Translating Science into Policy: setting nutrient limits for agricultural land use

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Abstract

The paper addresses the translation of science into policy prescriptions for managing impacts of nutrients from agricultural intensification on water quality. Developing policy prescriptions to manage cumulative effects of diffuse source pollution with the expansion of the dairy industry has been a significant challenge in New Zealand. Four case studies illustrate the problems of impact assessment processes, cap-and-trade markets, and, equity in allocation and with reliance on modelling. Alternative policies from other countries are identified to address these issues, respectively, demonstration of sustainability, mitigation cost recovery charges, and reallocation processes incorporating equity and other sustainability criteria.

1. Introduction

The paper addresses the translation of science relating to the impacts of nutrients from agricultural land use intensification on the water quality in lakes and rivers into policy prescriptions when the impacts have reached or surpassed critical environmental thresholds. The expansion of the dairy industry in New Zealand has led to increased nutrients in waterways with water quality deterioration resulting in algal and macrophyte growth and nitrate toxicity in rivers, eutrophication and algal blooms in lakes, and contamination of groundwater used for drinking water purposes (Parliamentary Commissioner for the Environment, 2013). Developing policy prescriptions to manage cumulative effects of diffuse source pollution has been a significant challenge.

The main legislative base in New Zealand for policy formation is the Resource Management Act (RMA) (New Zealand Government, 1991). It is based on enabling resource use while managing the effects of activities within environmental limits. The purpose of the legislation is to provide for the sustainable management of natural and physical resources. This is defined as enabling people to use resources while avoiding, remedying or mitigating adverse effects on the environment. The legislation has been effective in managing the impacts of point source discharges but is not well suited to managing cumulative impacts of diffuse sources from land use intensification.

The paper considers four case studies to highlight some of the challenges and then considers alternative policy frameworks from other countries that provide possible solutions to the issues identified in the case studies.

The first issue is the difficulty of environmental assessment processes to manage development with small to moderate impacts when the cumulative effects of current development exceed the desired environment limit. The example of the assessment of the Central Plains Water irrigation project is discussed where development was approved despite nitrate criteria already being exceeded for groundwater, surface water and a lake (Milne et al, 2010). An alternative to effects-based assessment is Arizona's approach to groundwater management where overdraft is severe; developers have to demonstrate that water of sufficient quantity and quality is available to sustain the proposed development for 100 years (Arizona Department of Water Resources, 1980). A second alternative is the Sydney Catchment Authority's approach in relation to catchments at water quality limits – the Neutral or Beneficial Effect on water quality assessment methodology (NorBE) (Sydney Catchment Authority, 2015).

The second issue is the use of a cap-and-trade market for nitrogen discharge allowances that was used for Lake Taupo (Environment Waikato, 2003). The nitrogen cap was met not by trade in allowances from improved management practices but by government purchase of allowances and farms. In addition, the nitrogen cap was set too high to achieve the water quality target so further reductions are needed. A more effective approach is the system of mitigation cost recovery charges used for the Murray Darling Basin Salinity Strategy (Murray-Darling Basin Ministerial Council, 2015). Every new action that adds salt to the Murray River and for every delayed action salinity impact of past actions there needs to be another action that reduces the salinity impacts of new actions and delayed effects of past actions by the same amount. Actions that increase salinity need to pay the marginal cost of salinity mitigation projects in order to offset the increases in salinity.

The third issue is the equity of allocation associated with discharge allocations when limits on nutrient loads are imposed to meet water quality requirements. The cases of the management of nutrient limits for the Hurunui River and Wainono Lagoon are discussed. There was not only the issue of allocation of limits among existing users but also the issue of creating headroom for future development. An alternative is the South African Water Act (Republic of South Africa, 1998) which has provisions for dealing with equity issues and matters of constrained allocation for water quantity and water quality for existing and new users. There is a compulsory licensing process for determining allocation that incorporates equity and other sustainability criteria.

