# Proceedings of the
# First conference of the
# IAHR Queensland
# Young Professional Network


## Griffith University,
## Gold Coast,
## 14 December 2021

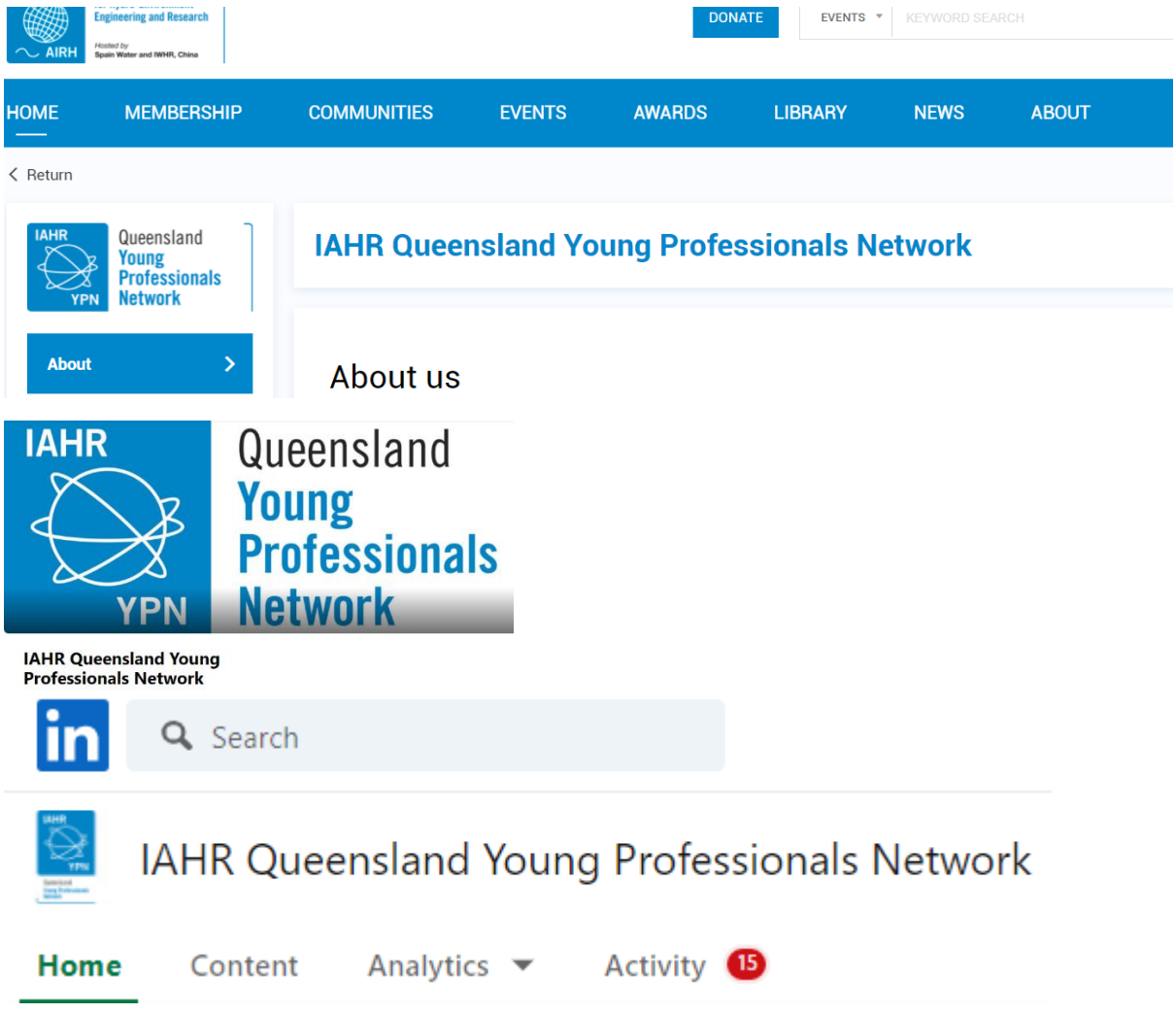
## Background: The IAHR QLD YPN

The IAHR Queensland YPN brings together students and young water professionals in the science and engineering fields and is supported by Griffith University's Cities Research Institute.

Our mission is to establish a vibrant community of young professionals driven by leading practices in the water sector. Our strategy is to share knowledge, research ideas and project opportunities, while also promoting young professionals' involvement in policy-making and strategic water research initiatives.

We also aim to build a shared vision between academia, industry, and government, enabling young researchers to better identify and understand the most pressing water problems in Queensland and Australia. We encourage an interdisciplinary approach to water-related projects that acknowledges and accounts for the complex interdependencies between water, energy, environment and climate systems, among others.

Our vision is to foster the next generation of water professionals in Queensland and to obtain the skills required to deal with, and find solutions for, the increased pressure on natural water resources that our society will face. We are on Facebook and LinkedIn.



## The Conference

The first IAHR Queensland Young Professional Network conference was organised as an opportunity for young researchers (such as PhD students in the early stages of their candidature) to present their research outputs and ideas to a network of like-minded academic and industry professionals, in a relaxed and constructive environment. It was also an opportunity to get to know and to join the group (conference registration costs were waived for members).

Presentations focusing on, but not limited to, the following field of research were encouraged:

- Water resources management
- Hydroinformatics
- Coastal and maritime hydraulics
- Climate change adaptation
- Water quality monitoring/modelling
- Water treatment
- Global water issues
- Groundwater modelling
- Hydraulic structures
- Fluvial hydraulics
- Ecohydraulics


An industry engagement session with guest speakers was also be part of the conference.

Members of the Australian Water Association (AWA) Queensland Young water professionals' group were also strongly encouraged to join the conference. Members (presenting or attending only) had registration costs waived too.

### Organising committee

- Dr Edoardo Bertone, President, IAHR QLD YPN, e.bertone@griffith.edu.au
- Martin Luna Juncal, Secretary, IAHR QLD YPN
- Benny Rousso, Vice President, IAHR QLD YPN
- Diane Mc Donald, Executive Assistant, Cities Research Institute, Griffith University

## Senior Water Professionals: Guest Speakers

Prof. David Hamilton - Deputy Director, Australian Rivers Institute, Griffith University

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Prof. Qin Li - School of Engineering and Built Environment - Civil and Environmental Engineering, Griffith University

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# Conference Program

| *Time* | **Presenter** | **Title** |
|---|---|---|
| *8:30* | **Registration and breakfast** | |
| *8:50* | **Welcome and introduction to the conference** | |
| *9:00* | Subaru Ken Muroi | Optimizing Submerged Breakwaters for Coastal Protection |
| *9:15* | Ali Koosheh | Empirical formulae for the prediction of mean wave overtopping at rubble mound structures |
| *9:30* | Despina Linaraki | The design concept of Living Islands |
| *9:45* | Jingwei Yao | Comparison of Darcy's law and Brinkman equation on saltwater intrusion simulations |
| *10:00* | Dima Al Atawneh | Interactions between groundwater recharge and usage in light of climate change: Study sites Southeast South Australia and Dead Sea Basin, Jordan |
| *10:15* | Chao Deng | Effect of climate change and dynamic vegetation and soil conditions on streamflow and water quality of a sub-tropical catchment in Queensland, Australia |
| *10:30* | Dhanushki Perera | Integrated coupled human and natural system complexity management for Climate Change |
| *10:45* | **Morning tea** | |
| *11:00* | Prof. David Hamilton<br>Prof. Qin Li<br>A/Prof Hassan Karampour<br>Dr Abel Silva Vieira<br>Dr Fernando Alvarez<br>Dr. Oz Sahin<br>Dr Juliane Wolf | Senior water professionals' presentations |

