Targeted extension strategies to improve water quality outcomes in the Australian sugar industry

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Abstract. Can extension programs have an impact on water quality entering the Great Barrier Reef (GBR) lagoon? Sugarcane farmers in the Herbert cane growing region (North Queensland, Australia) sought funding for a whole of Herbert catchment water quality monitoring project through various industry and government funding agencies in 2010. The Herbert Water Quality Monitoring Program (HWQMP) commenced in July 2011 and operated for 3 years to monitor water quality for the whole Herbert catchment. An extension strategy was developed as a part of the HWQMP, with linkages to other projects, allowing the sugar industry to assess its impacts from the cane block to the inner reefs of the GBR. The HWQMP and associated extension effort has been successful in building industry capacity to manage issues identified by the water quality monitoring program. The program has achieved positive environmental change leading to improved water quality outcomes without compromising industry viability.

Key words: Extension, Great Barrier Reef (GBR), Herbert Catchment, Sugarcane, Water Quality Monitoring.

Background

Over the past 150 years Great Barrier Reef (GBR) catchment areas have been extensively modified for agriculture production and urban settlement leading to a decline in water quality entering the GBR lagoon (Carroll et al. 2012). Sugarcane farming is usually undertaken on the floodplain of major river systems or their tributaries, which directly drain into to the GBR lagoon between Mossman and Bundaberg, Queensland.

The Reef Water Quality Protection Plan (Reef Plan) states that the majority of nutrients, sediments and herbicides entering the GBR lagoon are derived from agriculture, primarily sugarcane and grazing. Thus, in recent years the sugar industry has been under significant scrutiny associated with agricultural runoff into the GBR lagoon.

The development of the Herbert Water Quality Monitoring Program (HWQMP) was largely driven by Herbert sugar industry representatives who felt that the available data on water quality within the Herbert catchment (Bramley & Muller 1999; Bramley & Roth 2002; Bartley et al. 2003) was insufficient for use in the validation of load estimations being calculated as part of the assessment of catchment contributions of pollutants to the GBR. The sugar industry also wanted to gain a better understanding of its impact on water quality and investigate ways to address specific issues if they arose.

CANEGROWERS Herbert River, the peak industry body for sugarcane production, initiated discussions with Terrain NRM and James Cook University (JCU) - TropWater to develop a project proposal to monitor water quality in the Herbert catchment. A proposal was presented to the CANEGROWERS Herbert River Board on 9 February 2010 for consideration and was discussed at its annual general meeting on 22 April 2010. The meeting agreed to proceed with the development of a full project proposal for funding.

The sugar industry, with assistance from Terrain NRM, coordinated a series of meetings with government agencies and other commodity groups in the catchment to secure funding and seek support for the project concept. The project was successful in securing funding and commenced in July 2011.

The project objectives were:

1. To seek relevant and scientifically robust data to help inform and guide management decisions for land managers within the Herbert Catchment area.
2. Identify sources of pollutants at farm and sub-catchment level to enable issues to be addressed by land managers.
3. Implement a tailored monitoring program to support management decisions, complement and improve the Paddock to Reef program and grower monitoring and boost existing research findings.

4. Cross reference the existing grower monitoring activities against a scientifically rigorous monitoring program.
5. Develop appropriate extension strategies to engage growers and industry.
6. Empower industry (especially the sugarcane industry) to drive farm management change practices based upon sound research findings.

Project overview

The HWQMP commenced in July 2011 and operated for 3 years to monitor water quality for the whole Herbert Catchment area. The sugar industry initiated the project to investigate the relative contribution of different land uses on the delivery of reef pollutant loads to the waters of the GBR.

