A Trans-Disciplinary Approach for Refining Water Quality Objectives in the Wet Tropics, Australia

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ABSTRACT

The Wet Tropics region contains the highest biological diversity in Australia, has outstanding environmental values, is economically important, and is located close to the Great Barrier Reef (GBR). Increasing urban development and agricultural intensification in the Wet Tropics has raised water quality concerns. This paper focuses on a three month pilot water quality monitoring program for a tropical basin in north-eastern Australia. This pilot program was implemented using a trans-disciplinary approach, including the results of personal interviews, community workshops and biophysical information, to provide guidance in developing a long-term community driven water quality monitoring program to refine water quality objectives. Indigenous Rangers from Girringun Aboriginal Corporation (a legally incorporated organisation representing the interests of Traditional Owners from tribal groups in the basin) assisted with both the personal interviews and the pilot water quality monitoring program. The pilot program helped verify whether a monitoring plan could be feasibly undertaken by a local community group such as the Girringun Indigenous Ranger Unit. The Corporation has expressed a desire to continue water quality sampling for this basin, and has recently applied for Queensland State grant funding to continue monitoring over the next three years. Results of this study are expected to provide a successful community-based framework to refine water quality objectives in a tropical basin. Additionally, this strategy may encourage greater acceptance and compliance of future management actions, and provide a template for use in other basins worldwide.

KEY WORDS: *Trans-disciplinary, water quality objectives, biophysical data, social science methods.*

INTRODUCTION

The Wet Tropics region in Australia stretches approximately 500 km along the north-eastern coast of Queensland (Figure 1). World Heritage status was established for some 900 000 ha (48%) of his area in 1988, which encompasses natural and agricultural lands bordering the Great Barrier Reef (GBR); creating a distinctive area where these two World Heritage Areas (WHA) meet (Bohnet & Smith, 2007). The Tully Basin is in close proximity to the GBR, and was recently identified as one of the top ten pollution hot spots in the GBR lagoon (Terrain NRM, 2008). The Tully Basin includes the Tully River Catchment, the Hull River, coastal tributaries and the Murray River draining to the GBR (Figure 2). Agricultural production is a major economic livelihood in this area. Basin issues include in-stream water quality degradation in freshwater reaches. Increasing urban and agricultural growth within this basin is likely to increase water quality concerns in freshwater waterbodies and downstream marine environments (Tsatsaros *et al.,* in press).

The Tully basin was chosen as a case study as it is biophysically and economically representative of other Wet Tropics basins in the region, and is in close proximity to the GBR (Figure 2). This basin generally represents the wet tropical climate of the region (Devlin & Schaffelke, 2009). The Tully River is also the least variable river in the Wet Tropics with respect to annual discharge, and allows for accurate and defined water quality trends (Faithful *et al.,* 2008). Approximately 65% of the Tully Basin is in the Wet Tropics WHA (Figure 2) (Terrain NRM, 2008; Faithful & Finlayson, 2005).

The Tully Basin is characterised by high, summer-dominant rainfall (average 2000-4082 mm), and covers an area of 2787km^2 , draining wet tropical rainforest in its upper reaches (Webster *et al*., 2009). The basin's middle and lower reaches contain beef grazing, and a large coastal floodplain is comprised of wetlands modified to support sugarcane and banana production as well as urban areas (Terrain NRM, 2008; Faithful & Finlayson, 2005; Brodie *et al.,* 2009; Devlin & Schaffelke, 2009). Main land uses in this basin include natural forest (71%), sugarcane (13%), grazing (5%), plantation forestry (4%), banana and other horticulture (3%) and urban (1%). The remaining 3% are waterways (Brodie *et al.,* 2009). According to Brodie *et al.* (2009), the landscape of this Basin has been significantly altered since European settlement, including reductions in areas of floodplain vegetation (~80%, to 20.8 km^2), riparian areas (~60%, to 59 km^2), and wetland areas (~69%, to 72.5 km^2). These floodplain alterations for grazing, timber, and clearing for agricultural development have changed local hydrology and drainage patterns (Brodie *et al.,* 2009).