| | | |
|---|---|---|
| *12:15* | **Lunch** | |
| *13:00* | Hiua Darei | Raw water DOC data for alum dosing control |
| *13:15* | Ioana Corina Giurgiu | Planning tool for equitable urban design in areas adjacent to wetland ecosystems |
| *13:30* | Shenbagameenal Surendran | How Alternative Water Can Improve Urban Water Security? |
| *13:45* | Glauber Cardoso de Oliveira | Parsimonious mathematical optimisation modelling for integrated precinct-scale energy–water system planning |
| *14:00* | Shahid Ali | Potential Sites Screening for the development of Pumped Hydro Energy Storage in the Northern Queensland: A GIS Approach |
| *14:15* | Md. Atiqul Islam | Developing Intensity-Frequency-Duration Curves From Satellite Precipitation Products |
| *14:30* | **Afternoon tea** | |
| *14:45* | Mohammad Hassan Ranjbar | Individual-based modelling of Microcystis aeruginosa bloom dynamics in a shallow lake |
| *15:00* | Benny Rousso | Real-time cyanobacteria species monitoring: fluorescence enhancement using machine learning |
| *15:15* | Kane L. Offenbaume | Multi-Wavelength Specific Monitoring for E. coli and Enterococci in Waters, Using Fluorescence Sensors: Methods and Results |
| *15:30* | Jordan Luther McGrath | Excess Phosphorous and Nitrogen in the Great Barrier Reef: A Conceptual Model Mapping Fertiliser (Nutrient) Runoff Effects on Key Reef Flora/Fauna |
| *15:45* | Martin J. Luna Juncal | Application of High-Frequency, Real-Time Data for a Fertiliser Management Decision-Support System |
| *16:00* | Mackenzie K. Trenerry | Influence of Suspended Sediments Particle Size on Nitrate Readings from Real-Time Optical Sensors |
| *16:15* | **Closure** | |

# List of Abstracts

*In order of presentation time*

# Optimizing Submerged Breakwaters for Coastal Protection

**Subaru Ken Muroi** [a, b, c] **Edoardo Bertone** [a, c, d] **Nick Cartwright** [a, b] **Fernando Alvarez** [e]

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**Abstract:**

The understanding of how coastlines will be influenced by climate change uncertainty is critical in planning infrastructure and economic development in coastal zones. Offshore breakwaters that emerge above the waters are an effective and well-understood means of blocking waves, suitable for harbors and vital for coastlines that are vulnerable to large wave forces (Van Rijn, 2011). However, for natural sandy coastlines with beaches and dune systems that can absorb waves, having an object that emerges from the water is both unsightly and costly, and may have adverse consequences through its influence on the natural current, sediment transport, and ecological system that the structure is placed in (Sharif-Ahmadian, 2015). Therefore, a submerged breakwater is an appealing structure inspired by natural reefs that could be used as a coastal protection structure, while still enjoying natural waves and unimpeded views of the ocean. However, implementation hinges on the understanding of submerged breakwaters' complex interactions with dynamic coastal forces and how patterns of accretion and erosion lead to shoreline response.

The current study proposes a methodology in understanding shoreline response to submerged breakwaters by testing multiple environmental parameters in combination with structural design parameters in a numerical computer simulation. As this would create a complex multidimensional data set, a data-driven approach will be used to analyze the results, seeking patterns, and determining the parameters that are most influential when considering submerged breakwater designs. Currently, the study is determining an effective model for simulating the shoreline response through DHI's MIKE21/3. The program is capable of simulating radiation stress to determine shoreline change through an n-line model that takes into consideration the depth-averaged current field and morphodynamic change. Stable models have been produced with efficient runtime and resolution, that produces the expected shoreline response to multi-variate parameters.

Further testing is required to ensure the model is stable and robust for the necessary range in parameter values, and a data-driven framework will be developed as results produce an array of shoreline response to parameters.

**REFERENCES**

Sharif-Ahmadian, A. (2015). *Numerical models for submerged breakwaters: coastal hydrodynamics and Morphodynamics.* Butterworth-Heineman.

Van Rijn, L. (2011). "Coastal erosion and control" *Ocean & Coastal Management* **54**(12): 867-887

***Keywords:*** *Submerged Breakwater, Multi-Purpose Artificial Reef, Numerical Modelling, Coastal Engineering*

# Empirical formulae for the prediction of mean wave overtopping at rubble mound structures

**Ali Koosheh** [a], **A. Etemad-Shahidi** [a], **N. Cartwright** [a], **R. Tomlinson** [b], **M.R.A. van Gent** [c]

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**Abstract:**

Coastal rubble mound structures (e. g. seawalls, breakwaters) are generally constructed to protect harbours and shorelines against wave attack and flooding. For a safe design of coastal structures, the mean wave overtopping rate ($q$), as the main hydraulic response of the structure needs to be limited (EurOtop, 2018). To estimate the mean overtopping rate, several empirical formulae have been derived which correlate mean wave overtopping rate to predominate dimensionless wave and structural parameters. Large prediction errors of the mean overtopping rate at rubble mound structures using existing empirical formulae have been reported by Koosheh et al. (2020) where most of the empirical formulae significantly underestimate $q$ with more than a factor 10.

The present study attempts to improve the empirical formulae for the prediction of mean overtopping rates at rubble mound seawalls. For this purpose, 140 small-scale physical model tests on two-layer rubble mound seawalls were conducted to extend the limited existing data and fill its gaps in terms of key influential parameters. The limitations and weaknesses of the EurOtop (2018) formula, as the most recent one, were identified. Then, using regression analysis and physical justifications an improved formula, based on newly collected data and existing ones in the literature, was derived. As given in Table 1, the newly proposed formula, by adding the effect of wave steepness ($s_{m-1,0}$), improves the prediction accuracy by 36% (*RMSE*) in comparison to EurOtop (2018) formula for rubble mound seawalls. Although the proposed formula has only been developed based on rubble mound seawalls with an impermeable core, it outperforms EurOtop (2018) formula also when applied to breakwaters, which are permeable structures.

Table 1: Comparison of the prediction performances of EurOtop (2018) vs newly proposed formula

| Formula | Equation ($q$*: dimensionless mean overtopping rate) | Rubble mound seawall | | Rubble mound breakwater | |
|---|---|---|---|---|---|
| | | *BIAS* | *RMSE* | *BIAS* | *RMSE* |
| EurOtop (2018) | $q* = 0.09 \cdot \exp[-(1.5 \frac{R_c}{H_{m0} \cdot \gamma_f \cdot \gamma_\beta})^{1.3}]$ | -0.38 | 0.86 | -0.3 | 1.3 |
| Present study | $q^* = 0.013 \exp[-2.69(\frac{R_c}{H_{m0} \cdot \gamma_f})^{1.4}(s_{m-1,0})^{0.32}]$ | 0.00 | 0.55 | 0.21 | 0.87 |

**REFERENCES**

EurOtop, 2018. van der Meer, J.W., Allsop, N.W.H., Bruce, T., De Rouck, J., Kortenhaus, A., Pullen, T., Schüttrumpf, H., Troch, P., Zanuttigh (Eds.), B. Manual on wave overtopping of sea defences and related structures.

Koosheh, A., Etemad-Shahidi, A., Cartwright, N., Tomlinson, R., Hosseinzadeh, S., 2020. The comparison of empirical formulae for the prediction of mean wave overtopping rate at armored sloped structures. Coast. Eng. Proc. 22.

***Keywords:*** *Wave overtopping; Coastal structures; Rubble mound seawalls, breakwaters*

# The design concept of Living Islands

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**Abstract:**

This PhD research explores architectural design concepts for the growth of coral islands. These islands experience many challenges due to their limited land availability and low elevation height, making them susceptible to climate change impacts and anthropogenic pressures. As a result, researchers argue that by 2050 most of these islands will be uninhabitable, and some will be lost entirely (Oppenheimer, 2019), leading to degradation of the ecosystem and mandatory relocation of thousands of people.

