

Rezatec

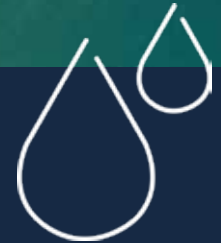
A VIEW FROM ABOVE

HOW SATELLITES ARE CHANGING THE WAY WATER RESOURCES ARE MANAGED IN THE PHILIPPINES

The Philippines has an abundant supply of surface water resources, estimated at 146 billion m³/year (Caparas, 2014), with groundwater accounting for 20 billion m³. Yet the country struggles to provide adequate levels of freshwater for the entire population, and experiences water-related problems.

Key challenges affecting water resource management are fragmented water agencies, rapid urbanisation and industrialisation, and inadequate water infrastructure (IWRM, 2018). Together, these and other factors mean the Philippine freshwater ecosystem faces severe problems of pollution and rising costs of potable water supply.





INTRODUCTION

In the Philippines, surface water from rivers and lakes dominates freshwater supply. However, 50 of the 421 major rivers are now considered biologically dead (Rola et al., 2015) due to over pollution, and the country's 79 lakes are also suffering from rapidly increasing pollution levels.

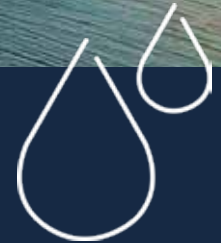
One of the most economically important lakes threatened by pollution is Laguna de Bay. The largest lake in the Philippines, Laguna de Bay is a shallow lake located south-east of Manila, covering an area of approximately 900 km², with an associated catchment area of approximately 1,800 km². The water body is used to support aquaculture (supplying Metro Manila's ~13 million people with a third of their fish) and also provides a key resource for the local drinking water supply network.

Rapid urbanisation and industrialisation has seen significant land conversion in the basin in the past few decades (Endo et al., 2016). The western edge of the lake is densely populated with residential and industrial land use. And the eastern sub-catchments contain residential areas split by large swathes of agricultural land, including rice farming, and forestry.

Consequently, the lake is surrounded by a host of different sources producing effluents that are discharged into it. For example, nutrients such as nitrogen and phosphorus from agricultural fertiliser run-off and domestic untreated wastewater have caused fish die-offs and algal blooms (Santos-Borja & Nepomuceno, 2004). And heavy metal concentrations in edible fish and aquatic plants have been shown to pose health risks to eating them (e.g. Saito et al., 2012).

Faced with a varied topography and geography, and wide range of pollution sources, water resource managers face significant challenges in identifying and mitigating against major pollutants, and ensuring healthy food sources and potable water supplies are available to the local population.





PROJECT: SATELLITE HYDROLOGY OF LAGUNA DE BAY

In 2018, Metro Pacific Water (MPW) tasked UK-based Earth Observation analytics company Rezatec Limited with producing synoptic datasets depicting the structure, hydrological process and significant changes within selected catchments on Panay Island (Iloilo) and around Laguna de Bay; see figure 1 (In this article, the focus is on the Laguna de Bay project for brevity).

Metro Pacific Water is the sister company of Maynilad Water Services, Inc. (Maynilad), which operates the water and sanitation concession for the western part of Metropolitan Manila. Since 2010, Maynilad has been producing up to 100 million liters per day (MLD) at its Putatan Water Treatment Plant, which sources raw water from Laguna de Bay. The aim of the study commissioned by MPW was to gain an understanding of which land uses within the Laguna de Bay basin have the greatest impact on the lake's water quality, allowing for targeted future studies into potential land management activities.

Metro Pacific Water and Maynilad restricted the study to the periods August to September, December to February and March to May, in 2016 and 2017. They also specified key pollutants of concern which were known to them as affecting downstream water quality. These were nitrate, phosphate, ammonia, manganese, sediment loading and total dissolved solids associated with untreated effluent.