In 2011, the Tully River Basin had an estimated resident population of 6,235 people (OESR, 2011). Three Aboriginal Traditional Owner groups live in the area including the Girramay, Jirrbal and Gulnay people (Terrain NRM, 2008). The Girringun Aboriginal Corporation represents these Traditional Owner groups in the association. The Aboriginal

Corporation has expressed a desire to recognize the Tully Basin as an Indigenous Protected Area (IPA), thereby creating opportunities for Traditional Owners to be involved in monitoring, protecting, co-managing water resources (freshwater and marine), assisting with enforcement measures, and creating future research opportunities in the area.

In 2008, a Water Quality Improvement Plan (WQIP) was developed for the Tully Basin to reduce sediment, nutrient and pesticide loads for waters entering the GBR. The WQIP was developed with industry and community members (including Traditional Owners) over a three-year period to establish local environmental values (EVs), and Water Quality Objectives (WQOs) targeted for estuarine, marine and selected freshwater parameters in the Tully WQIP area. This plan was endorsed by the local community (Terrain NRM, 2008).

The Plan also prioritized key water quality issues for this basin. These included:

1 – Nitrate and particulate nitrogen: Nitrate from sugarcane and bananas, and particulate nitrogen from eroding soils, grazing, cropping, and urbanization.

2 – Herbicide residues from sugarcane.

3 – Suspended sediment, particulate phosphorus and acid sulphate soil runoff. Suspended sediment from forested areas (natural sources), residual sources in sugarcane, drains, roads, horticulture, and grazing. Particulate phosphorus from eroding soils and fertilizer use. Acid sulphate soil from soil disturbances in lower catchments close to the sea from deep drains.

4 – Dissolved organic nitrogen, dissolved oxygen and weeds. These are from forested areas, cropping, sugarcane, mill and sewage treatment plant effluents, mill mud, weed infestation and control.

5 –Other pesticide residues.

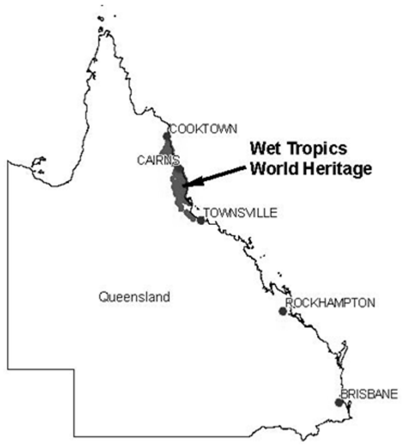
Through the WQIP community consultation process, several local water quality issues of concern (relevant to freshwater reaches) were also identified. These concerns included the safety of drinking water, limited or no access to areas of cultural and spiritual significance, and loss of local waterbodies including wetlands, lagoons and small streams.

During this process, various interview and workshop activities supported setting WQOs for the freshwater reaches in this basin to protect the community's EVs and uses (Bohnet *et al*. 2006; Bohnet *et al*. 2007). The WQIP recommended additional consultation was needed with the community to develop freshwater WQOs, as the Tully WQIP was mainly focused on developing downstream WQOs for estuarine and marine environments including the GBR (Terrain NRM, 2008).

RESEARCH AIM

The overall aim of this research project is to provide a conceptual framework for integrating both biophysical and social science research and data into refining freshwater WQOs for a basin in the Wet Tropics. This is a critical component of the research as it was not developed fully with the basin community during the WQIP. The design and implementation of a pilot water quality monitoring program for this basin is a main part of this framework.

METHODS



Source: http://www.wettropics.gov.au

Figure 1. Wet Tropics World Heritage Area Location

The research methodology consisted of four main linked steps, these included:

Step 1. Verify environmental values (EVs) from all user groups in the Tully Basin.

Step 2. Design a locally driven Pilot Water Quality Monitoring Program to provide additional local water quality knowledge to fill in water resources gaps.