The project was successful in attracting funding from the Sugar Research and Development Corporation (SRDC), Sugar Research Australia (SRA), Queensland Government Department of Agriculture Fisheries and Forestry (DAFF), Queensland Government Department of Natural Resources and Mines (DNRM), Queensland Government Department of Environment and Heritage Protection (EHP), Hinchinbrook Shire Council (HSC) and the Tablelands Regional Council (TRC) to assess water quality from the major land uses and develop appropriate extension outcomes. The project monitored sediment, nutrient and pesticide concentrations in surface waters collected from various sub-catchments and capturing numerous land uses contributing to the Herbert River end of catchment loads. Surface water samples were collected from 17 sites covering the main land uses within the Herbert catchment. These were rainforest, mixed cropping, urban, dairy, mining and grazing in the upper catchment and sugarcane and urban in the lower catchment.

As a part of the project, an extension strategy was developed whereby the various project stakeholders were provided with water quality monitoring results six months prior to the information being made public. This allowed the project stakeholders the opportunity to be informed of pending issues and to develop strategies and implement activities when issues arose. The data generated informed the Herbert community, NRM managers and various industry stakeholders that use the land in this region. Further, the data generated also provided 'land use specific' water quality data which could be used in the validation of catchment models for the Paddock to Reef Integrated Monitoring, Modelling and Reporting Program (Paddock to Reef Program) managed by the State government.

Extension methodology

Capacity and resilience

The influence that extension services in the Australian sugarcane industry have had on industry capacity and resilience against pest and diseases over the years has been based upon biological and socio-economic understanding (Hunt et al. 2011; Hunt et al. 2012; Hunt, Birch & Vanclay 2012; Vanclay 2004). However the influence that extension services have provided in relation to natural resource management (NRM) has been much weaker. This could be attributed to:

- Industry extension services being strongly focused on productivity related issues aimed at increasing cane and sugar yields.
- The sugar industry not being directly involved in NRM research with most of this activity occurring in governmental departments and regional NRM groups.

This disconnect between has been slowing changing over the past 10 years with industry groups like CANEGROWERS, BSES (now SRA) and Productivity Service groups now taking a more active role in research projects and NRM programs, especially those focussed on reef water quality outcomes.

Macadam et al. (2004, p. 17) describes the building of capacity in agriculture as 'externally or internally initiated processes designed to help individuals and groups to appreciate and manage their changing circumstances, with the objective of improving the stock of human, social, financial, physical and natural capital'. Coutts et al. (2005, p. 4) saw capacity as 'increasing the abilities or resources of individuals, organisations and communities to manage change'. Thus, the greater the level of capacity that industry participants have in relation to the management of NRM issues the more they should be able to manage issues like reef water quality outcomes.

The capital framework

To measure the evidence of capacity and resilience building, we used a framework of 'capitals'. We can measure the relative levels and change in capacity and resilience around the framework of asset sets as defined by Hunt et al. (2014, p. 78-79) as:

Human capital (the knowledge, skills and competencies of the individual within the industry);

Natural capital (the contribution to the state of the natural biophysical environment);

Institutional capital (i.e. influence of the initiative upon industry organisations and institutions that can be drawn on as industry capacity); and

Social capital (relationships and cooperation within the industry).

This framework should allow us to assess and explain changes in practice over time, in this case, the management of natural resources in relation to reef water quality during the duration of the HWQMP. To allow the analyses of the 'capitals' and their effectiveness, it is first necessary to provide the context within which they will be assessed. It is necessary to document the NRM issue of concern, the methodology by which the water quality data were collected, the extension structures put in place to manage the research findings and the response by industry in relation to the research findings.

Extension structures put in place to manage the HWQMP

As a part of the project, a data management, stakeholder engagement and extension strategy was developed whereby the water quality monitoring data would be communicated and reported to the various stakeholders. It was important to develop and implement this strategy because the project could have revealed potentially sensitive water quality information. A technical working group was responsible for checking the data and interpreting the results. The collated information was then presented to a stakeholder reference group comprising representatives from the main land uses, government, NRM and the local catchment group. The agricultural land use representatives were responsible for engaging their constituents to discuss the results and develop management strategies to address issues arising from the monitoring data within a six months period before the data would be published. The sugarcane industry used the Sugarcane Industry Working Group to achieve this. This approach also provided industry the opportunity to take ownership of the issues and act upon them before they were reported to the wider community. This approach was successful in coordinating project activities, whilst building industry capacity to communicate water quality and project outcomes.