Although the numerous challenges, these islands are engineering examples of sustainable ecosystems that can self-grow, self-maintain and self-adapt to environmental changes. They are made of sediments produced by living organisms such as corals, foraminifera, algae and molluscs. Moreover, the living organisms that have formed them protect them from extreme environmental conditions and produce sediments for their growth and maintenance.

This research explores how coral islands grow and adapt to environmental changes to enhance the natural growth processes and increase the available land. At the same time, the aim is to create design concepts where the environment, corals and people can coexist sustainably.

The architectural design concepts are based on the formation of "*Living Islands*". Living organisms are incorporated in the design as a fundamental element of the structure. The architectural design of the structure and the chosen materials create preferable conditions for specific species growth. Living organisms attach and grow like a coating on top of the primary structure, providing in this way extra stability and durability. Also, they increase sediment production and local biodiversity. This research explores architectural design concepts for the growth of living organisms while it creates an optimized design that would use the minimum material resources, interferes less with the environment and at the same time achieve the maximum structural performance.

**REFERENCES**

Oppenheimer, M., B.C. Glavovic , J. Hinkel, R. van de Wal, A.K. Magnan, A. Abd-Elgawad, R. Cai, M. Cifuentes-Jara, R.M. DeConto, T. Ghosh, J. Hay, F. Isla, B. Marzeion, B. Meyssignac, and Z. Sebesvari. (2019). *Sea Level Rise and Implications for Low-Lying Islands, Coasts and Communities. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate*.

***Keywords:*** *Living Architecture, Living Islands, Coral Islands, Sustainability*

# Comparison of Darcy's law and Brinkman equation on saltwater intrusion simulations

**Jingwei Yao** [a], **Hong Zhang** [a]

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**Abstract:**

Coastal areas have been widely threatened by the global expansion of seawater intrusion with the anthropogenic activities and climate change. A thorough understanding and accurate prediction of the process is required for a sustainable management of the fresh groundwater resources. The exchange between inland groundwater and the ocean has been investigated over the last six decades and achievements have been made to optimise the accuracy of numerical solutions. But most recently, the limitations of traditional hydrodynamic models appear especially for transition flows in the vicinity of surface water bodies.

Classical seawater intrusion models apply Darcy's law as the governing equation, which describes the linear relationship between the pressure gradient and groundwater flux. Darcy's law neglects the viscous force acting on a moving fluid considering the porous media constrains the flow velocity. It makes Darcy' law valid for slow-moving groundwater, practically with Reynolds number smaller than one. Brinkman (1949) extended the traditional Darcy's law which included a viscosity term to account for the dissipation of the kinetic energy by viscous stress. For seawater intrusion problems, it is necessary to discover under what conditions Darcy's law is invalid and Brinkman equation can produce more accurate results.

In this study, numerical simulations of saltwater intrusion were conducted with COMSOL Multiphysics, which can solve for groundwater flow and dispersive solute transport by mass and momentum conservations. Models using Darcy' law and Brinkman equation were both tested. The numerical model simulated a vertical section of the coastal aquifer with one side exposed to a tidally affected saltwater body. The hydraulic head and density difference drive the salt entering the aquifer from seaside.

Simulation results indicate that outcomes from the two models highly respond to each other. However, discrepancy increase with the increase of Reynolds number. The effect of viscous shear intensifies with Reynolds number. Thus, Darcy's law tends to overestimate the flow velocity. The main difference appears at the saltwater-freshwater interface. Noted that this accuracy is compensated by longer computational time. In seawater intrusion studies, Brinkman equation can provide a more accurate description of the saltwater-freshwater interface dynamics especially in high permeability areas including the transition areas close to surface water bodies and pumping wells, which facilitates a better freshwater resources and salt management in coastal zones.

**REFERENCES**

Brinkman, H.C., 1949. A calculation of the viscous force exerted by a flowing fluid on a dense swarm of particles. Appl. Sci. Res. 1. https://doi.org/10.1007/BF02120313.

***Keywords:*** *Darcy's law, Brinkman equation, seawater intrusion, numerical simulation*

# Interactions between groundwater recharge and usage in light of climate change: Study sites Southeast South Australia and Dead Sea Basin, Jordan

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**Abstract:**

Groundwater recharge (GWR) is an integral part of sustaining the hydrological balance of groundwater aquifers. It has been confirmed that global warming is happening as evidenced by the rise in global average air and ocean temperatures, snow and ice melting, and occurrence of extreme events (Moeck et al., 2020). There is a global consensus that groundwater resources, in particular, recharge are negatively affected by climate change and socio-economic factors in terms of quantity and quality. Therefore, climate change impacts on the dynamic interaction between GWR and usage are of particular concern for dry to semi dry areas. Improved understanding of the dynamics can inform better groundwater management in such areas. The proposed study aims to model the future interactions between climate variability, GWR and groundwater usage at regional level, in two sites; State of South Australia (SA) and Dead Sea Basin (DSB), Jordan.

We anticipate this will deliver predictive methods for analysing groundwater dynamics resulting from climate change that can be used to inform adaptation and mitigation measures. Preliminary research findings (review paper) revealed an expected decrease in GWR in most regions, i.e. North Africa, Southern Europe, and Latin America regions. Other regions such Oceania, North America, Europe, and Asia had varying results based on emission scenario and season (Al Atawneh et al., 2021). MODFLOW model linked to FloPy resources (Python environment) was chosen to model GWR and then calculate the safe yield. Further, machine learning and Bayesian Network will be utilised to run different GWR prediction simulation scenarios, along with sensitivity analysis to indicate which factor most influences GWR in the future.

**REFERENCES**

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Moeck, C., Grech-Cumbo, N., Podgorski, J., Bretzler, A., Gurdak, J. J., Berg, M., & Schirmer, M.,2020. A global-scale dataset of direct natural groundwater recharge rates: A review of variables, processes and relationships. Science of The Total Environment, 717, 137042.

***Keywords:*** *Climate Change, Groundwater recharge, South Australia, Dead Sea Basin*

# Effect of climate change and dynamic vegetation and soil conditions on streamflow and water quality of a sub-tropical catchment in Queensland, Australia

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**Abstract:**

Changing climate has been investigated to affect the vegetation cover and soil properties, but most of current hydrological studies incorporate the constant vegetation and soil database during the assessment of climate change and land cover change on hydrological processes and water resources. This study examines the prospective impacts of climate change on vegetation and soil, and the combined effects on hydrological processes and water quality using the Soil Water Assessment Tool (SWAT) for the Upper Nerang River catchment located at South-east Queensland, Australia. Leaf area index (LAI) and soil organic carbon (SOC) are projected for two future periods (2040 – 2069 ('2050s') and 2070 – 2099 ('2080s')) under two future medium-to-high emission scenarios (Representative Concentration Pathway (RCP) 4.5 and RCP8.5) following Tesemma et al (2014) and Sierra et al (2014), respectively. The result shows a decrease of 0.4% – 16.9% in LAI and of 5.9% – 11.6% in topsoil SOC, separately, pending on the future periods and emission scenarios. Climate change is likely to bring more extreme flows, especially for those with high return periods, in terms of the relative changes in magnitude. There is also expected with less streamflow (-3.5% to -11.2%), loads of suspended sediment (SS) (-4.7 to -28.4%), total nitrogen (TN) (-5.9% to -26.2%) and total phosphorous (TP) (-11.1% to -21.3%) under a high emission scenario of RCP8.5 from all future cases. Comparatively, changed LAI and SOC induced by climate change may have the potential to offset the impact of climate change on extreme streamflow, and yield more annual streamflow but lower sediment and nutrient loads than the climate change scenarios for each period and RCP case. The findings of this study indicate that incorporating such non-stationary features of climate-induced change in vegetation cover and soil carbon may benefit the overall assessment of impact from climate change on catchment streamflow and water quality, which can help the water resource managers and decision makers take actions to attenuate the effects of climate change on water resources.