Step 3. Outline the steps needed to interpret EVs and water quality information into the development of basin WQOs.

Step 4. Identify factors supporting or inhibiting the establishment of WQOs in the basin.

The trans-disciplinary approach involved a selection of tools from the biophysical and social sciences. Social science tools included one-on-one stakeholder interviews and community workshops. Five community workshops were held and one hundred and twenty-four interviews were conducted in the basin. Five main stakeholder groups were identified and individuals belonging to these groups were interviewed as these stakeholder groups have the greatest potential to influence water quality changes in this basin. These stakeholder groups included Traditional Owners; local residents; farmers (including sugarcane/banana/tropical fruit farmers, growers and graziers; general community members (e.g. not for profit natural resource management bodies, community and government organizations, extension agents, industry people, tourism operators, conservation and environmental groups, schools); and researchers/scientists working on basin water quality issues.

Biophysical tools included reviewing existing biophysical data and other studies for the basin, analysing interview and community workshop responses, and designing and implementing a three month pilot water quality monitoring program (based on biophysical data/reports and results from the stakeholder interviews/workshops).

The pilot water quality monitoring program was developed to provide guidance in developing a long-term community driven water quality monitoring program that could be undertaken for this basin. The pilot program verified whether a monitoring plan could be undertaken by a local community group, allowed preliminary results to be discussed, presented opportunities and obstacles encountered during the pilot program, and identified recommendations for refining a long-term water quality monitoring program. A three month timeframe was chosen (May-July 2012) to determine whether a community driven monitoring plan could be feasibly undertaken. Design considerations of the pilot program included prioritizing key water quality parameters and sampling locations (in consideration of existing biophysical data and stations), basin coverage and dominant land uses, safety, ease of sampling, budget availability and project time constraints.

Rationale for the Pilot Water Quality Monitoring Program

- **1 – Federal and State of Queensland Water Quality Guidelines:** Australian Government guidelines state that locally relevant water quality guidelines should be developed for in-stream water quality protection. In addition, local authorities should use their own tools to better refine these guidelines.
- **2 – Tully Water Quality Improvement Plan (WQIP):** The basin community had issues of concern regarding freshwaters. The community supported setting WQOs to protect EVs for freshwaters.
- **3 – Water Quality Data and Reports Indicated Potential Water Quality Issues in the Basin.** There is no comprehensive water quality sampling network in the basin. Current water quality sampling schemes are patchy; and do not take into account seasonality and different flow regimes.
- **4 – Workshops and Interviews from this Research.** There are community concerns about water quality issues, and input from the community indicated they would like to be involved in a pilot water quality monitoring program for this basin.

Existing biophysical data and interview responses from all five main stakeholder groups were used to initially design the pilot water quality monitoring program (Table 1). Sampling stations were also selected at specific waterbody locations draining subcatchments dominated by a single land use. Land use types included forest (rainforest), sugarcane, bananas (horticulture), grazing and urban (existing and lands being developed). Although most subcatchments have a mixture of land use types, it is expected that concentrations of water quality parameters (measured at subcatchment stations) will reflect the dominant land use of the subcatchment, as each land use utilizes very different management regimes (Faithful *et al.,* 2008).

Before the pilot monitoring study was implemented, a community workshop was held in a central basin location so that everyone interviewed for the research could attend. In addition, a separate meeting was held at Girringun Aboriginal Corporation with the Girringun Indigenous Ranger Coordinator and Girringun Rangers. The purpose of the workshops was to discuss preliminary results from the interviews, highlight main water quality issues from existing biophysical information for the basin, and discuss the rationale for implementing a pilot water quality monitoring program in this basin. The workshops were also held to solicit additional input into the pilot water quality monitoring program, as well as providing an opportunity for interviewed stakeholders to be invited to participate in the pilot program.

In consultation with stakeholders, the final design of the pilot program focused on prioritising key water quality parameters and locations in consideration of existing biophysical data, dominant land uses, existing monitoring stations, project time constraints, safety, ease of sampling, basin coverage and budget.