The role of the Project Stakeholder and Management Group

The Project Stakeholder and Management Group's role was to bring together all Herbert project stakeholders and land use representatives to discuss results and to provide opportunities for building knowledge and capacity within the project area. This group was unique in that it took a whole of catchment approach to the water quality data to discuss strategies and direct extension effort into addressing priority water quality issues. This group was also used to identify knowledge gaps and to act as an open forum for stakeholders, while providing a mandate to the Project Technical Working Group to develop strategies to attempt to answer specific questions. The Project Stakeholder and Management Group consisted of representatives who actively invested in the project like the SRDC, SRA, DAFF, DNRM, EHP, HSC and TRC, Terrain NRM (as project manager), the various agricultural commodity groups and other relevant projects such as the Herbert Catchment Group and the Reef Guardian program. This group was also responsible for project communications and reporting to funding agencies.

The role of the Project Technical Working Group

The Project Technical Working Group (PTWG) was established to coordinate water sampling activities associated with the project; ensure water sampling and analysis was undertaken at a high standard; and interpret data for presentation to the Project Stakeholder and Management Group. The PTWG membership consisted of scientists from JCU- TropWater, EHP and Herbert Cane Productivity Services Limited (HCPSL).

Sugarcane Industry Working Group (SIWG)

The SIWG consisted of representatives from the sugarcane industry peak body CANEGROWERS Herbert River, the local sugarcane miller Wilmar Sugar, together with HCPSL, the local research and extension providers.

The purpose of the group was to:

1. Review data relevant to the sugarcane industry and develop extension strategies for communicating the results to the wider industry.
2. Review farming systems and practices that may be the cause or contributing to specific issues identified by the water sample results.
3. Work with growers to implement improved farming practices.

Linkage projects associated with the sugarcane industry

At the inception of the HWQMP it was proposed to create linkages to other projects or programs focusing on water quality and agricultural production systems operating within the Herbert catchment. This was specifically the case for the sugarcane, dairy, beef cattle and mixed cropping industries.

In the sugarcane industry this project was linked to the following projects:

- The Herbert Demonstration Farm project funded by DAFF.
- The Queensland Government Department of Natural Resources and Mines (DNRM) funded rainfall simulation project and end of catchment monitoring under the Paddock to Reef program.
- The Australian Government National Environmental Research program (NERP) funded inshore and reef water quality monitoring activities.
- The DAFF funded Herbert Reef Plan Extension and Education project.
- The Australian and Queensland Government funded Project NEMO.

The Extension and Education project and Project NEMO provided extension opportunities and resources aligned to the HWQMP during the project and after its completion. These linkage projects also allowed the industry to better understand what water quality impacts it may have from 'Paddock to the Reef', while being supported by targeted extension activities to seek on-farm change in practices. This knowledge built industry capacity to better manage and understand issues associated with on-farm activities and water quality outcomes.

Extension based upon paddock scale water quality monitoring Both the Herbert demonstration farm and rainfall simulation projects provided the Herbert cane industry with the ability to undertake water quality monitoring at a paddock scale. These projects allowed the industry to assess different farming practices in terms of the runoff of nutrients, sediments and herbicides associated with nutrient and pesticide application, application methods and products. A good example was the rainfall simulation research undertaken in the Herbert cane region, which investigated nutrient runoff losses for the 5 most common fertilizer application methods used by the cane industry (Cowie et al, 2013 p.1-2). The project findings allowed industry to evaluate farming practices which impacted on water quality outcomes. The project findings were communicated through extension activities like small grower focus groups, shed meetings, bus tours, print and electronic media throughout the Herbert cane region.