**REFERENCES**

Sierra, C. A.; Müller, M.; Trumbore, S. E., 2014. Modeling radiocarbon dynamics in soils: SoilR version 1.1. Geosci. Model Dev. 7 (5), 1919–1931.

Tesemma, Zelalem K.; Wei, Yongping; Western, Andrew W.; Peel, Murray C., 2014. Leaf Area Index Variation for Crop, Pasture, and Tree in Response to Climatic Variation in the Goulburn–Broken Catchment, Australia. Journal of Hydrometeorology 15 (4), 1592–1606.

***Keywords:*** *climate change, leaf area index (LAI), soil organic carbon (SOC), SWAT*

# Integrated coupled human and natural system complexity management for Climate Change

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**Abstract:**

Coupled human and natural system (CHANS) represents dialectic coopetition among the human and nature subsystems that proved to be complex and involving numerous social, economic and cultural aspects. This interaction is prone to dynamic interrelations and linkages that involve high level of complexity stems from the coupled systems as well as the incorporated subsystems. The complexity within CHANS includes reciprocal effects, nonlinearity, uncertainties, and heterogeneity. Although most of the researchers realize the significance of understanding the nature of the coupling effect, yet the prevailing research emphasizes either human or natural systems separately, while considering the other as exogeneous, despite appreciating the reciprocal and complex interlinkages.

Developing anthropogenic activities leading to pervasive environmental repercussions continues to destabilize the long-standing ecological, social, and biogeochemical balances and leading to severe phenomena including the anthropogenic Climate Change (CC). In turn, these adverse impacts can severely influence the human reaction to the nature. CC continues to pose a significant risk to the natural ecosystem as well as the livelihood. CC has gained particular significance among researchers, public, governments and policy makers as well as other stakeholders due to the prevailing adverse impacts. An integrated interpretation of this dialectic human- nature nexus deemed necessary to the establishment of precise and equitable policies and regulations to deter these potential adverse impacts. CC is happening across various contexts and the translation of the CC knowledge into policies programs and strategies remains a profound challenge due to the many complex social and economic drivers.

The current research investigates the possible gathered Climate Change Social Perceptions (CCSP) and economic factors to highlight their relative influence using Expert Judgement approach. Recognised driver factors will then be assessed and quantified through sample data which consists of the knowledge of Subject Matter Experts (SME) who are able to prioritise these drivers and judge their relative significance. Although each of these drivers have unique perspectives and contribute to the understanding of the anthropogenic drivers of CC, yet they complement one another and contribute to integrated complex frameworks. The research will also address the spatial and temporal scale of these drivers and elaborate on the appropriate policy measures that can be enforced to lessen the complexity of the CHANS.

***Keywords:*** *complexity management, climate change, coupled human and natural system*

# Raw water *DOC* data for alum dosing control

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**Abstract:**

In this presentation, a model is described which was developed for determination of alum dosing for removal of dissolved organic carbon (*DOC*) in drinking water treatment.

Water samples (*n=72*) were collected from *16* different surface water sources. Seventeen samples (from 15 different sources) were used for jar tests and model development. The remaining samples from the same water sources were used for testing the model performance in a comparison study with a previously developed model by van Leeuwen et al. (2003). That model, named *mEnCo* is based on other parameters, *i.e. colour* and *UV* light absorbance at *254 nm* ($A_{254}$), and also with turbidity data.

The *DOC*, $A_{254}$, *colour* and *turbidity* data were acquired for the water samples and following treatment with alum in jar tests. From an understanding of the *DOC* removals behaving as an 'exponential decay' a *semi-empirical* model based on the removal behaviour of *DOC* is proposed here [The average $R^2$ (*adjusted*) value for the model fitted to the jar test data of the samples studied is $0.96 \pm 0.05$]. Enhanced coagulant doses (*EnD*), to maximize removal of organics) determined using the *DOC* model were compared to th*ose* obtained experimentally through jar testing and through the *mEnCo* software. The results show a comparable performance to the *mEnCo* software for the *DOC* model, based on the *EnD* data acquired through jar testing. The new *DOC* model also shows potential suitable capability for prediction of the *EnD* for waters with very high organic matter content as may occur under extreme climate conditions. A comparative study between the *DOC* model and *mEnCo* using testing samples demonstrated the comparative predictivity for these two models, which use different input data ($R^2=0.92$).

A software referred to as '*WTC-Coag*$^{plus}$' was developed using the *DOC* model with intent as an extended option to the *WTC-Coag* software (Chow et al., 2017). It is proposed that the *DOC* model, with the capability to provide a comparable performance for dose prediction using input signal from an online *DOC* analyser, has the potential for online feedforward coagulant control.

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van Leeuwen, J., Holmes, M., Heidenreich, C., Daly, R., Fisher, I., Kastl, G., Sathasivan, A., Bursill, D., 2003. Modelling the application of inorganic coagulants and pH control reagents for removal of organic matter from drinking waters, Proc. Modsim. Citeseer, pp. 1835-1840.

***Keywords:*** *Drinking water treatment, Coagulation process, DOC model, Coagulant dosing control*

# Planning tool for equitable urban design in areas adjacent to wetland ecosystems

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**Abstract:**

As integrated urban landscapes, wetlands provide numerous vital ecosystem services such as wastewater treatment, coastal erosion protection or flood protection. However, the full range of services and potentials associated with urban wetlands is often underrepresented (McInnes, 2013).

While, at a large (national/regional) scale, there is an intense focus on the conservation of existing wetlands, strategies which balance interests at the small scale of individual stakeholders are less developed. Albeit their numerous ecological functions, urban growth represents a tangible threat to the preservation of these endemic ecosystems and the associated ecosystem services they provide. As cities expand, wetland areas outside of designated natural conservation zones are commonly reclaimed for urban development (Davidson, 2014), to maximize short-term profits for landowners.

As part of ongoing PhD research focusing on hybrid urban-wetland design, an interactive planning and design tool was developed. The tool focuses on small-scale development and aims to provide a method for managing complexity and interdependencies in the early conceptual phases of a project.

The interface provides a holistic understanding of the implications of design decisions such as use of wetlands for water treatment, energy and water efficiency, assessing two main criteria: cost/benefit ratio and "fair share" ratio (ratio describing resource allocation).

The potential applications of the tool could range from influencing planning policy to influencing small scale developer decisions.

Initial modelling revealed that a high number of urban functions are or can be supported via the expansion of wetland areas.

Further testing and development are required to provide recommendations and conclusions in relation to the proposed assessment criteria.

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***Keywords:*** *system thinking applications, water resources management, interactive planning tool*

# How Alternative Water Can Improve Urban Water Security?

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**Abstract:**

Water scarcity is one of the biggest threats and a widely recognised problem among the global community. Its multi-faceted nature, coupled with more significant uncertainty, makes it a wicked problem of this century. Despite water insecurity being familiar to most parts of the world, urban areas can be hard-hit due to urbanisation and population growth. This work focuses on urban water security in Australia, the driest inhabited country with more than 90 percent of the urban population and is expected to have significant population growth. Despite the growing evidence of the need for IUWM (Integrated Urban Water Management), a substantial percentage of climate change mitigation strategies focus only on extensive engineering infrastructures such as dams, desalination and inter-basin transfers. The majority of research studies still appear to overlook the role of a diversified/alternative/portfolio approach to urban water security. This study focuses on the contribution of rainwater tanks to urban water security at a precinct level.