Field reconnaissance of the monitoring sites was conducted to ensure sites could be feasibly sampled. The pilot water quality monitoring program was implemented from May 2012-July 2012.

Fifteen sub-catchment stations were selected to be sampled over a two day period (each month) to represent the major land uses of the region, and were classed as sugarcane, grazing, urban, banana, or natural forest land use categories, as defined using Queensland Land Use Mapping Program data. Sites were also selected based on access to the site and the size of the waterway.

Water quality parameters for the pilot program included Total Suspended Solids (TSS), turbidity and selected pesticides (the herbicides atrazine, diuron, hexazinone), and total and dissolved nutrients. As well, basic streamflow measurements were taken and visual assessment sheets for riparian vegetation condition, presence absence of fish and other aquatic life at each sampling location, and a potential pollutant source and site condition field form were provided (Table 1).

Quality Assurance/Quality Control was developed in conjunction with James Cook University (JCU) TropWater protocols for monitoring, assessment, reporting and laboratory procedures. The pilot water quality monitoring program was lead by a JCU Principal Researcher and co-lead by a JCU TropWater Quality expert. The Girringun Indigenous Rangers assisted in all phases of the pilot water quality monitoring program.

RESULTS

As stated previously, the main focus of the pilot program was to provide guidance in developing a long-term community driven water quality monitoring program. This pilot program verified that a monitoring program could be successfully undertaken by a local community group.

The focus of this pilot program was not to provide a comprehensive water quality data set for this basin; however, the data collected for this pilot program indicated long-term water quality monitoring is needed for this basin.

Water quality data collected from the pilot program indicated that Dissolved Inorganic Nitrogen (DIN) values were similar to previous long-term data collected for this basin. DIN is the most readily bioavailable form of nitrogen that can be quickly consumed and cycled in the water column by algae, phytoplankton and macrophytes (aquatic weeds).

Nitrate is typically the main contributor to DIN and is the main runoff form of nitrogen fertilisers. It has also been identified as one of the key pollutants in the GBR catchment area. The highest DIN values during the pilot program were in areas draining sugarcane and below towns. These nitrate values were also similar to previous long-term water quality data collected for this basin (Bainbridge *et al*., 2009), and exceeded existing water quality guidelines at most sampling locations.

Phosphorus is important as a limiting nutrient for plant growth and can be an important contributor to eutrophication (particularly in freshwaters and

