dr. Arthur Beusen)
  - Developed a Python based tool for calculating the nutrient loading into Manila Bay, Philippines from different sources.
- Modifications on the original model to fit local site peculiarities:
  - Use of septic tanks as the major mode for waste collection and treatment
  - Schematic of how people are connected to sewage systems


The study site
Manila, Philippines
Hot, humid, wet
Two pronounced seasons:
Wet and dry
Archipelagic: > 7,000 islands
Population: 101 Million (2015)
Manila Bay
West Philippine Sea
Negombo, Sri Lanka
Negombo
We are here:
Negombo, Sri Lanka
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat
Google earth

Manila Bay, Philippines

190 km coastline

1,700 km^2 surface area

2.98 trillion m^3 approximate volume

22 km long at the mouth

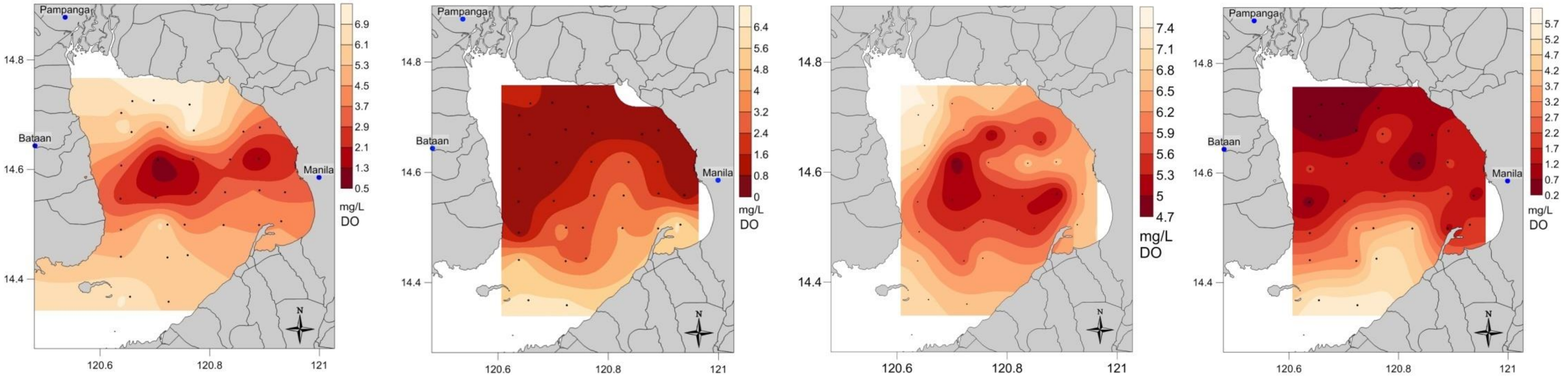
60 km at its widest point

17 m average depth

Manila Bay shows evidence of the detrimental effects of excessive nutrient loading – HABs

Harmful Algal Blooms

Manila Bay shows evidence of the detrimental effects of excessive nutrient loading – **hypoxia**

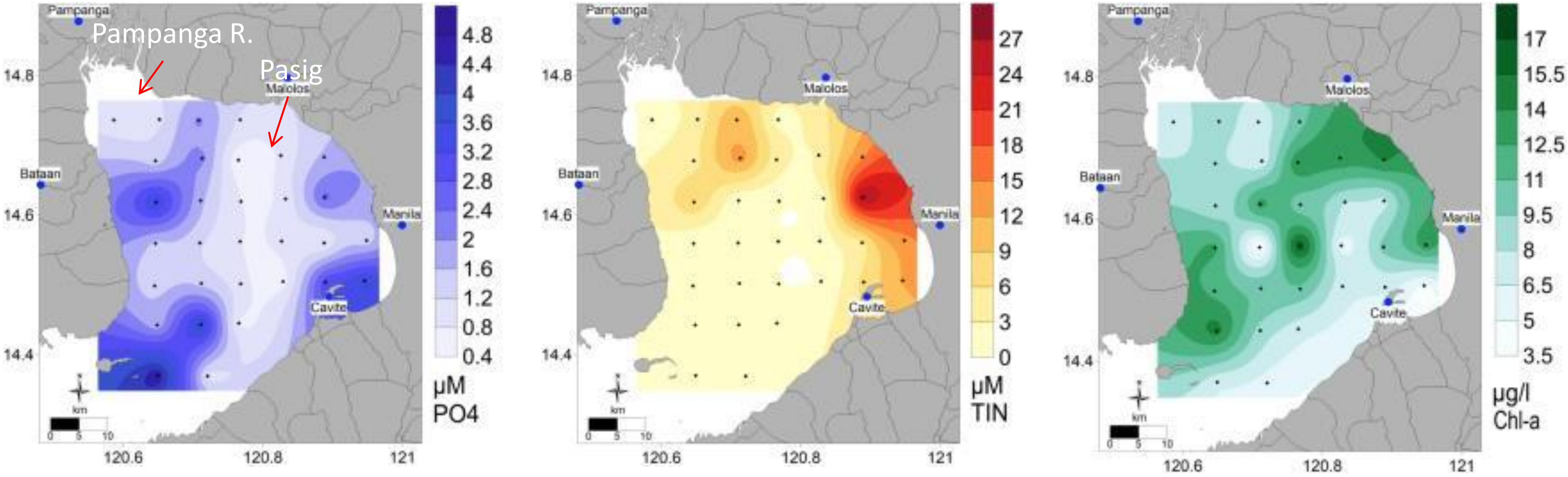


Feb 2010 Jul 2010 Feb 2011 Aug 2011

BOTTOM Diss. Oxy.	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}**			

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

Manila Bay shows evidence of the detrimental effects of excessive nutrient loading – **eutrophication**