This study focuses on a brownfield precinct in Knutsford, Fremantle in Perth, to assess the contribution of rainwater tanks. The rationale for this choice is, Perth is one of the capital cities with very low rainfall and distinctively dry summer. It is also selected because it is the state with the lowest rainwater uptake among Melbourne, Brisbane, Sydney and Adelaide. Moreover, to address the effects of urbanisation and limit the sprawl of cities, infill targets are set by most capital cities to utilise under-utilised parcels of land. Hence this study selected an infill precinct to assess the contribution of rainwater tanks. The study uses Aquacycle (Mitchell, Mein, & McMahon, 2001), an urban mass balance method to model the behaviour of rainwater tanks using historic rainfall and evapotranspiration for the past 15 years. Three rainwater tank connection options were modelled (i) indoor (toilet and laundry), (ii) outdoor and (iii) combined (both) for a range of tank size from 1 kL to 10 kL.

The three most common indicators to assess rainwater tank performance are volumetric reliability, yield (rainwater volume used) and self-sufficiency are used in this assessment. Volumetric reliability of the indoor connection ranges from 65 – 99%, outdoor is 7 – 23%, and combined is 16 – 27%. Yield of the rainwater of indoor, outdoor and combined are at the range of 1150 – 1760 kL/yr, 400 – 1400 kL/yr, and 1100 – 2000 kL/yr, respectively. There can be an avoided imported water volume of 8 – 40 kL/hh/y based on the connection and tank size. If we assume all individual dwellings in Perth adopts a 3 kL rainwater tanks similar to the Knutsford precinct; there can be an avoided imported water volume of 7 GL/year which is equivalent to 3% of the Perth's scheme urban water use. This study shows even a low-cost alternative water source such as a rainwater tank can contribute to overall urban water security. Hence it is eminent to include alternative water sources in UWS assessment to support evidence-based policy-making.

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***Keywords:*** *Rainwater tanks, infill development, water-sensitive development and urban water security.*

# Parsimonious mathematical optimisation modelling for integrated precinct-scale energy–water system planning

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**Abstract:**

In local water system networks, the power system operation denotes a substantial share of the total costs. Water pumping is energy-intensive due to its high power consumption. Consequently, a fundamental link between energy and water is established for optimising operational costs of water distribution, especially at local sites such as urban precincts. In fact, modelling local energy–water distribution networks seems critical towards sustainable, cost-effective, and reliable urban integrated precinct-scale energy–water system planning and engineering design. From the scientific paradigm of physics-informed data-driven optimisation modelling, this study attempts to generalise integrated energy–water system plans in real applications. To support decision-making under uncertainty, a parsimonious mathematical optimisation model was developed for enabling optimal energy-water system integration at precinct scale. Aiming at the simplest possible principled way, spatiotemporal energy–water interactions were captured for attaining desirable conflicting technoeconomic/environmental objectives subject to hard coupling nodal/operational constraints.
Envisioning a decentralised community microgrid to augment operational flexibility across controllable infrastructure assets, the local energy–water distribution network was modelled surrounding the built environment among candidate and built facility locations. In this engineering domain, a robust deterministic optimisation problem was formulated tackling critical energy-water system sizing/scheduling tasks over the planning horizon [Cardoso de Oliveira, 2021]. Formally, weighting scalar convex quadratic objective functions minimise: (1) power consumption and load volatility; (2) nodal/operational energy–water system and electricity costs including long/short-term capital/managerial investment expenditures; as well as (3) carbon emissions and water wastage. Given the inherent energy–water demand/supply uncertainties, representable random perturbation sets were parameterised by random incorporating partially known distributional information.
To proceed computational experiments, demonstration cases are considered in prospective energy–water demand/supply scenarios. Different generation/storage technologies can be selected according to local site-specific requirements. To meet resource-related end uses, polygeneration schemes are dynamically simulated in realistic conditions for powered heating, cooling, and pumping services. Numerical results demonstrate the model applicability in finding Pareto-efficient feasible solutions that reduce variable loads, system costs, and carbon emissions for renewable energy penetration and nonpotable water exploitation in urban-precinct infrastructure developments.

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***Keywords:*** *Precinct-scale, energy-water nexus, system integration, optimisation modelling.*

# Potential Sites Screening for the development of Pumped Hydro Energy Storage in the Northern Queensland: A GIS Approach

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**Abstract:**

Pumped hydro energy storage (PHES) provides the largest and most mature form of energy storage compared the energy storage technologies currently on market. Nevertheless, the primary challenge for their development is site selection, as their decision depends on various techno-environmental and socio-economic factors. This study is an extension of an ongoing research project and proposes a Geographic Information System (GIS) based method to do the initial screening of areas in the Northern Queensland for the development of PHES. To this aim, technical, environmental, and economic factors were derived from the first part of the research project, that covered the drivers and barriers to the deployment of PHES applications – and has been published. The principal factors taken into the consideration for the site searching were topography (i.e., slope and elevation), landcover and land use, infrastructure (i.e., roads and high voltage power lines), and water resources. The data required during this research were collected from publicly available sources and the analysis was conducted in ArcGIS 10.3.0. The results show that out of the total area (659,910 sq km) of the Northern Queensland (includes North Queensland, North West Queensland, and North Queensland) only 768.43 sq km was suitable. Out of this total suitable area, 557.54 sq km was classified as highly suitable, and the remainder (210.89 Sq km) were classified as suitable area (see ***Figure 1***). It is noted that the method developed in this study can be applied in other locations.

***Keywords:*** *Geographic information system; Energy storage; Pumped hydro energy storage.*

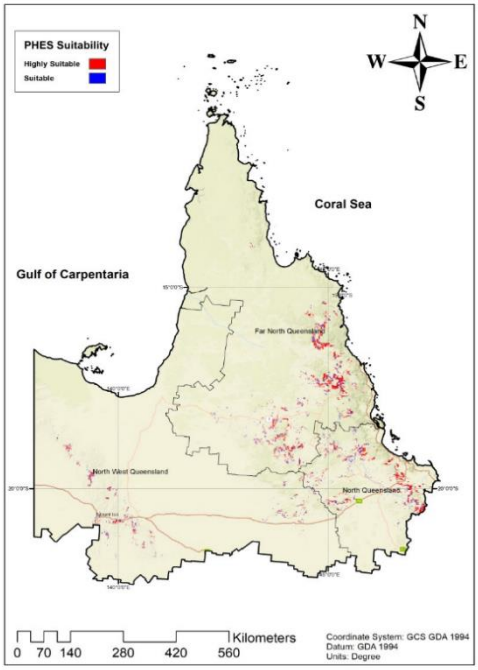


**Figure 1**. Potential area for the development of PHES sites in the Northern Queensland.

# Developing Intensity-Frequency-Duration Curves From Satellite Precipitation Products

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**Abstract:**

Intensity-frequency-duration (IFD) curves are widely used in the design of hydrologic, hydraulic, and water resources systems. IFD curves link duration, intensity, and frequency of occurrence of storm events. As IFD curves are derived through frequency analysis of annual maximum rainfall data, the accuracy and reliability of the curves depend on the length and temporal resolution of historical rainfall record.

Traditionally, rain gauge records are used to estimate IFD curves at the gauge locations. Although the record of daily data is longer, observations at sub-hourly timescales are sparse and limited in length or even unavailable in many parts of the world. In such a situation, satellite-derived precipitation products (SPPs) with quasi-global coverage and finer spatiotemporal resolution can be utilized to develop IFD curves.

Recently, an innovative framework was developed to integrate long-term daily gauge data and sub-hourly SPPs to generate IFD curves at sub-hourly timescales (Islam, Yu, and Cartwright 2021). The proposed framework was called the satellite-derived IFD curves (SIFD). IMERG, Integrated Multi-satelliE Retrievals as part of Global Precipitation Measurement (GPM) mission was selected to provide sub-hourly rainfall statistics. Within the framework, a stochastic precipitation generator, namely the Bartlett-Lewis Rectangular Pulse (BLRP) model was calibrated using IMERG to disaggregate daily gauge data.