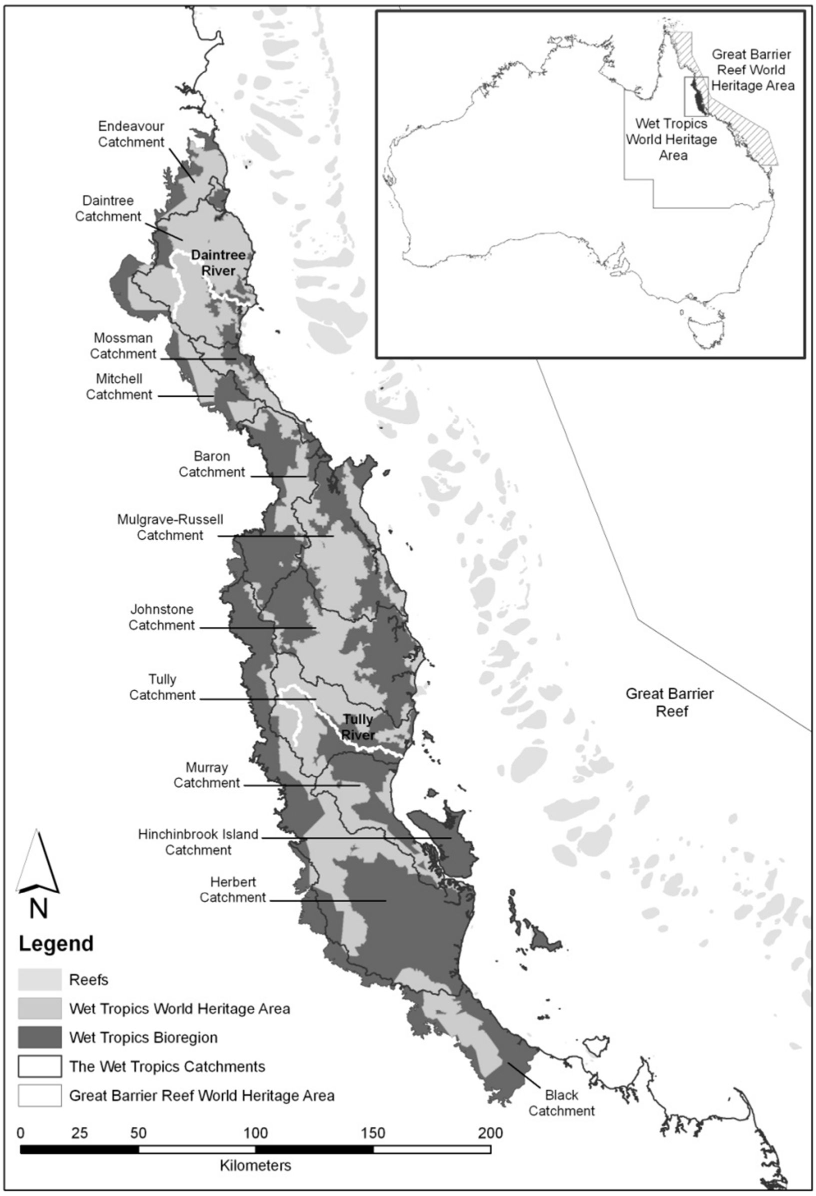


Figure 2. Location of the Tully Basin in Queensland, Australia

tropical/subtropical estuarine marine systems). Total phosphorus values also exceeded existing water quality guidelines at most basin locations during the pilot program.

Total Suspended Solids (TSS) values were low at most sampling locations during the pilot program, and may be indicative of healthier land conditions, reflecting the increased use of green harvesting, trash blanketing, and minimal tillage practices adopted by the Cane industry to reduce soil erosion in the basin.

Faecal coliform values were low and did not exceed water quality guidelines. Diuron, Atrazine, and Hexazinone were below laboratory detection limits and water quality guidelines.

CONCLUSION

The pilot water quality monitoring program provided guidance in developing a long-term community driven water quality monitoring program. This pilot program also provided an important step in helping to refine freshwater water quality objectives for a Wet Tropics basin.

Long-term data collected across all seasons could be used to better refine potential pollutant sources in the basin, characterise current water quality conditions, indicate pollutant levels, identify water quality changes, and

Table 1. Overview of the Pilot Monitoring Program

Parameter	***Frequency***	***Location***
Total Suspended Sediments (TSS)	Once a month	All fifteen stations
Turbidity	Once a month	All fifteen stations
Pesticides/ Herbicides (Atrazine, Diuron, Hexazinone)	Once during the study	Three locations
Total and Dissolved Nutrients	Twice during the study	All fifteen locations
Probable Source(s) & Site Condition Field Form	Once a month	All fifteen stations
Stream Condition and Riparian Condition Field Form Visual)	Once a month	All fifteen stations
Supplemental Field Form (including flow)	Once a month	All fifteen stations

help protect and improve areas of spiritual and cultural significance.

A long-term water quality monitoring program could also be valuable in helping develop co-management possibilities for water resources in the basin (both freshwater and marine), provide opportunities for assisting with enforcement measures, and developing future research opportunities (e.g. utilizing both scientific and local/traditional ecological knowledge for effective water resources management).

Girringun Aboriginal Corporation has expressed a desire to continue the pilot water quality monitoring program over a longer timeframe (in partnership with a local not-for-profit natural resource management body in the basin). The Corporation has applied for long-term funding from the State of Queensland and would continue the collaborative community effort for this basin. This framework may provide a template for other tropical basins worldwide.

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