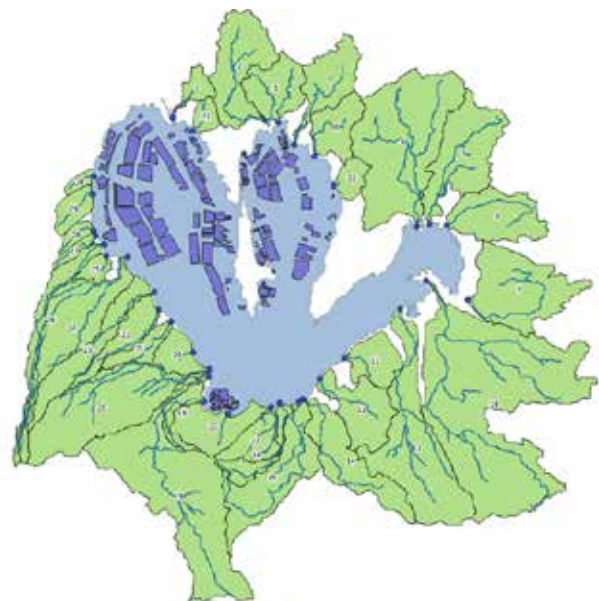
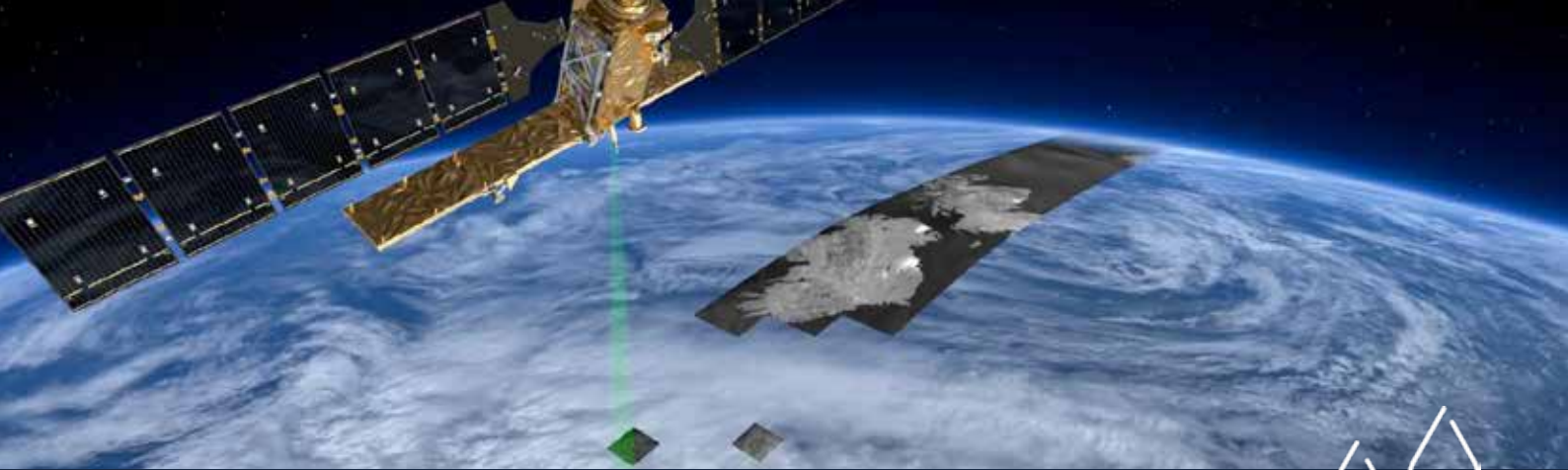


Figure 1: Delineated hydrological catchments in the Laguna de Bay basin. Catchments are numbered and shown in green. Laguna de Bay waterbody is shown in blue.



PROJECT METHODOLOGY

Rezatec used freely-available Earth Observation satellite imagery from the National Aerospace and Space Administration (NASA) and the European Space Agency (ESA) with proprietary machine learning algorithms to classify land use, land cover (LULC) types across the Laguna de Bay catchment. LULC datasets were produced for a baseline period (2016) and four time periods during 2016 and 2017.

Each LULC class was associated with an emission rate for the five pollutant species identified by Maynilad. These data were then integrated with spatial datasets of topography, soil parameters, climate variables, and stream flow meter data in

a hydrologic model to identify flow paths and estimate diffuse pollutant loadings to the lake. This model simulated the effects of land use activities on catchment hydrology and water quality.

To assess the impact of potential water management policies on reducing pollutant loading, all land use types were reduced by different specific percentages in the model, and results compared to 2016 and 2017 figures. These data were made available to the client in a data portal to enable visualisation, catchment prioritisation for remediation efforts and further data interrogation (see figure 2 for an illustrative example).



Figure 2: Illustrative example of data visualisation afforded by satellite imagery combined with the hydrological model of Laguna de Bay. The image reveals an analysis of the average volume of Total Dissolved Solids (TDS) as run-off during a 3-month period.



PROJECT RESULTS

Results reveal that both urban and agricultural land uses contribute significantly to elevated levels of pollutants and resulting poor water quality. However, pollutant concentrations are most sensitive to inputs from residential and urban areas, backing up investigations focusing solely on nitrogen concentrations using time-series water quality data and satellite imagery (Endo et al., 2016).

Though the density of urban areas is high to both the north-west and south-west of Manila, the catchments to the south-west are larger and indicate a more responsive hydrology. Targeting these areas for land management improvements, including septic tanks and sewerage infrastructure, is thus likely to result in the most significant benefits to pollutant loadings in Laguna de Bay.

The catchments show a similar sensitivity to pesticide application on agricultural land and areas of rice farming. Targeting these areas with enhanced pesticide regulation and monitoring, for example, may reduce more acute increases in pollutants following periods of application.

In conclusion, the model results indicate that further studies aiming to improve water quality by optimising land management should be focused on residential and urban areas to the south-west of Manila, and agricultural areas along the southern edge of Laguna de Bay.





DISCUSSION

The rich insights produced by EO satellite data analytics could be enhanced through on-ground activities measuring emissions using sensors in different areas where flows enter the lake. This would help calibrate the model for even deeper insights and more granular results, potentially helping to identify point sources (individual major polluters). Furthermore, a study assessing a full year (that would include June which is at the height of the rainy season and covers summer pesticide application), the underlying hydrogeology, and incorporating additional land use activity and pollutants would provide a more holistic understanding of pollutant impact in Laguna de Bay.

Yet despite these limitations, Earth Observation satellite data analytics have for the first time provided actionable data for water resource managers to home in on areas in which they can make land management improvements in the Laguna de Bay basin, and thereby improve water quality.

Given comparable challenges are faced throughout the Philippines, this study highlights the efficacy of satellite data analytics in modelling the effects of land use activity on hydrology and water quality, and offers a blueprint for planning and managing water resources throughout the region, making it easier for water resource managers to be

sure they are investing their limited time and budgets in activities that will have a genuine impact on water quality.

FIND OUT MORE

For more information, please contact us on **+44 (0)1865 817 500** or email **info@rezatec.com**

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