2. Assessments of Proposed Developments When Cumulative Effects Exceed Environmental Limits

Effects-based legislation does not require elimination of adverse effects. In the case of New Zealand, the RMA seeks to ensure that adverse effects "are no more than minor". This allows small adverse effects for projects that are approved. The cumulative outcome is for increasing degradation of the environment. Effects-based legislation allows for extraction or discharge up to and even beyond environmental limits.

2.1 New Zealand Case Study: Central Plains Water Irrigation Scheme

A significant concern with the Central Plains Water Irrigation Scheme was nitrate leaching into groundwater from land use intensification. Groundwater is used for drinking water supplies and feeds lowland streams that discharge into a coastal lake.

At the time of the hearings for the consent application, 3% of the monitoring wells exceeded the nitrate standard for drinking water (11.3mg/L). In relation to nitrate toxicity, nitrate concentrations in the lower reaches of the Selwyn River exceeded the threshold for chronic toxicity of highly disturbed systems in environments that are considered measurably degraded (3.6mg/L nitrate-nitrogen median value). For algae in lowland streams the maximum limit for chlorophyll *a* is 200mg/m^2. This is exceeded 95% of the time in the Selwyn River. The coastal lake had a Trophic Level Index (TLI) of 7.0 while the objective was to achieve a TLI of 6.0. The catchment already exceeded the sustainability limits for water quality (Bidwell & Norton, 2009).

The hearing commissioners acknowledged that the Scheme would increase nitrate concentrations in the aquifer, lowland streams and coastal lake. They also acknowledged that nitrate levels would be further increased from other recent intensification because of the time lag in groundwater transport. They noted the conflict of the Scheme with water quality objectives and policies but considered the likely adverse effects of the project would be “minor”. Where the purposes of the RMA (i.e. enabling resource use, and, managing effects within environmental limits) are in conflict an ‘overall judgement’ is needed (Skelton & Memon, 2002). The hearing commissioners’ judgement was that the project should proceed because of the economic benefits but be subject to conditions requiring a high standard of management of nitrate discharges. The consent was granted subject to the adoption of best management practices through Farm Environmental Plans to mitigate the impacts of land use intensification (Milne et al, 2010).

Subsequent cumulative effects analysis estimated that the current nitrogen load to the lake is 2,650 tN/y. The equilibrium load (i.e. allowing for the time lag in groundwater transport) for the 2011 land use was estimated to be 4,100 tN/y. With the addition of Central Plains Water Irrigation Scheme and from further gradual intensification the load is estimated to be 5,600 tN/y (Canterbury Water, 2013). This is more than double the nitrogen load where the sustainability limits of water quality have been exceeded.

2.2 Compliance with Sustainable Strategy Policy Option: Arizona Groundwater AMA

Rather than a reliance on effects-based assessment, the alternative of demonstrating compliance with a regional sustainability strategy is a more effective way of achieving sustainable management of cumulative effects. A water quantity example of this policy approach is in Arizona with its Groundwater Code. The Code designates groundwater basins where water extraction is at sustainability limits as ‘active management areas’ (AMAs) (Arizona Department of Water Resources, 1980). In these areas developers have to demonstrate that water of sufficient quantity and quality is available to sustain the proposed development for 100 years including demonstrating consistency with the AMA’s Groundwater Management Plan.

The Arizona requirements for AMAs are set out in their “Assured and adequate water supply rules”. Developers are required to demonstrate:

- Physical water availability: Physical availability of the water supply is typically demonstrated through a hydrologic study. For groundwater, the study must consider demands of area users for a 100-year period, and projected water levels may not exceed depth limitations specified in the rules.

- Legal water availability: Legal rights to the water must exist.
- Continuous water availability: Water providers or developers must demonstrate that the water supply is uninterruptible for the 100-year period, or that sufficient backup supplies exist for any anticipated shortages.
- Financial capability: Water providers or developers must demonstrate financial capability to construct the water delivery system and any storage or treatment facilities.
- Water quality: Proposed sources of water must satisfy existing state water quality standards and any other quality standards applicable to the proposed use after treatment.
- Consistency with the management goal: Developers or water providers must demonstrate that renewable water supplies will be available.
- Consistency with the management plan: Each AMA's Groundwater Management Plan prescribes water conservation requirements for municipal water providers. Water demand associated with proposed developments is evaluated in accordance with these conservation requirements.