High chl-a biomass

Attributed to nutrient loading from rivers

High TIN and P near the coast

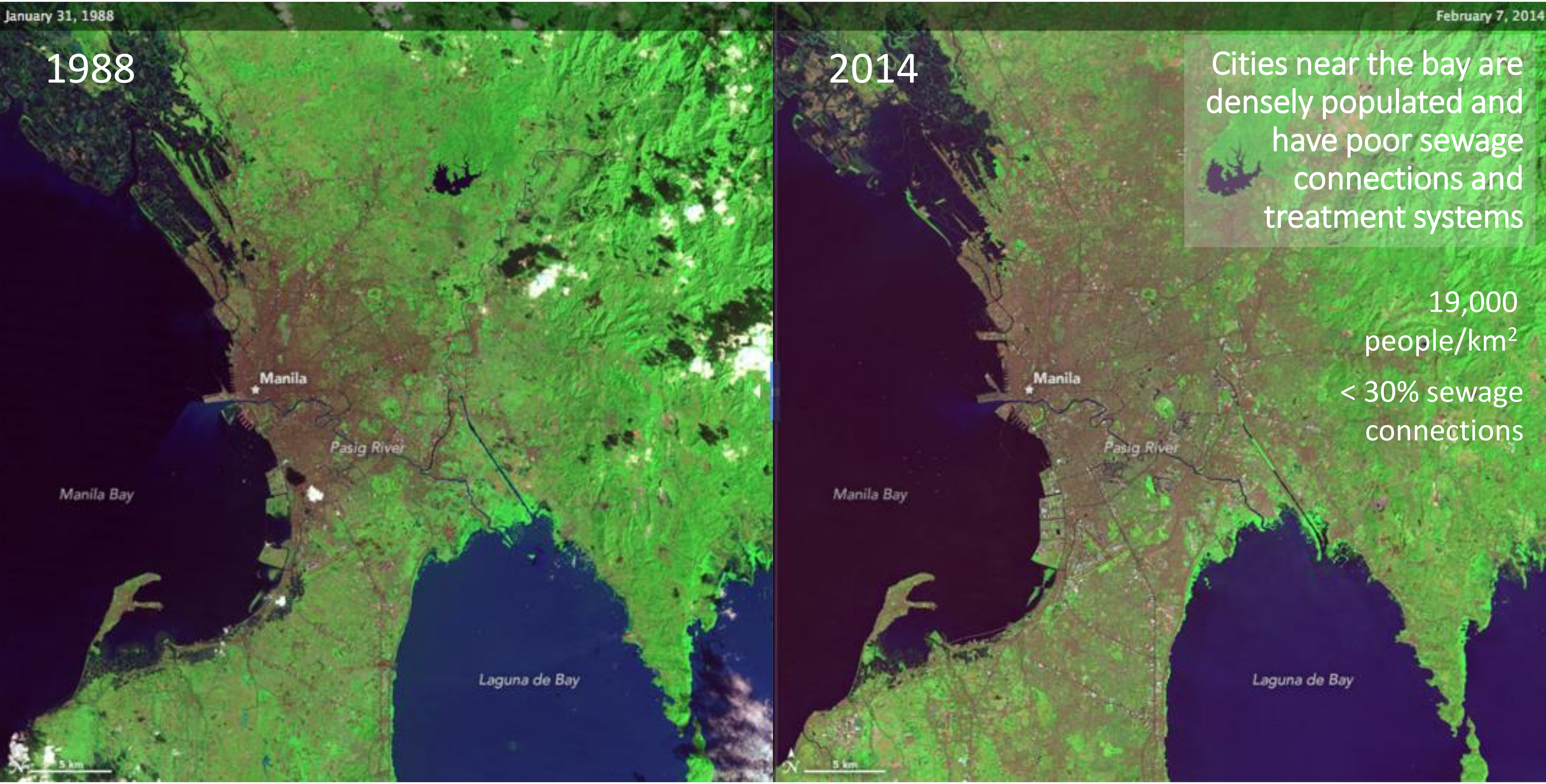
Pasig and Pampanga Rivers

Runoff include domestic, industrial, agricultural, and untreated sewage waste

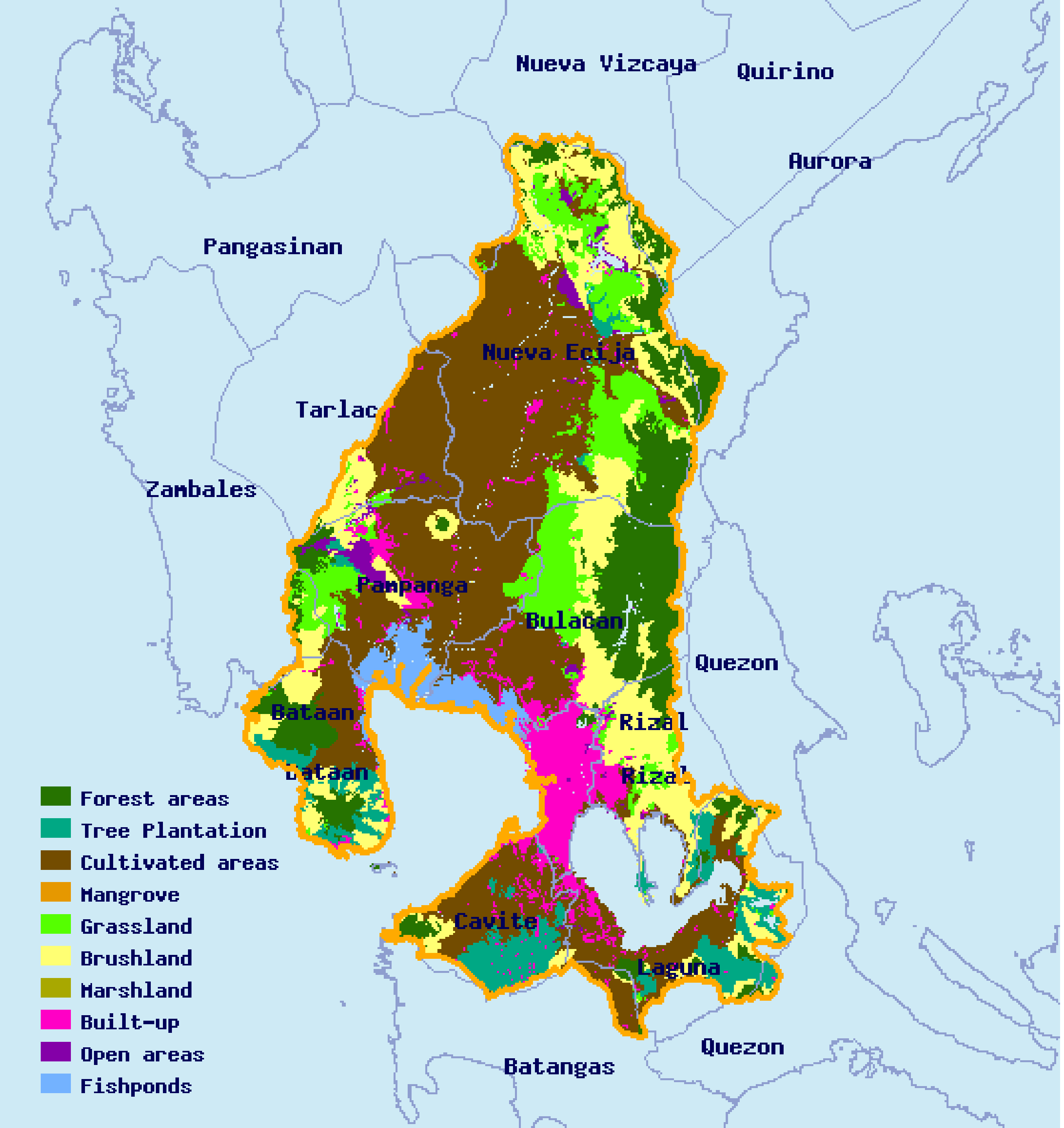
August 2012

- SW Monsoon
- Wet season

Surface nutrient and chl-a levels



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



Agricultural and aquaculture activities are also load nutrients into the Bay

19,268 km^2 catchment area (EMB, 2012; BSWM, 2012)

- Home to 34% of the total population of the Philippine - ~34 Million (NSO, 2010)
- **42% (~8000 km^2) are agricultural areas (BSWM, 2012)**
- **3% wetlands including fishponds (BSWM, 2012)**

Sewer coverage (Manila Waters, MWSS)

- 3% in 2003
- 30% in 2012
- Up to secondary treatment only

Nutrient loading into water bodies can be estimated using statistical data

- For studies at this scale where primary data may be hard to obtain, different secondary data can be used to estimate loads
- Model written in Python developed by Beusen and Bouwman (2013) patterned after the models in the Global Nutrient Export from Water(S)heds (Global NEWS) program.
- Calculates from inputs such as:
    - CSV files
    - Maps (land use, etc.) converted into ASCII files

Simple statistical data can give you a wealth of information

- Data inputs:
  - Statistics (population, fertilizer use, volume of production, % connection to sewage systems, etc.)
    - National Statistics Office/Philippine Statistics Authority, Bureau of Agricultural Statistics
  - Maps (land use, population density, digital elevation maps (DEM), flow direction maps)
- Input as *.CSV files (easily edited)
- Georeferenced or map inputs are converted to *.ASCII files
- Outputs:
  - CSV tables, maps, charts

Different scenarios can be tested using the model

- What if population were to increase and sewage treatments and connections do not improve?
- What if sewage connections and treatment are improved?
- What if P content in detergents is regulated?

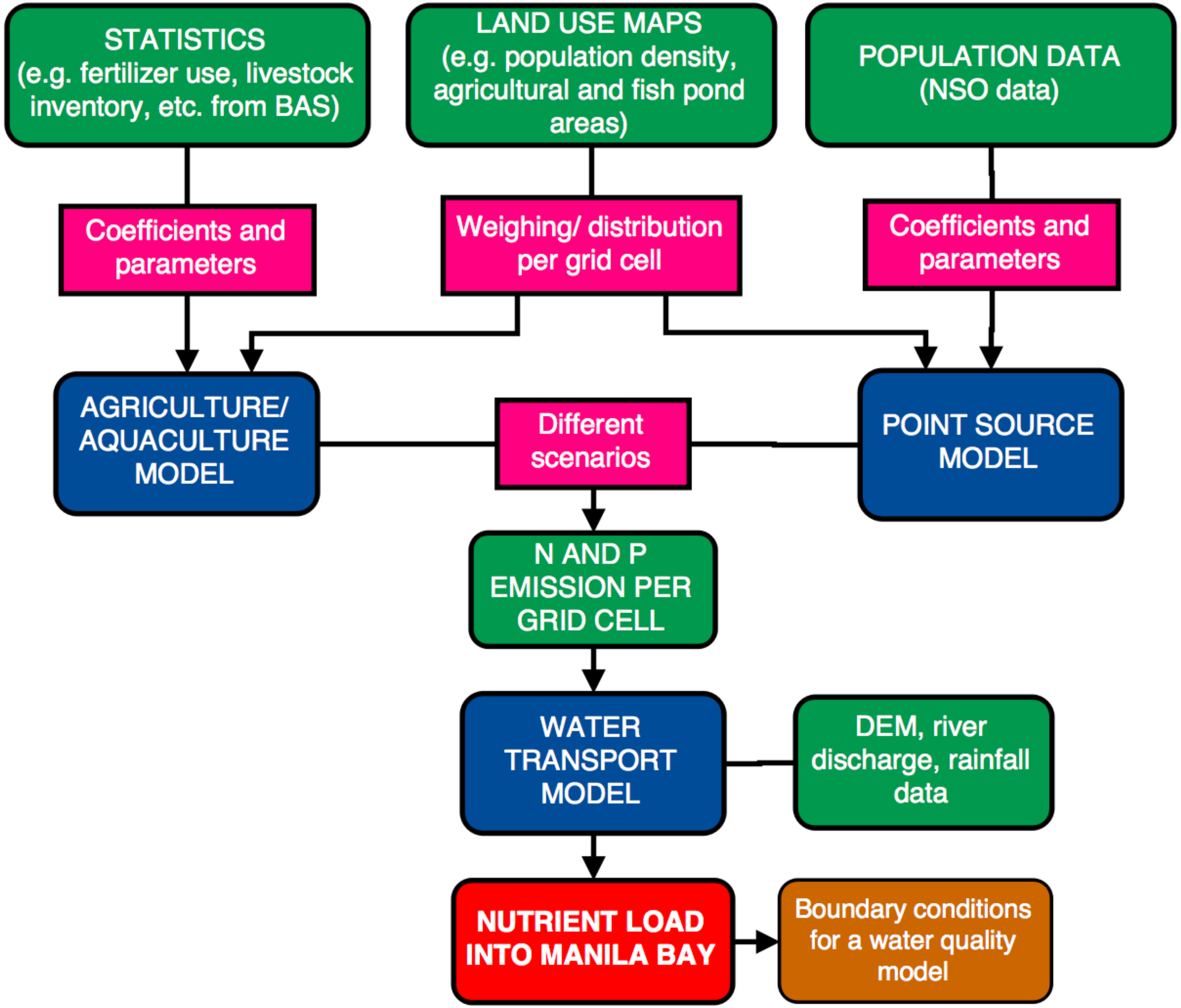
These scenarios in turn can help with policy guidance