The current study extends the first study (i.e. Islam, Yu, and Cartwright 2021) by replacing the single parameter exponential distribution of cell intensity with two parameters Gamma distribution to examine the potential improvement of the SIFD framework. Further, the third order moment of precipitation depths was also included in the model fitting. This study was carried out at a single site in Darwin. With respect to Bureau of Meteorology (BoM) IFD curves, the SIFD framework performs reasonably well with BR of 0.86, RMSE of 16.2 mm/h, $R^2$ of 0.90, and NSE of 0.80. However, the results showed that the Gamma distribution of cell intensity and inclusion of skewness in the model fitting did not improve the performance of the SIFD framework to estimate the IFD curves.

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***Keywords:*** *Intensity-frequency-duration curves, Bartlett-Lewis Rectangular Pulse model, GPM, IMERG*

# Individual-based modelling of *Microcystis aeruginosa* bloom dynamics in a shallow lake

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**Abstract:**

*Microcystis aeruginosa* is a species of cyanobacteria that can produce toxins (e.g., Vasconcelos et al., 1993) and adversely impacts water quality, human and animal health (e.g., Codd et al., 1999). In this study an individual-based model (IBM) was developed to simulate *Microcystis aeruginosa* bloom dynamics in a shallow lake. Key physical and physiological processes controlling the growth and size of *Microcystis aeruginosa* colonies were incorporated into the IBM which included a coupled 3D hydrodynamic model. Hydrodynamic modelling was performed by considering wind stress, heat exchange with the atmosphere, bottom friction, inflows, and net precipitation. The model was applied to Forest Lake in South-East Queensland, Australia, in summer of 2020. During this period, cell counts of *Microcystis aeruginosa* exceeded $3\times10^5$ cells $mL^{-1}$. Model results were compared with high frequency in situ observations. The lake model successfully reproduced the measured water temperature and current speed, and the IBM captured the observed *Microcystis* bloom dynamics under different environmental conditions.

Model results showed that when the lake was mixed, the percentage of small-size colonies was very high as a result of colony disaggregation; whereas the development of strong stratification suppressed vertical mixing and increased the percentage of large-size colonies. The simulations supported the hypothesis that aggregation of colonies at low turbulence is important for *Microcystis* bloom development because it supports colony aggregation that leads to the formation of larger colonies with a higher floating velocity that can dis-entrain from turbulent mixing and accumulate at the surface. Capturing variations in colony size is shown to yield a more accurate forecast of cyanobacterial bloom development and should be included in modelling dynamics of colony-forming cyanobacteria.

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***Keywords:*** *Agent-based modelling, Cyanobacteria, Individual-based modelling, Lake modelling*

# Real-time cyanobacteria species monitoring: fluorescence enhancement using machine learning

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**Abstract:**

Cyanobacteria are diverse group of microorganisms that can rapidly grow and dominate the phytoplankton community in events known as Cyanobacteria harmful blooms (CyanoHABs). Successful CyanoHAB management must take into account, among other factors, cyanobacteria dynamics and species-specific traits. The rapid succession of cyanobacteria requires continuous and high-frequency monitoring of susceptible waterbodies, which is currently tackled by deploying sensors based on the fluorescence of phycocyanin (f-PC). However, f-PC cannot determine the dominant cyanobacteria species. Determining the dominant cyanobacteria species is important because the effectiveness and choice of CyanoHAB mitigation and response strategies depend on the dominant species. Cyanobacteria species also respond differently to variable environmental conditions (e.g., nutrients availability, water column conditions), which can be used to predict species dominance. This research focused on developing an integrated model able to support real-time cyanobacteria species-specific management. The developed model integrated f-PC sensors calibration, and cyanobacteria species dominance prediction. Laboratory experiments were performed to test and quantify interferences on f-PC according to diel light variability and species composition (Rousso et al. 2021a, Rousso et al., 2021b). At the same time, a data analysis (Rousso et al., 2021c) followed by machine learning applications to predict the dominant cyanobacteria species in an Australian drinking reservoir based on routine water quality monitoring was performed. The integrated model was able to determine, quantify and compensate for the dominant cyanobacteria species, increasing the accuracy and meta information (i.e., species taxa) from raw f-PC sensors data. A comprehensive framework to support the development of similar models to other locations was developed, highlighting data number and quality as crucial factors for it success.

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Rousso, B. Z., Bertone, E., Stewart, R.A, Hughes, S. P., Hobson, P., & Hamilton, D. P. (2021c). Environmental drivers of cyanobacteria species dominance, diversity and bloom-formation in three Australian reservoirs. *Hydrobiologia* (submitted September 2021).

***Keywords:*** *Blue-green algae, fluorescence sensors, water quality monitoring, water resources management.*

# Multi-Wavelength Specific Monitoring for E. coli and Enterococci in Waters, Using Fluorescence Sensors: Methods and Results

**Kane L. Offenbaume** [a,b,c], **Edoardo Bertone** [a,b] **and Rodney A. Stewart** [a,b]

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**Abstract:**

The use of fluorescence sensors to monitor *E. coli* and enterococci could provide rapid and non-invasive quantification in situ if appropriate calibration is performed. By taking advantage of the fluorescence properties of certain substances, fluorescence sensors can provide a near-instantaneous quantification of several critical water-quality parameters. This research examines correlations between wavelength-specific fluorescence signals and the amount of Faecal Indicator Bacteria (FIB) in water samples. The laboratory experiments quantify *E. coli* and enterococci fluorescence and discover how an indole pulse within culture broths with *E. coli* can be implemented into a unique three component *E. coli* or enterococci recognition system. This is evidenced in the Excitation Emission Matrices (EEMs) signatures for *E. coli* and enterococci cell pellet alone, likely a result of biochemical reactions within cells and their external environment. Then, examines how the signature for *E. coli* seen in EEMs is affected by different carbon sources and Tryptophan additional to minimal broths specific for *E. coli*; and Indole remains in the broth after pulse (Gaimster and Summers, 2015).

Absorbance measurements estimate the time stamped concentrations for the bacterial curve of *E. coli* which are displayed against the EEMs. The Tryptophan content and the indole content is assay calculated throughout the typical bacterial phase of *E. coli* in (1) *E. coli* specific minimal media M9 broth alone, then (2) with the addition of Tryptophan and (3) in Nutrient Broth No. 2 a typical culture media; and all is presented against EEMs over time. Promising results show unique peak Excitation-Emission combinations in EEMs for *E. coli* and enterococci cell pellet, in Nutrient Broth No.2 and in Minimal Media M9; unique EEMs for Indole pulses and Tryptophan at known concentrations. When laboratory work is concluded, it is expected that results would provide an opportunity for the development of real-time *E. coli* and enterococci monitoring tools which combine reagent less fluorescence sensors targeting the three component FIB-related wavelengths, with compensation algorithms to improve their robustness.

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***Keywords:*** *E. coli; enterococci; water quality monitoring; fluorescence spectroscopy*

# Excess Phosphorous and Nitrogen in the Great Barrier Reef: A Conceptual Model Mapping Fertiliser (Nutrient) Runoff Effects on Key Reef Flora/Fauna

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**Abstract:**

Excessive nutrient runoff from agricultural practices in the Australian Great Barrier Reef (GBR) is understood to have major disruptive effects on the ecosystem biodiversity. The nutrient excess must be therefore contained through effective management and protection plans to reduce further ecosystem damage. To inform these plans however, progress must be made towards modelling the relationship between these nutrients and the ecosystem health in an effort to inspire proactivity. Populating this model with numerical data allows simulated outcomes to be predicted, informing pre-emptive mitigation methods to prevent dire outcomes, as opposed to monitoring only which relies on delayed adaptation tactics.

Fertiliser use is a prominent source of surplus nutrients. Past research has considered fertiliser use as a part of a larger model consisting of many anthropologic and weather-based influences. This project aims to be more specific regarding the influence of fertiliser, primarily the common phosphorus and nitrogen types, on key flora/fauna of the GBR ecosystem food web. The food web is a crucial part of the complex relationships in the ecosystem and therefore modelling the key species will be essential to predicting risks and protecting them to avoid ecosystem destabilisation and collapse as a result of population decline or eradication.