Extension based upon sub-catchment water quality monitoring As part of the HWQMP, sub-catchment water monitoring sites were established in 4 sugarcane sub-catchments. The on-farm practice data (on pesticide and nutrient applications) was collected by HCSPL for the duration of the project. These data provided a useful insight to what farm practices were being undertaken in a sub-catchment and allowed the industry to better understand what impact various farming practices may have on water quality. To ensure that individual grower privacy was maintained, HCPSL only reported on aggregated data to growers, the project stakeholder and technical groups for reference. HCPSL did take the opportunity to use aggregated data to engage on a one on one basis with some of its clients to seek opportunities to better manage water quality impacts.

Extension based upon whole of catchment water quality monitoring The DAFF Extension and Education project funded technical agronomic extension staff to provide extension support to the main agricultural commodity groups in the Herbert catchment. This project worked in parallel with the HWQMP, whereby the extension staff reviewed the water quality monitoring results and used them to develop and deliver targeted extension strategies to address water quality issues across the catchment. The project also established a network of extension providers working with the different agricultural commodities and set up a forum for them to discuss their respective extension projects and assess different extension methodologies and approaches.

Extension activities post the HWQMP HCPSL secured funds from the Australian and Queensland Government to deliver Project NEMO (Nutrient Efficient Management On-farm for profitability and productivity) to undertake extension activities post the HWQMP. This project commenced in late 2014 and is funded for a 3 year period. Project NEMO will take the research findings found in the HWQMP and linkage projects and communicate them through an extension program managed by HCPSL. HCPSL extension agronomy staff will work with growers (within the Herbert region) through one-on-one and group extension processes. The project will also allow growers to evaluate on-farm practices that could lead to improvements in water quality outcomes through on-farm demonstration plots. HCPSL extension agronomy staff will support growers

with the establishment, monitoring and reporting of results from the on-farm demonstration plots; the findings from these plots will be communicated to the wider cane industry.

Results

Research findings specific to the sugarcane industry

The specific water quality monitoring results collected by the HWQMP for all land uses have been reported in O'Brien et al. (2013; 2014). Nitrogen levels and some pesticides, including diuron, hexazinone and atrazine, are frequently measured at concentrations exceeding the national guidelines for freshwater ecosystem protection in waters discharging from sugarcane sites in the Herbert sugarcane sub-catchment area (O'Brien et al., 2014). The project also detected levels of imidacloprid, a pesticide used to control cane grubs, just below the Canadian guideline (as there are no Australian guidelines published at present) for freshwater ecosystem protection in waters discharging from specific sugarcane sub-catchments in the first year of the project (O'Brien et al. 2013).

These data provided an insight into on-farm practices in relation to water quality and allowed the sugar industry to act upon issues as they arose. The industry is currently reviewing all its practices in relation to pesticide and nutrient management since the findings of the HWQMP have been made available. This paper will now present two examples of specific approaches adopted by the industry to address issues associated with imidacloprid and nitrogen use.

Extension response to Imidacloprid issues

In response to these findings, HCPSL conducted a number of grower shed meetings throughout the district in late August - early September 2012 to inform growers of the impending risks associated with the improper use of imidacloprid, its impact on water quality and recommendations for effective grub control with minimal runoff. Over 150 growers attended the meetings.

HCPSL and Bayer Crop Science (who own the registered product, Confidor®) technical staff reviewed industry practices to investigate ways to minimise imidacloprid impacts on water quality and to better target the pest species.

Since the targeted extension approach in late 2012 associated with product timing and placement there has been a considerable reduction in imidacloprid levels detected in water samples in the sugarcane sub-catchments monitored by the HWQMP. Imidacloprid levels detected in water decreased while the area treated to the product in the Herbert has increased substantially over the 3 year period during the HWQMP (T. Murphy 2014, pers. comm., 5 Sept). This change could be attributed to the large extension effort and improved practices adopted by the Herbert industry to manage the use of imidacloprid.