- What are the problematic areas to address?
- What are the cost effective measures that can be applied?
    - e.g., regulating P in detergents

Manila Bay Nutrient Load Model

Objectives:

- Estimate the **amount of nutrient load** to Manila Bay from domestic, agriculture, and aquaculture **activities**
- Determine the **efficiency of sewage connections, treatment, and P reduction** in detergents through different scenario runs
- Suggest possible **policies or strategies** for nutrient load reduction based on the results of the different scenario model runs



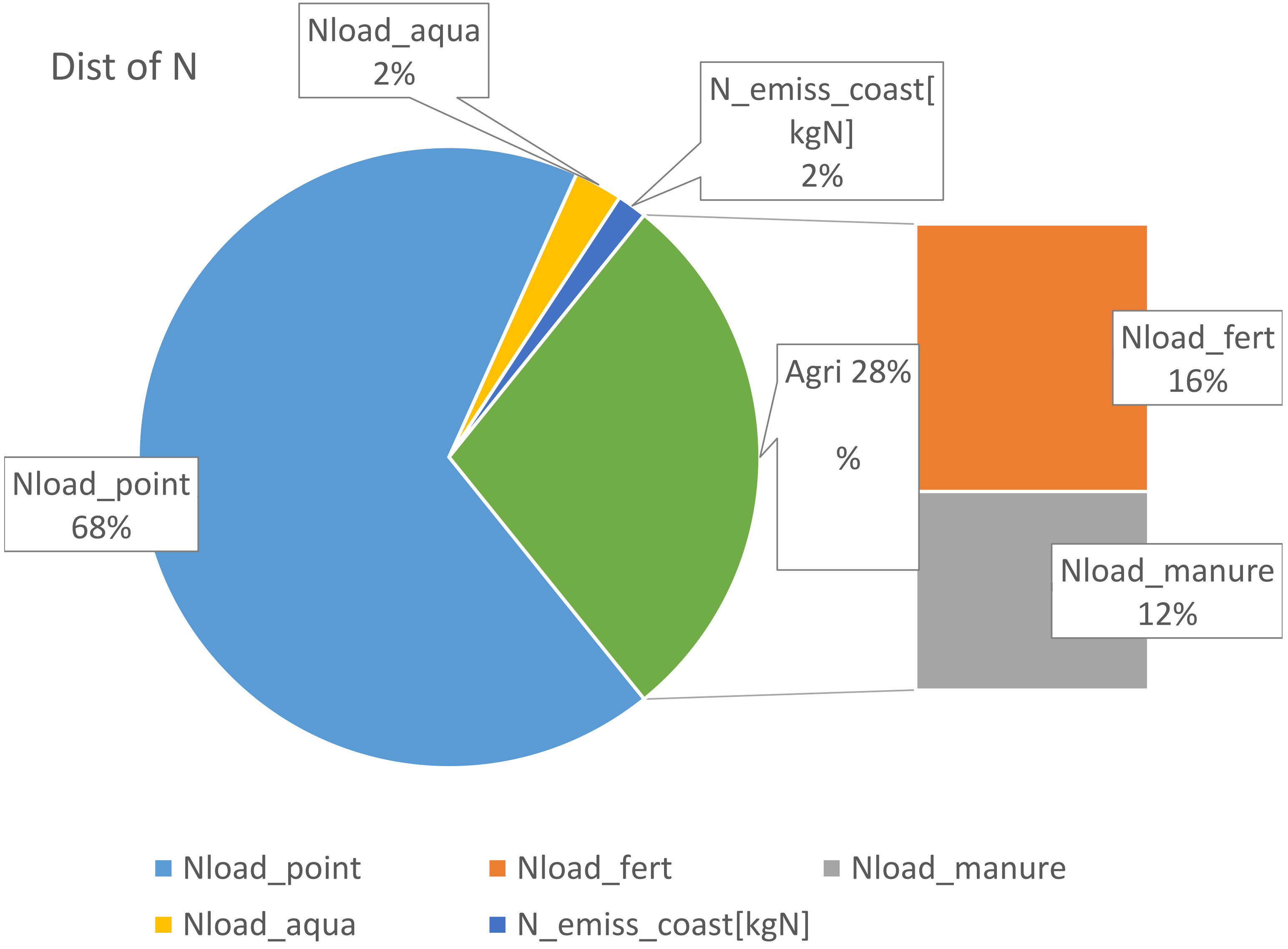
Nutrient load model overview

There are 3 modules: agriculture, point sources, and water transport.

Data is distributed onto a 1km grid.