The initial conceptual model will be developed following extensive review of relevant academic literature. Further model elaboration/editing will occur as experts are approached to provide insight on the drafted model. In addition, a Bayesian Network approach will be explored as an option for producing a numerical model, where the probabilities of the mapped relationships are planned to be derived from collected data and expert opinion.

The final model is expected to generate new knowledge on the impact of phosphorous/nitrogen on these key species and will inform stakeholders and policy makers through simulated outcomes. The advisement given to these key decision makers will be essential to proactively protect key species of the GBR food web to ensure the reef's stability. This study method can be further developed and varied to accommodate other areas of specific interest, such as pesticides and sediments.

***Keywords:*** *Agricultural Fertiliser, Nitrogen/Phosphorous Runoff, Biodiversity, Great Barrier Reef*

# Application of High-Frequency, Real-Time Data for a Fertiliser Management Decision-Support System

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**Abstract:**

A mobile monitoring station was developed to remotely measure an array of water quality parameters, including nitrate, turbidity, pH, temperature and salinity, in real-time and at high frequencies (thirty minutes). Nitrate plays a significant role for crop growth; however, elevated levels in waterways have been shown to cause eutrophication and subsequently, lower water quality, leading to fish kill events and the overall degradation of water systems, as evidenced in the Great Barrier Reef (GBR).Given that substantial changes in water quality can occur in short time-periods, typical monitoring and analysis methods (such as grab samples) do not provide timely data to decision-makers, hindering the ability to act promptly to improve waterways. Despite the advent of new high-frequency optical nitrates sensors, scepticism towards their reliability has prevented their wide-spread implementation, making it difficult to manage areas that are particularly prone to considerable variations in nutrient levels.

In this study, the authors have identified several key findings that oppose this view and justify the necessity of real-time monitoring. Firstly, a remote optical (UV-VIS) sensor (known as NiCaVis 705 IQ) was compared to a laboratory spectrophotometer to measure the accuracy of both instruments in measuring nitrate concentrations, particularly when affected by interferences such as turbidity, pH, temperature, salinity, organic matter and like-wavelength substances. In doing so, NiCaVis was found to be mostly unimpeded by interference sources; a data-driven compensation model was developed to account for turbidity and further improve accuracy. NiCaVis was capable of providing measurements within 0.1mg/L of the known sample concentration in 81% of cases, while the spectrophotometer could only achieve such accuracy 63% of the time, largely due to an Inner Filter Effect (IFE) attenuating the excitation beam.

Next, the sensors were installed in a mobile water quality monitoring station and deployed in the field. Data highlighted remarkable intra-daily changes in creeks' nutrient concentrations from, for example, tidal cycles, thus reinforcing the necessity to regularly monitor sensitive waterways. The GBR presents a greater challenge to monitoring, as the initial pilot study only had small nutrient fluxes; however, due to the higher levels of agricultural activity around the GBR region, it is emphasised that such accurate, real-time data could be critical to expand the knowledge of the fate and source of nutrients in critical waterways, providing the potential for machine learning to develop predictive and optimisation models to mitigate the issue. Consequently, coupling the versatility of a mobile monitoring station with the added benefits of compensated high-frequency, real-time data, provides significant opportunities to assist in fertiliser management programs for agriculture and aquaculture runoff, as well as the preservation of environmentally sensitive areas.

***Keywords:*** *agriculture; nitrate runoff; real-time monitoring; water quality*

# Influence of Suspended Sediments Particle Size on Nitrate Readings from Real-Time Optical Sensors

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**Abstract:**

Laboratory experiments were conducted with field-collected sediment samples to measure the effects of turbidity features on nitrates optical sensors. Suspended sediments (turbidity) cause optical interference when attempting to measure the concentration of nitrates using real-time optical sensors (Luna Juncal et al., 2020), and particle size distribution may determine the amount of interference caused by the suspended sediments; it is hypothesised that smaller particles cause more interference than larger particles (Saraceno et al., 2017). Two sensors (EXO2 and NiCaVis 705 IQ) were originally used to test the relationship between the amount and type of turbidity and the inaccuracies given by the optical sensors.

The EXO2 sensor proved unreliable and was discarded in the preliminary tests, however NiCaVis 705 IQ was used to measure nitrate concentrations of solutions as the turbidity increased. The results showed that as the concentration of small (<90µm) turbidity increased, the optical sensors became more inaccurate in reading the concentration of nitrates. Sediment sized between 90µm and 150µm gave a similar relationship, but this was not as strong, nor as impactful on the sensors. Any sediment larger than 150µm was found to have a minimal effect, as it was too heavy to remain suspended in solution, and thus would not be picked up by the sensor. A model was developed to counteract the inaccuracies seen, based upon the reading given by the sensor and the concentration of the turbidity, as well as the particle size. More studies are needed to refine the turbidity model created and make it more transferrable to environments such as saltwater systems, but this report has allowed for compensation modelling to be preliminarily applied to promote the accurate use of optical sensors.