Extension response to nitrogen losses

In response to the elevated levels of nitrogen in water quality samples collected by the HWQMP and research undertaken by the associated linkage projects (like the Herbert demonstration farm and rainfall simulation project), the Herbert industry is now investigating ways to better manage nitrogen losses associated with sugarcane production.

The rainfall simulation project validated that sub-surface application of fertiliser in sugarcane crops had the lowest nitrogen runoff losses when compared to other application methods available to the industry (Cowie et al., 2013). Since the inception of the Australian Government's Reef Rescue grants program, HWQMP, and reporting of the Rainfall Simulation trial results, there has been a significant shift from surface fertiliser application to sub-surface application, in the Herbert cane growing region. Surface application of fertilisers reduced from 78% of area treated in 2008 to 38 % of area treated in 2013, for the Herbert sugarcane growing region (unpublished HCPSL data).

During the HWQMP, HCPSL utilised various extension methodologies to inform growers of research findings associated with nitrogen losses. Grower shed meetings and field days were well attended throughout the HWQMP, with up to 150 growers attending some events. All Herbert growers were sent copies of the 2012 and 2013 Herbert Sugar Industry Reports, which highlighted the results of the HWQMP and issues associated with water quality entering the GBR.

Project NEMO will now establish numerous farm demonstration trials to allow growers to assess ways to improve nitrogen use efficiencies and improve water quality outcomes on their own farms, which will be supported by ongoing water quality monitoring.

Discussion

The success of the HWQMP and its affiliated projects can be measured by the significant development of 'capital' in the Herbert catchment (especially by the sugarcane growing industry) during and after the project period. The success and development of 'capital' can be measured by the following:

- Human capital - The Herbert catchment land managers (especially the sugarcane industry) now have a sound knowledge concerning water quality pertaining to the various land uses within the Catchment area. The HWQMP has brought together land managers to discuss issues raised by the scientific research and to seek approaches to address issues like the use of nitrogen and products like imidacloprid.
- Natural capital - The HWQMP has added significant value to the regions knowledge in relation to what land uses contribute to water quality in the whole of catchment area. This knowledge will allow the State government Paddock to Reef modellers to use real data generated within the catchment, instead of implied data from adjacent catchment areas when developing models for managing water quality across the Reef Catchment areas.
- Institutional capital - The lasting legacy of the HWQMP is that specific land users (like the sugarcane) industry have now invested into long term monitoring of water quality, allowing them to proactively manage issues as they arise. The continued long term monitoring of water quality is done through a collective approach where-by numerous organisations and institutions work together to collect, collate, report and act upon the data generated.
- Social capital - the HWQMP has allowed industry organisations and institutions to come together to work together on the difficult issues like land use practices impacting on water quality. Prior to the inception of the HWQMP some industry organisations and institutions worked in isolation from each other. This project has brought such groups to the table to discuss issues pertaining to water quality and develop methods to manage such issues. After the HWQMP finished, these industry organisations and institutions still come together (now less frequently, but still regularly) to discuss whole of catchment issues and what practices are being implemented to address specific issues for their various land uses.

Conclusions

The investment into the HWQMP and aligned projects has built the regions capacity by 'increasing the abilities or resources of individuals, organisations and communities to manage change' Coutts et al. (2005, p.4). Macadam et al. (2004, p.17) described the building of capacity in agriculture as 'externally or internally initiated processes designed to help individuals and groups to appreciate and manage their changing circumstances, with the objective of improving human, social, financial, physical and natural capital'. This project has certainly achieved this. The HWQMP demonstrates that local water quality data coupled with a targeted extension effort has built capacity within the Herbert sugarcane industry to better manage cane production systems to improve water quality entering the GBR.