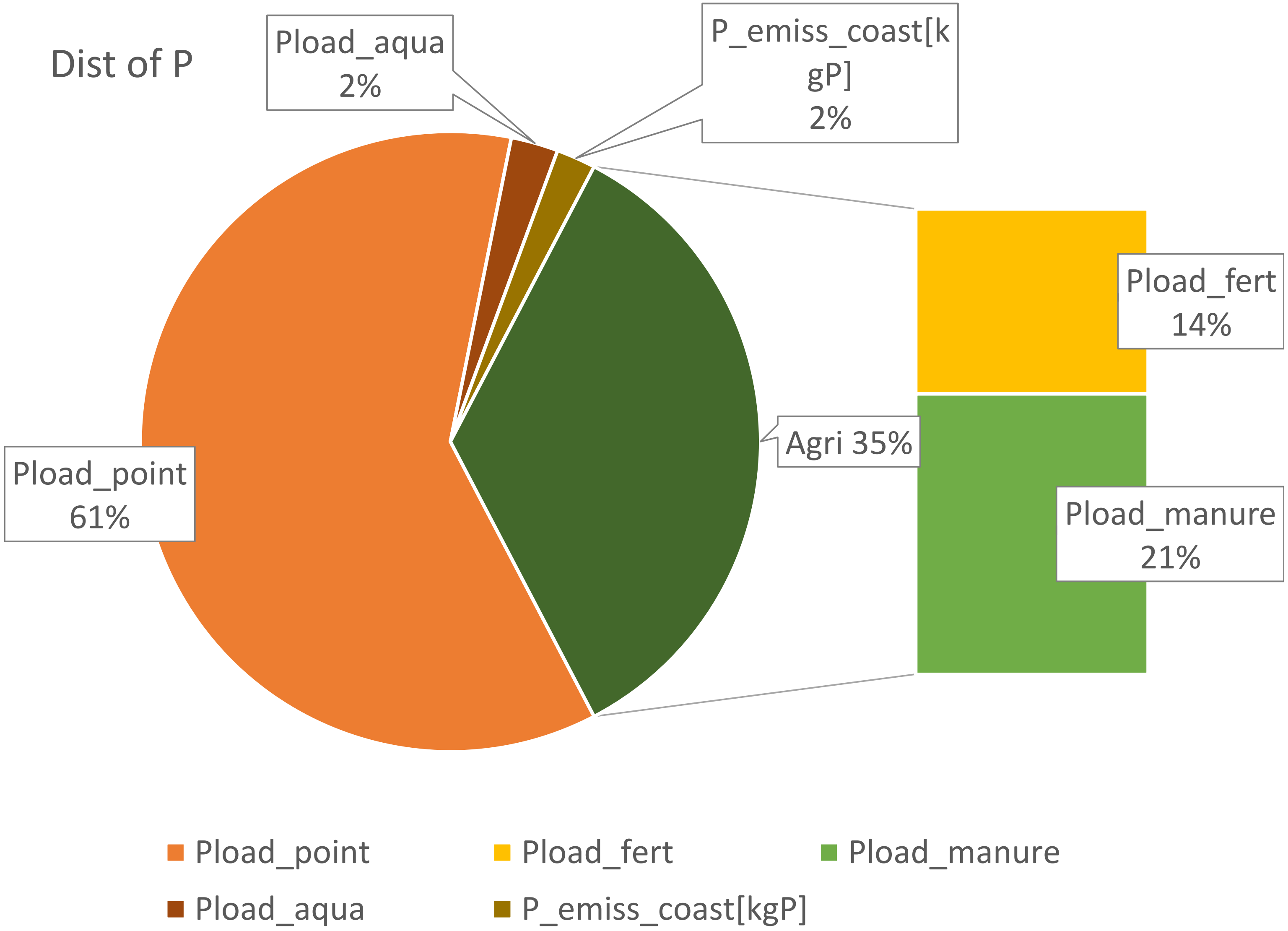
Baseline results by sector

Nitrogen load from domestic sources comprise a bigger part of the total nutrient load



Baseline results by sector

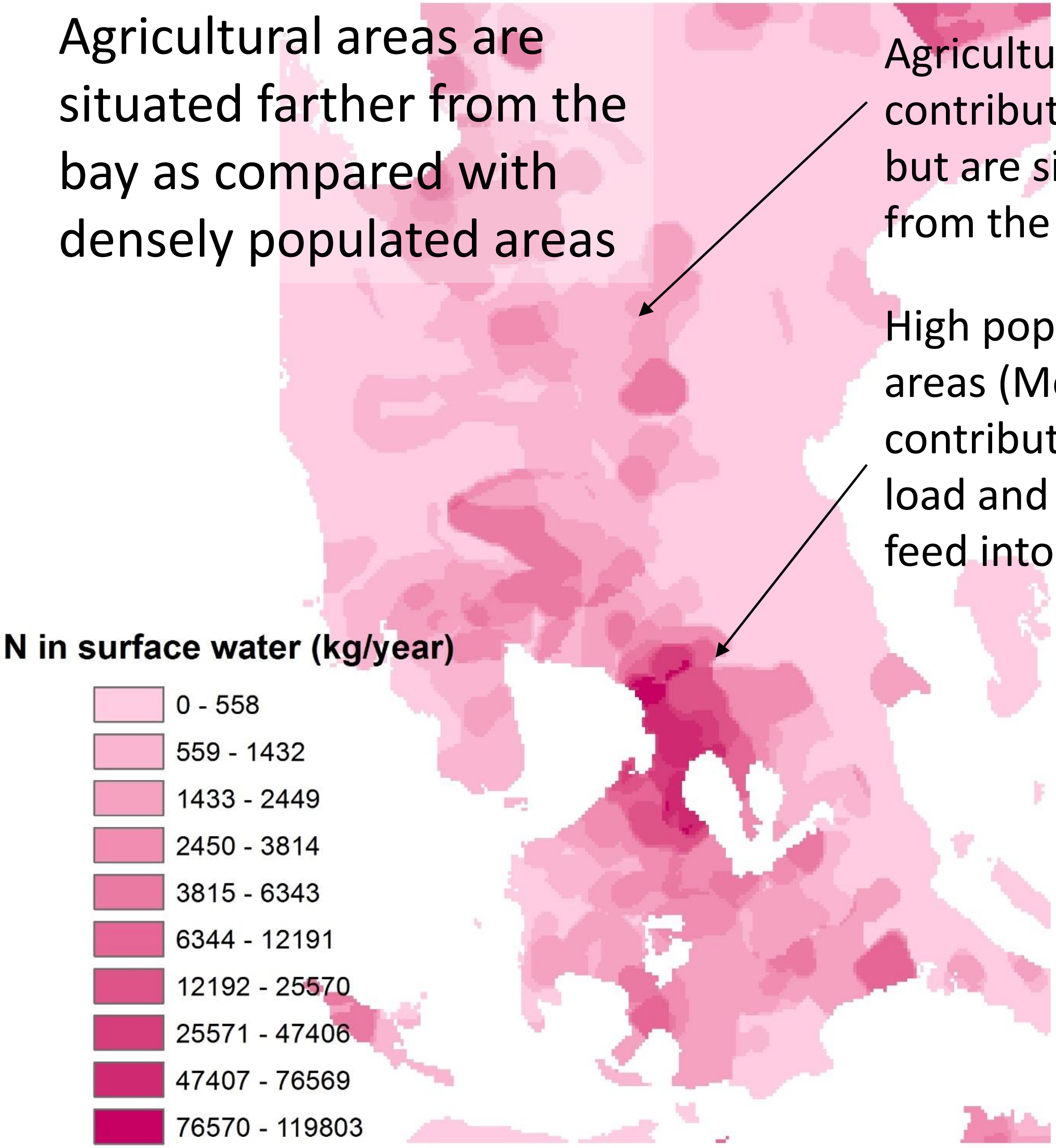
Phosphorus load from domestic sources comprise a bigger part of the total nutrient load

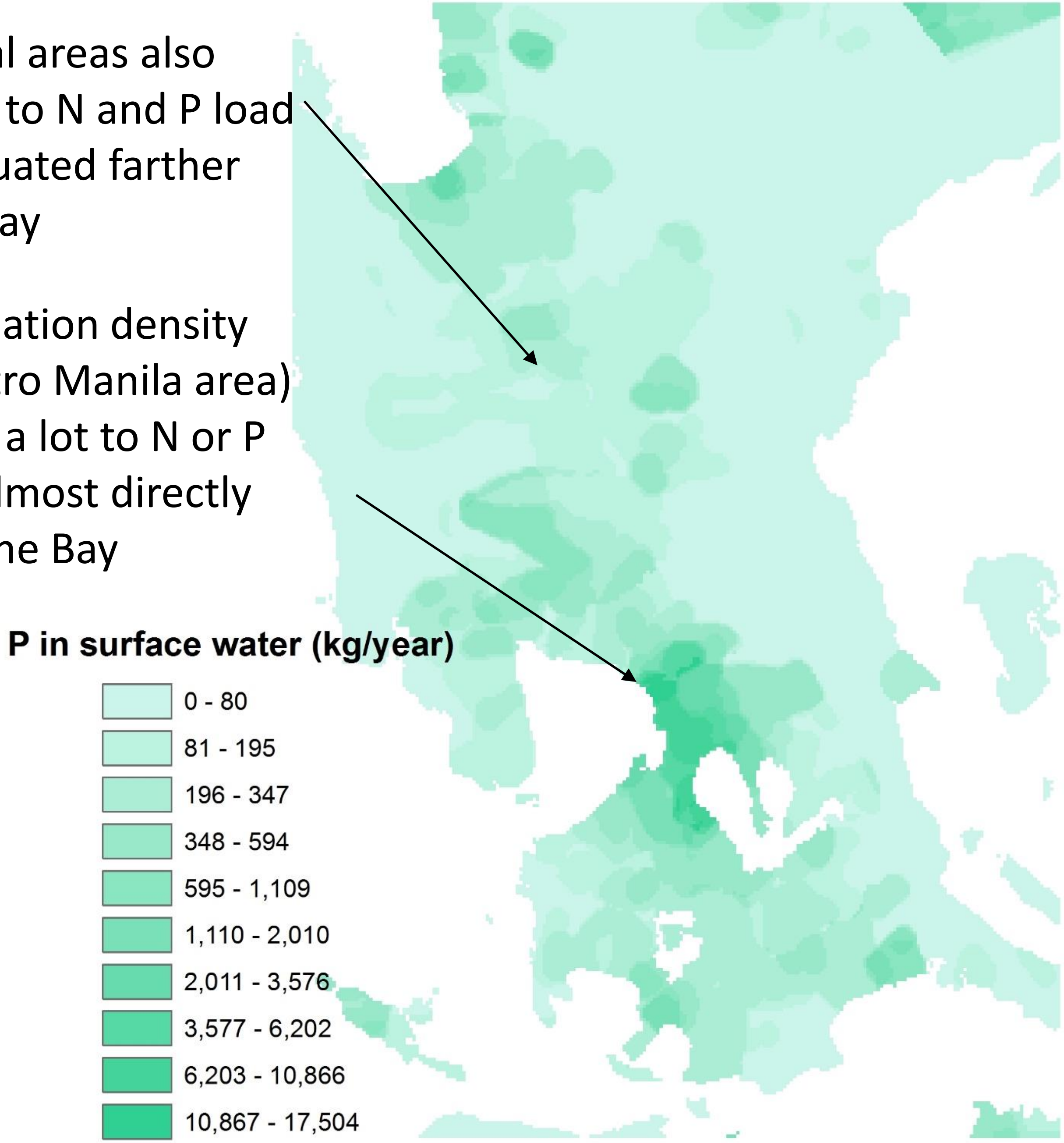


Agricultural areas are situated farther from the bay as compared with densely populated areas