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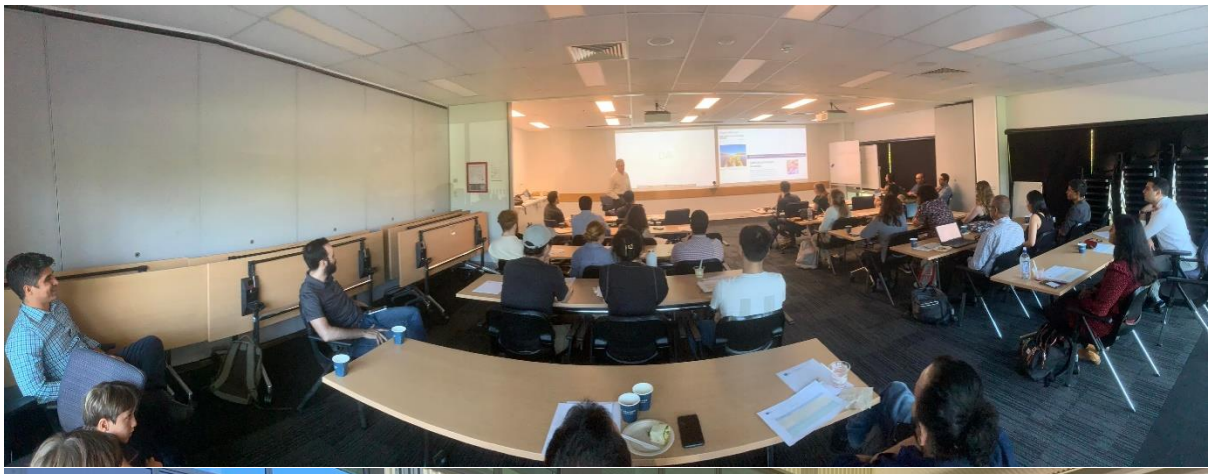
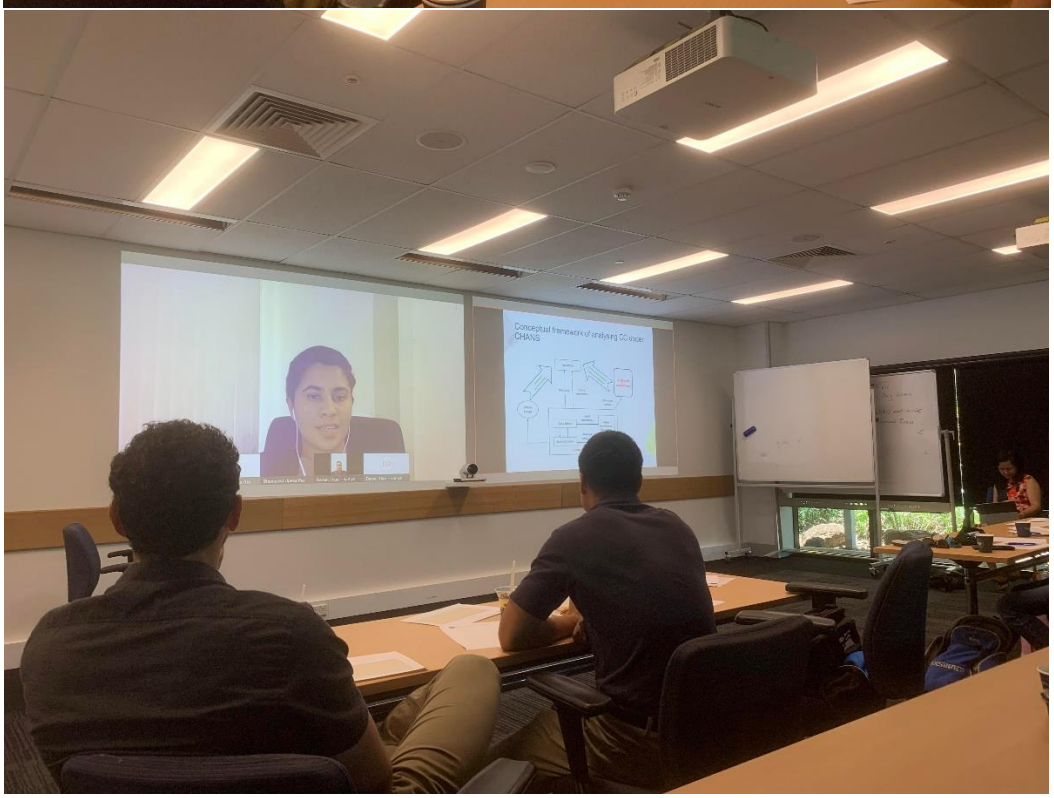
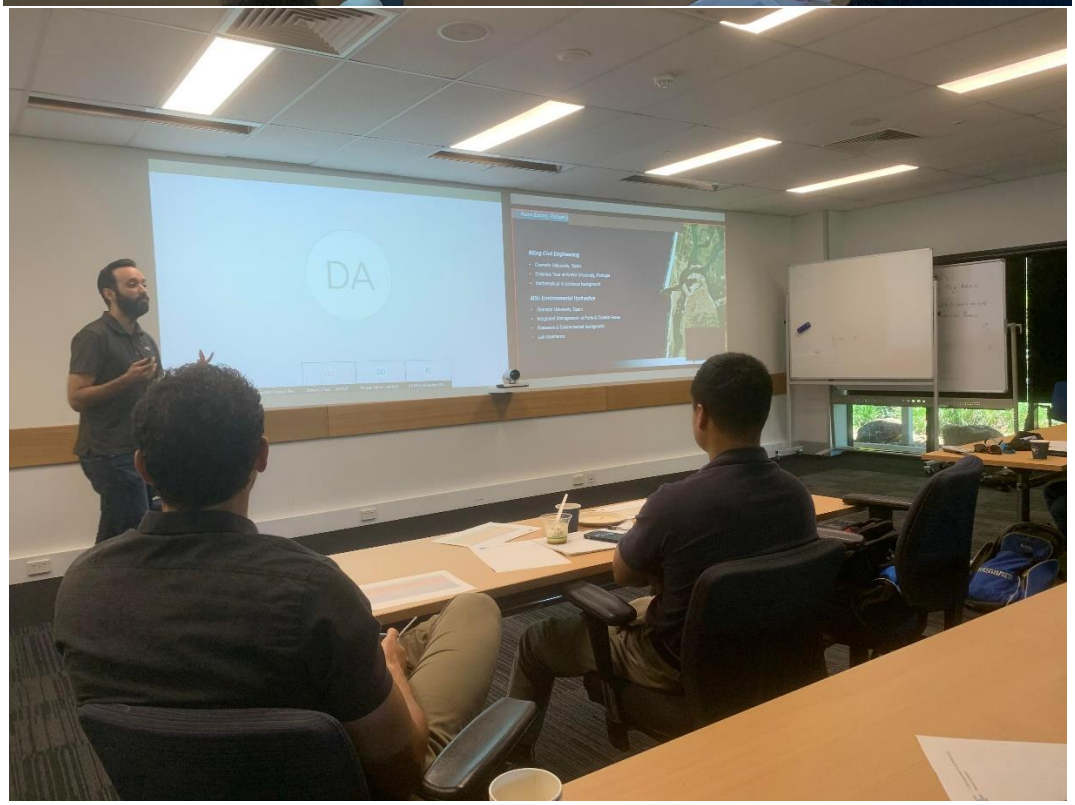
***Keywords:*** *Nitrates, Turbidity, Interference, Model*

# Conference Pictures




Stuart Mitchell
1996: Jörg Imberger, Australia


Conceptual framework of analysing GC nexus
CHANS

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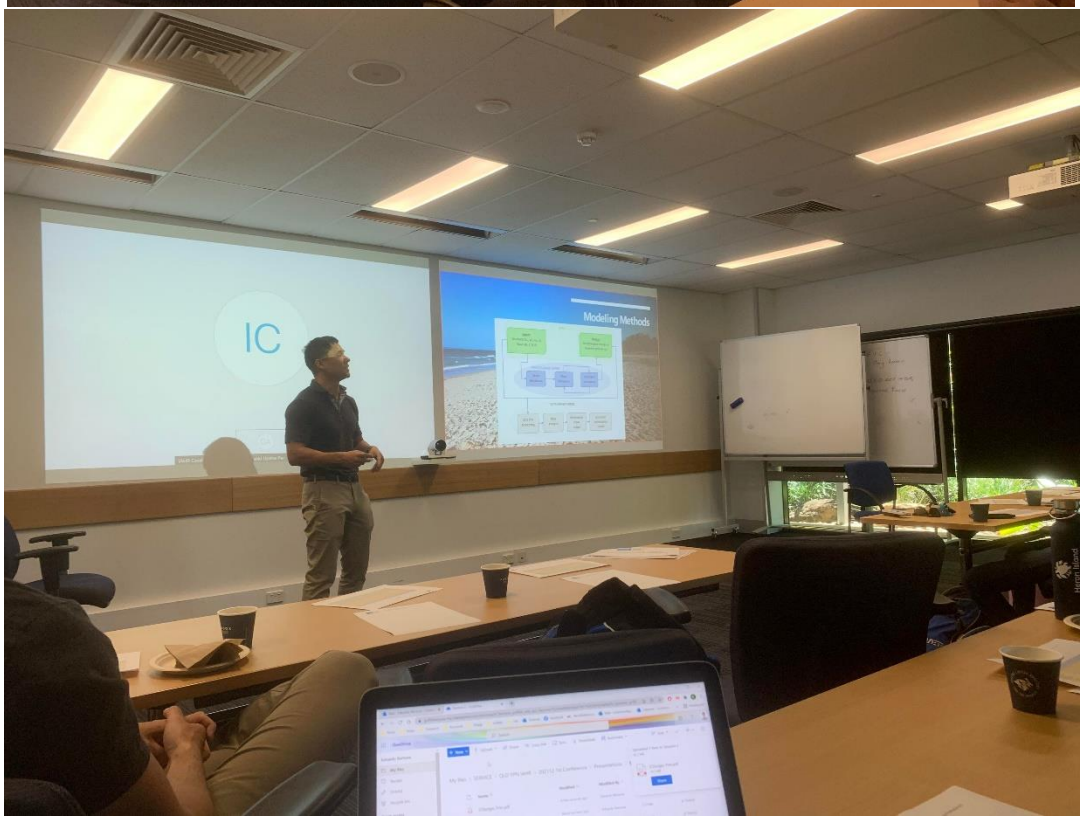
IC
Modeling Methods