The HWQMP and aligned linkage projects have provided the Herbert cane industry with local, timely water quality data and agronomic support to build industry capacity to address reef water quality issues. These projects have provided the Herbert sugarcane industry with specific local data at paddock, sub-catchment and whole of catchment scale and inshore reef scale for a sound extension approach to be developed. This has allowed the Herbert sugarcane industry to 'join all the dots' from paddock to the onshore reef in relation to managing the quality of water leaving a cane farm.

The HWQMP has clearly shown that extension programs can have an impact on water quality entering the Great Barrier Reef (GBR) lagoon, if they are well planned, targeted and managed accordingly. This paper has also shown that targeted extension programs can lead to positive NRM outcomes, without compromising industry productivity and profitability long term, a 'win win' situation for all.

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References

Bartley, R, Henderson, A, Prosser, IP, Hughes, AO, McKergow, L, Lu, H, Brodie, J, Bainbridge, Z & Roth, CH 2003, 'Patterns of erosion and sediment and nutrient transport in the Herbert River catchment, Queensland', Consultancy Report, CSIRO Land and Water.

Bramley, R & Muller, D 1999, 'Water quality in the lower Herbert River - The CSIRO dataset'. Technical Report 16/99, CSIRO Land and Water.

Bramley, RGV & Roth, CH 2002, 'Land-use effects on water quality in an intensively managed catchment in the Australian humid tropics', *Marine and Freshwater Research*, vol. 53, pp. 931-940.

Carroll, C, Walters, D, Vardy, S, Silburn, DM, Attard, S, Thorburn, PJ, Davies, AM, Halpin, N, Schmidt, M, Wilson, B & Clark, A 2012, 'A paddock to reef monitoring and modelling framework for the Great Barrier Reef: Paddock and catchment component', *Marine Pollution Bulletin*, vol. 65, pp. 136–149.

Coutts, J, Roberts, K, Frost, F & Coutts, A 2005, *The role of extension in capacity building: what works and why*? Publication 05/094, Rural Industries Research and Development Corporation, Kingston, ACT, pp 1-86.

Cowie, B, Davison, L, Tang, W, Shaw, M, Di Bella, L & Benson, A 2013, 'Paddock Case Study Sugarcane Reef Water Quality Protection Plan. Sub-surface fertiliser application reduces nutrient runoff in the Herbert catchment'. Reef Water Quality Protection Plan Secretariat, April 2013.

Hunt, W, Vanclay, F, Birch, C, Coutts, J, Flittner, J & Williams, B 2011, 'Agricultural extension: building capacity and resilence in rural industries and communities', *Rural Sociology*, vol. 20, pp. 112-127.

Hunt, W, Birch, CJ, Coutts, J & Vanclay, F 2012, 'The many turnings of agricultural extension in Australia', *Journal of Agricultural Education and Extension*, vol. 18, pp. 9-25.

Hunt, W, Birch, C & Vanclay, F 2012, 'Thwarting plague and pestilence in the Australian sugar industry: Crop protection capacity and resilience built by agricultural extension', *Crop Protection*, vol. 37, pp. 71-80.

O'Brien, D, Davies, A, Nash, M, Di Bella, LP, Turner, R, Reghenzan,i J & Brodie, J 2013, 'Water quality within the Herbert River catchment associated with specific land use', in *Proceedings of the Australian Society of Sugar Cane Technologists*, vol. 35.

O'Brien, D, Davies, A, Nash, M, Di Bella, L, Turner, J & Brodie, J 2014, 'Herbert water quality monitoring project: 2011-2013 results', in *Proceedings of the Australian Society of Sugar Cane Technologists*, vol. 29.

Macadam, R, Dinan, J, Inall, N & McKenzie, B, 2004, '*Growing the capital of rural Australia: The task of capacity building*'. Rural Industries Research and Development Corporation, Canberra , pp.1-68.

Vanclay, F, 2004, 'Social principles for agricultural extension to assist in the promotion of natural resource management', *Australian Journal of Experimental Agriculture*, vol. 44, pp. 213-222.