Agricultural areas also contribute to N and P load but are situated farther from the Bay

High population density areas (Metro Manila area) contribute a lot to N or P load and almost directly feed into the Bay





Scenario building can help address important questions and hypotheses

- What is the current or **baseline** status?
- What are the **sources** of pollution?
- What if population increases and nothing is done to improve sewage connections or treatment? (same number of people are connected)
- Impact of better sewage connections and treatment?
- Effect of population growth rate?
- Contribution of P from detergents? What if we regulate P in detergents?

Overview of the scenarios

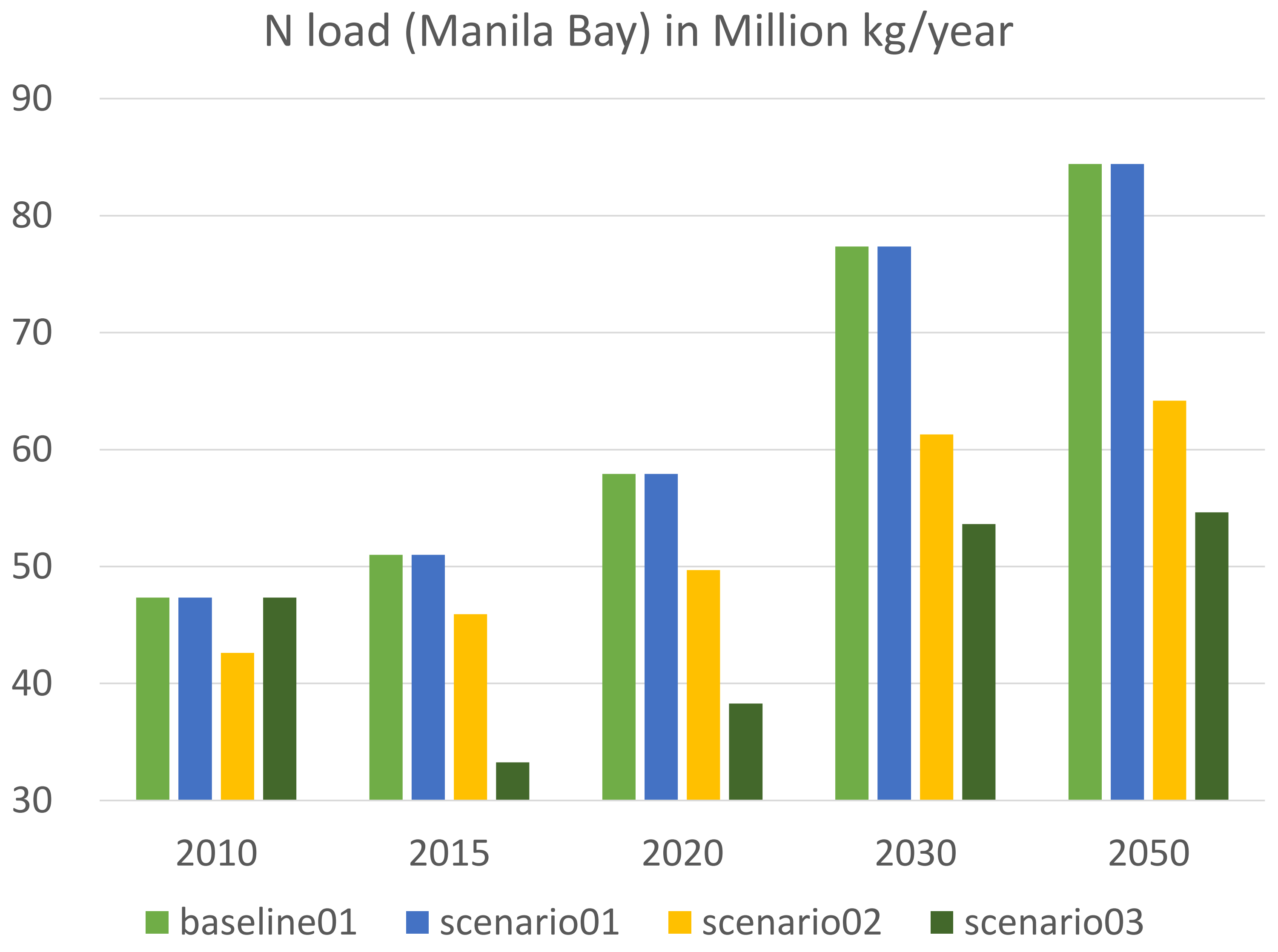
	Baseline01	Scenario01	Scenario02	Scenario03
Population growth rate	Normal (as projected by NSO/PSA or FAO)	Normal (as projected by NSO/PSA or FAO)	Normal (as projected by NSO/PSA or FAO)	Half the published growth rate
P regulation	None	Total P ban on dishwashing and laundry detergents	None	None
Sewage connections	10% in the provinces 30% in Manila	10% in the provinces 30% in Manila	Improving sewage connections 2020 – 30% everywhere 2030 – 50 % everywhere 2050 – 50% everywhere	10% in the provinces 30% in Manila
Sewage treatment	Full secondary treatment	Full secondary treatment	Full tertiary treatment	Full secondary treatment

Scenario comparisons - N

Baseline01 – limited connections, full secondary treatment
Scenario01 – Total P ban on detergents
Scenario02 – Improving connections, full tertiary treatment
Scenario03 – Half the population growth rate

Sewage treatment and decreasing the population growth rate (decentralizing population density) helps decrease nutrient loads

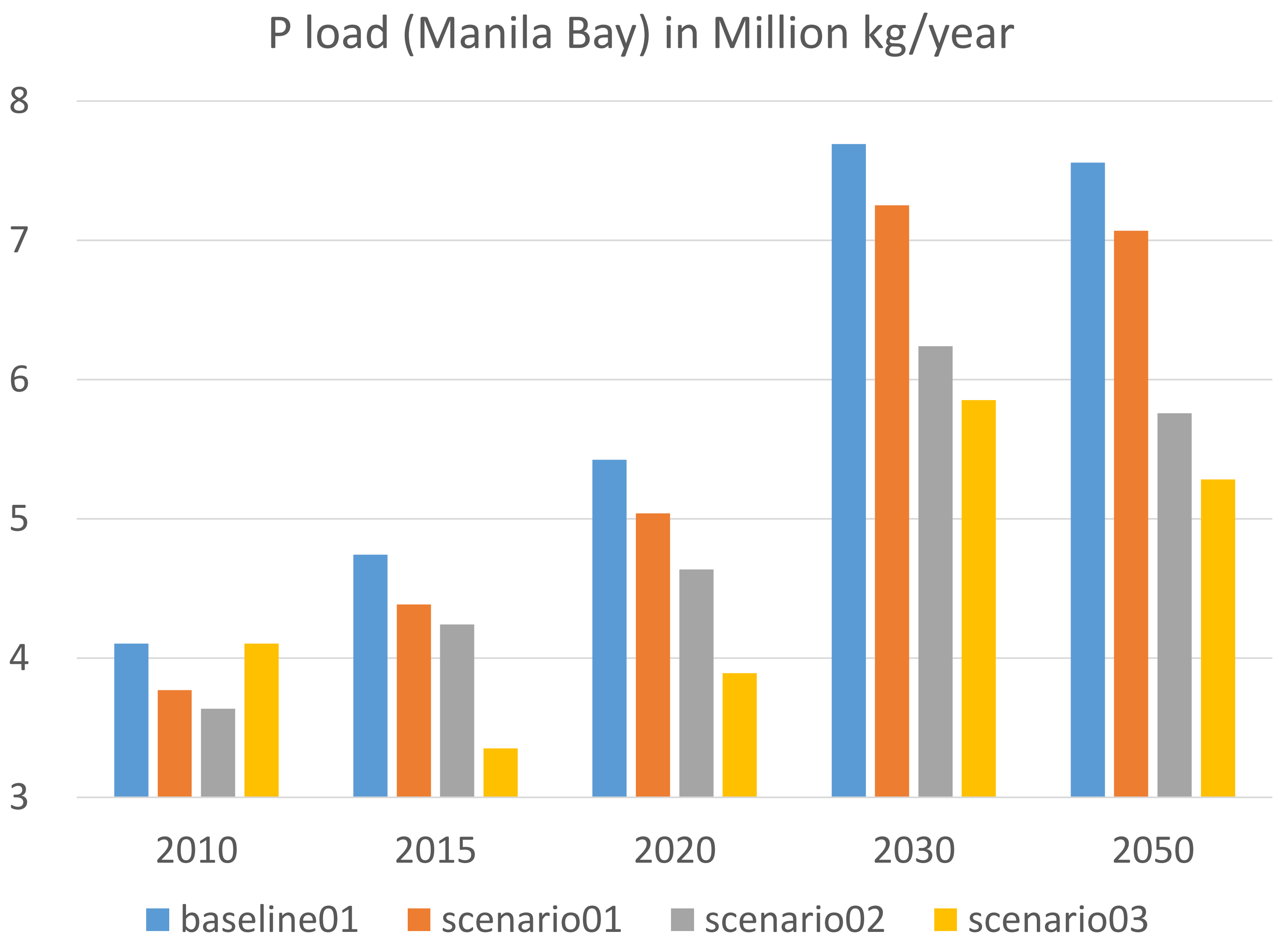
Loads are still increasing but at a slower rate if improvements are made – might be a way for the bay to recover



Scenario comparisons - P

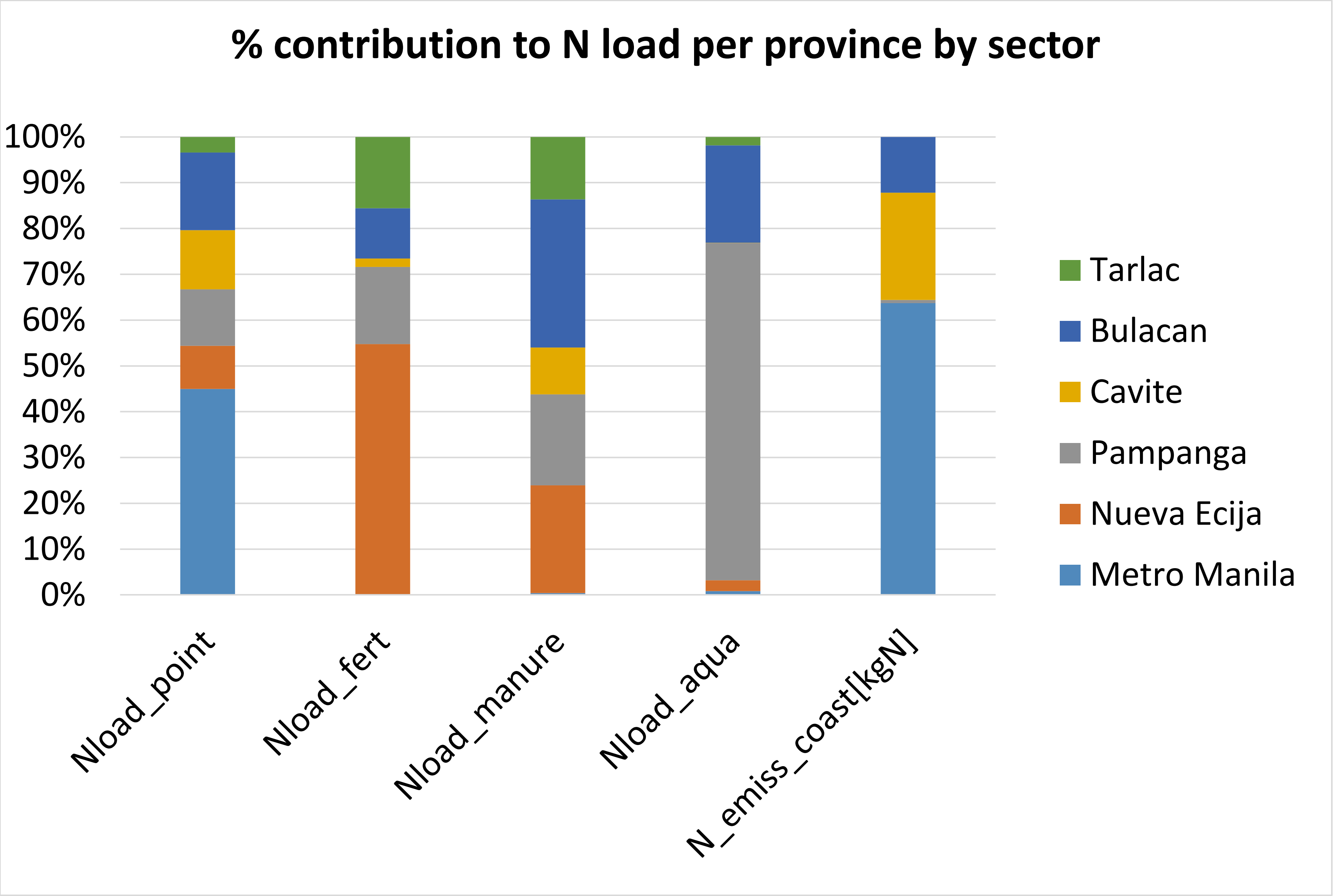
Baseline01 – limited connections, full secondary treatment
Scenario01 – Total P ban on detergents
Scenario02 – Improving connections, full tertiary treatment
Scenario03 – Half the population growth rate

Banning P is almost as effective as sewage treatment in reducing P loads (scenario01 and scenario02)



Per province comparisons

- Manila – pointsources/
- domestic waste
- Rural provinces like Nueva Ecija and Pampanga – agricultural waste
- Pampanga – a lot of fish ponds



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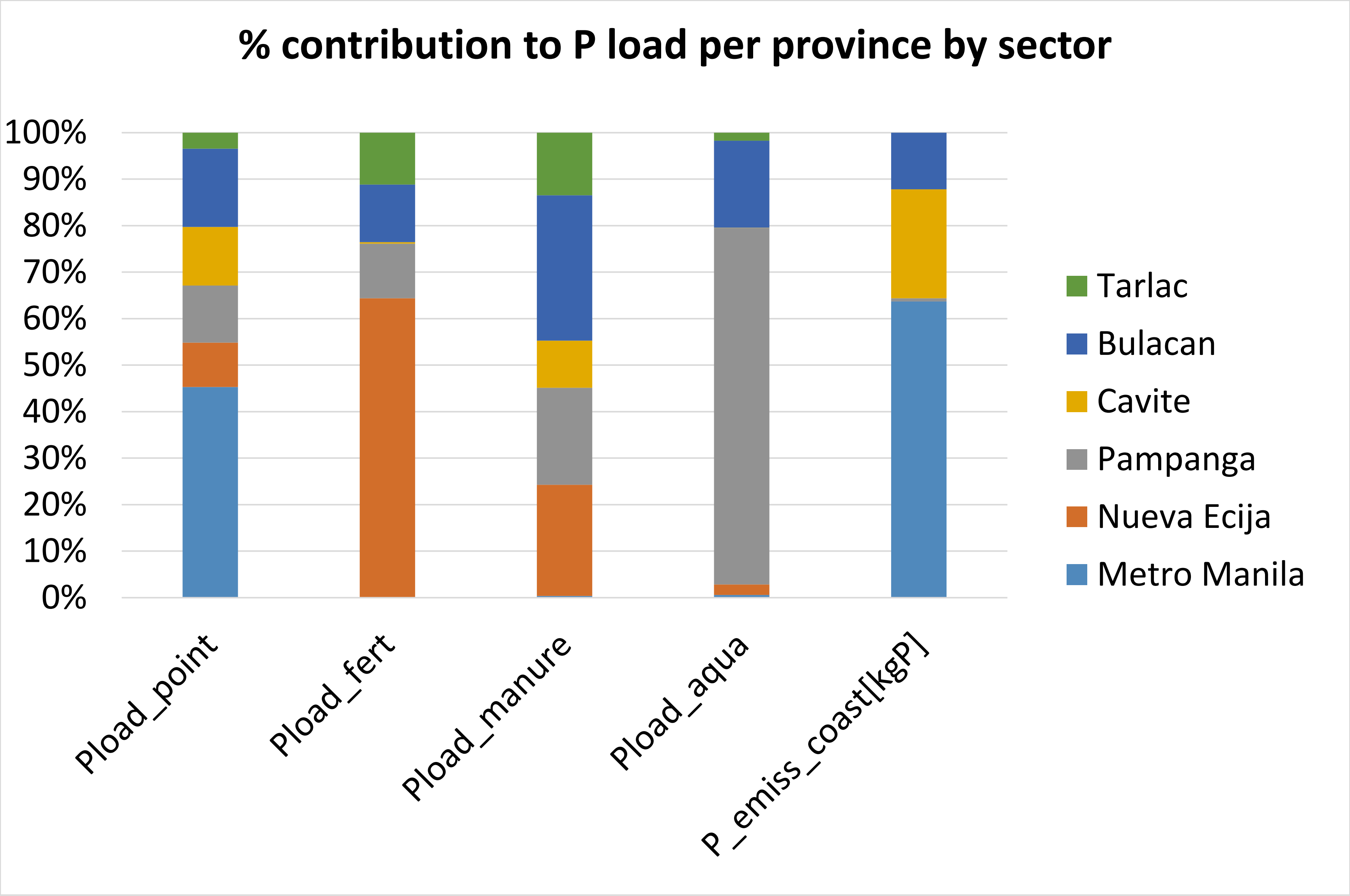
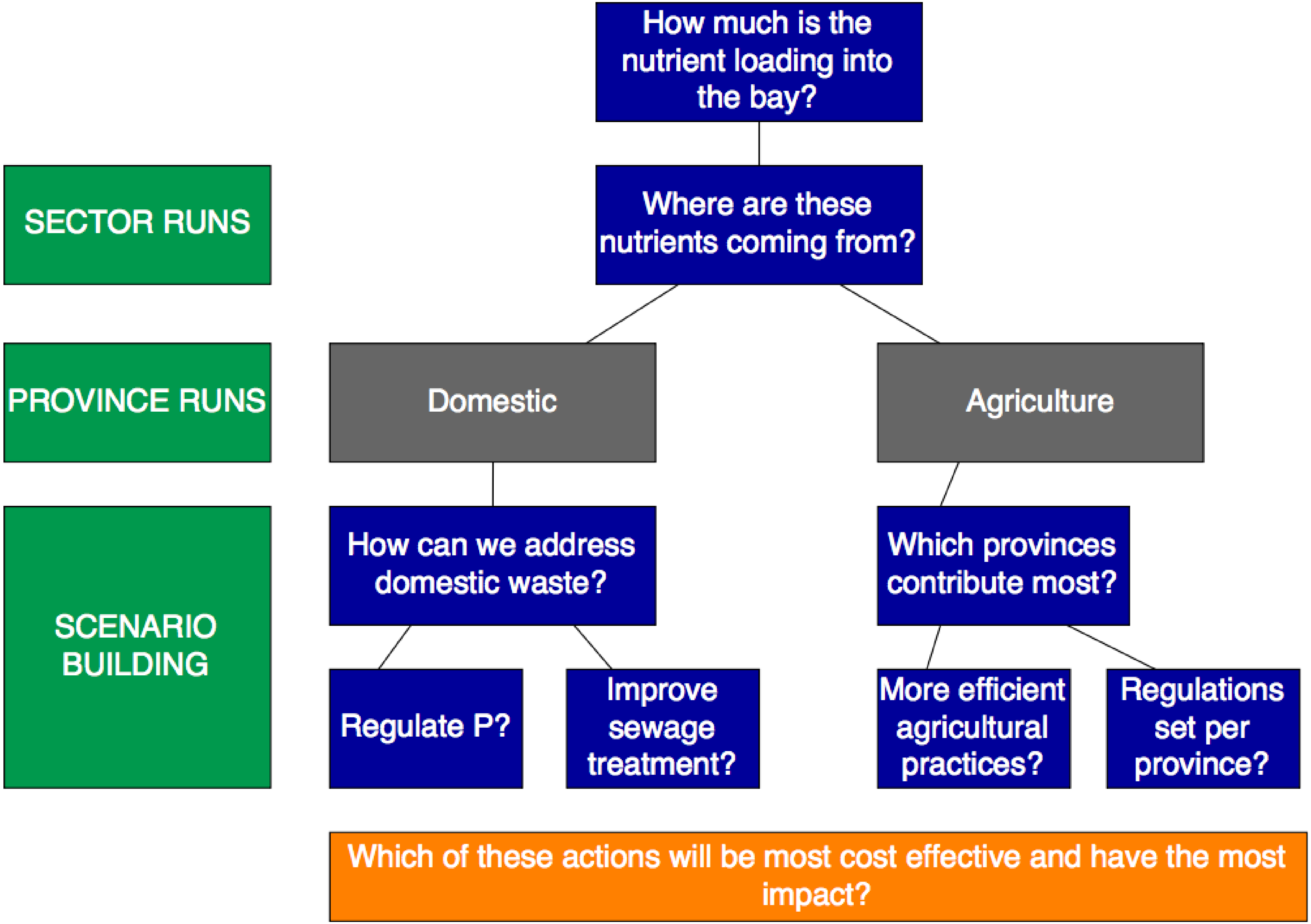



How much is the nutrient loading into the bay?
SECTOR RUNS
Where are these nutrients coming from?
PROVINCE RUNS
Domestic
Agriculture
SCENARIO BUILDING
How can we address domestic waste?
Which provinces contribute most?
Regulate P?
Improve sewage treatment?
More efficient agricultural practices?
Regulations set per province?
Which of these actions will be most cost effective and have the most impact?

Key points from the scenario building exercise and the nutrient load model

- Domestic sources a bigger source of nutrient load
- With continued high population growth (driven principally by migration into Metro Manila), nutrient loading from the domestic sector will continue to increase
- Sewage treatment will help decrease the nutrient load
- A ban on P in detergents could help decrease P loads almost as much as tertiary treatment but at a lesser cost
- Decentralizing the highly dense urban areas and making living outside of Metro Manila (and the immediate vicinity of the bay) attractive will also help in better waste management

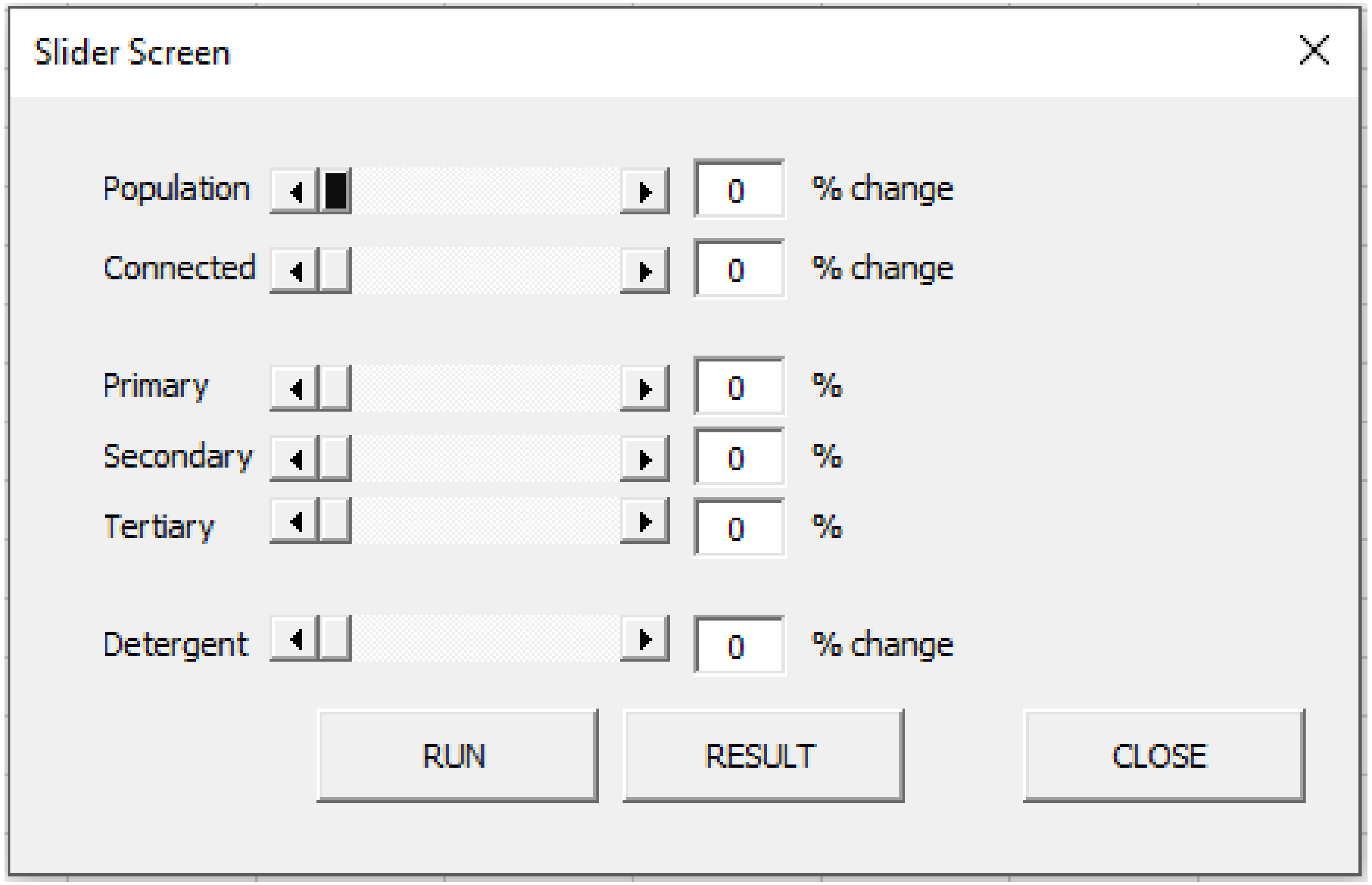
Advantages, disadvantages, and limitations of the model

- Runs fast, minimum software requirements
- Input files and parameters are *.csv files, you can easily change it as data is updated
- Schematic/methodology of the model has been modified to fit some of the local factors in the Philippines (e.g. septic tanks)
- No GUI, some knowledge of programming required, not as “user friendly”
- Three different modules have to be run separately (for now)
- Still based on many assumptions where data is unavailable
    - Industry contributions are set as a factor of domestic waste

The model can be applied to other basins via parameters which can be easily modified

- % connections
- Primary, secondary, and tertiary treatment
- % urban and rural
- Protein consumption
- River retention
- Other coefficients
- Input maps – converted to ASCII file

Prototype user interface – sliders to adjust the different parameters – build scenarios easily



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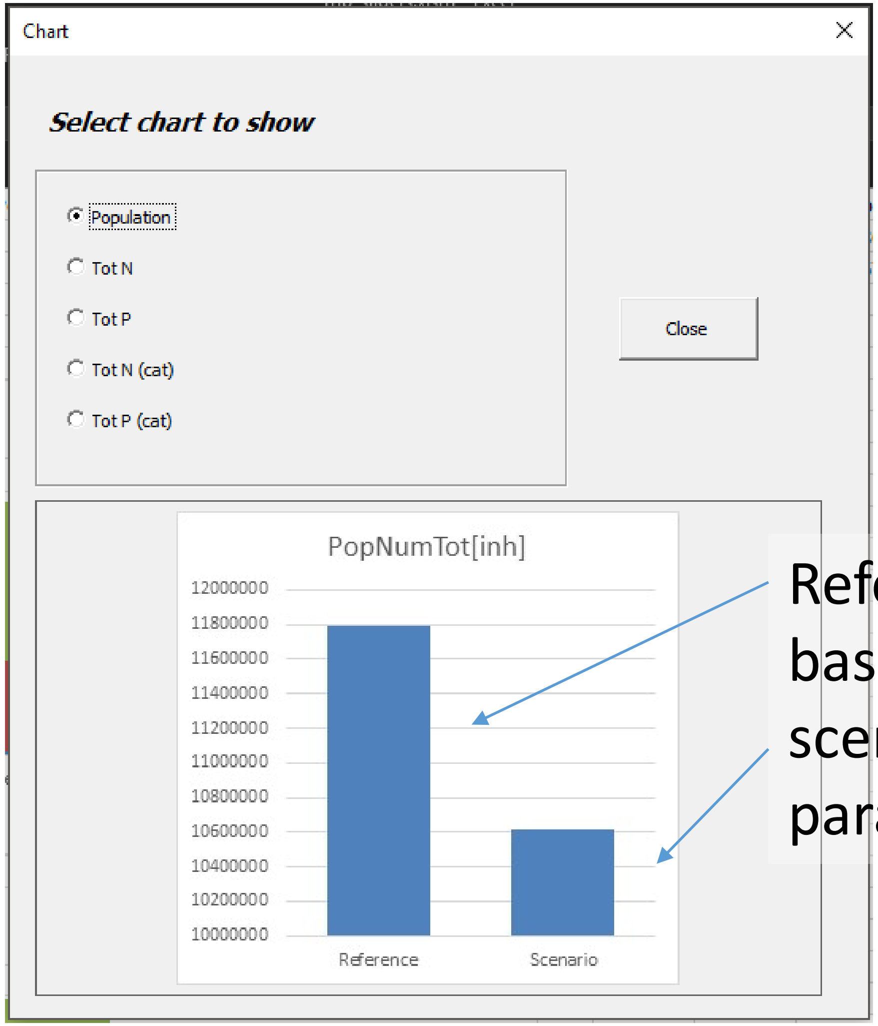
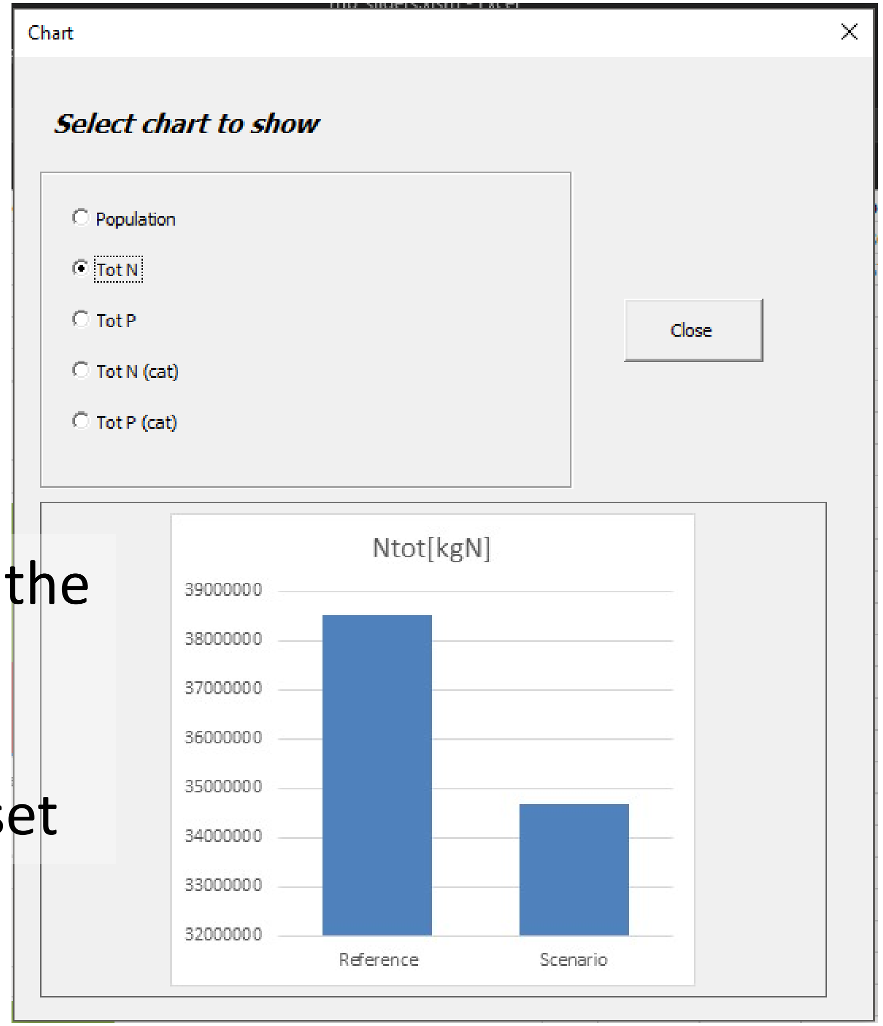


Reference – refers to the baseline runs and scenario refers to the parameters you just set



Prototype user interface – sliders to adjust the different parameters – build scenarios easily

- You can still change the parameters and variables in the model but it is easier to quickly change the inputs and build scenarios
- Without the user interface, all the different *.CSV files for input have to be changed manually

Conclusions

- The Manila Bay Nutrient Load model prototype has been a useful tool in exploring, confirming, and estimating nutrient sources and loads
  - Identify problematic areas where efforts can be focused
- The scenario building feature is a tool that can be used to generate and validate policy options for addressing the nutrient loading problem
  - Different factors can be taken into consideration like ease and cost of suggested policies like sewage treatment and P regulation in detergents