Rather than an assessment of environmental effects there is a requirement to determine the consistency with the management goals in an active management area.

2.3 Neutral or Beneficial Effect Policy Option: Sydney Catchment Authority

Another policy approach is the Sydney Catchment Authority's Neutral or Beneficial Effect on Water Quality Assessment Methodology (NorBE) (Sydney Catchment Authority, 2015). The approach was developed in response to the State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011 requirement (Part 2 Clause 10(1)) to have a neutral of beneficial effect on water quality. This is a very different approach to the RMA which allows resource use and development while avoiding, remedying or mitigating any adverse effects of activities on the environment.

Under Section 34B of the New South Wales Environmental Planning and Assessment 1979 Act, provision is to be made in a State Environmental Planning Policy to refuse consent to development applications relating to any part of the Sydney drinking water catchment unless the consent authority is satisfied that the proposed development would have a neutral or beneficial effect on water quality.

A neutral or beneficial effect on water quality is satisfied if the development:
(a) has no identifiable potential impact on water quality, or
(b) will contain any water quality impact on the development site and prevent it from reaching any watercourse, waterbody or drainage depression on the site, or
(c) will transfer any water quality impact outside the site where it is treated and disposed of to standards approved by the consent authority.

This can be contrasted with RMA Section 104D which provides an alternative to refusal when a development is contrary to a plan i.e. the development can be approved if the adverse effects are considered minor even if contrary to the planning objective.

3. Economic Instruments for Achieving Water Quality Criteria

Economic instruments are one tool to improve water quality in degraded water bodies. A common policy approach is a cap-and-trade system. The concept is that individual nutrient discharges are limited to an allowance and the total amount of allowances is limited to an overall cap set to achieve the desired water quality. Individual allowances can be traded. Individual dischargers must surrender sufficient allowances to cover their discharges at the end of a trading cycle. If a discharger has insufficient allowances to cover their discharges they must purchase additional allowances. If a discharger has surplus allowances, they can sell the surplus. The theory is that trading facilitates the least cost solution to pollution reduction.

3.1 New Zealand Case Study: Lake Taupo Nitrogen Cap-and-Trade Approach

Lake Taupo is New Zealand's largest lake. The lake is sensitive to nitrogen, with algal growth increasing with more nitrogen. Under pre-agricultural development the nitrogen load is estimated to be 650 tN/y and it is currently estimated to be 1360 tN/y. Groundwater carries most of the nitrogen from land use intensification and can take many decades to reach the lake. Studies estimate that between 20 and 80% of the current amount is yet to come before equilibrium is reached with current land use (Vant & Smith, 2004). Water quality was deteriorating and in 2001, for the first time, a potentially toxic algal bloom occurred.

The goal became to return water quality to 2001 levels by 2080. To achieve this goal a target was set to remove 20% of manageable (i.e. human-induced) nitrogen (186 tN/y of 930 tN/y) by 2018. While farms occupied 18% of the catchment, they contributed more than 90% of the manageable nitrogen. A cap-and-trade approach was introduced for farmers' nitrogen discharges. A cap was placed on the total nitrogen that was to be discharged and nitrogen discharge allowances were provided to farmers (Waikato Regional Council, 2011).

The allocation of nitrogen discharge allowances (NDAs) was a contentious issue as they not only enabled farms to function but also had value in any trading system. NDAs were allocated on historical use – referred to as 'grandparenting'. This is consistent with existing use rights under the RMA. Farm-specific figures were calculated (rather than measured) using a farm nutrient management model called Overseer®.

The Lake Taupo Protection Trust was established to administer an $81.5m fund from central, regional and district government to stand in the market to purchase NDAs and/or farmland to achieve the permanent removal of 186 tN/y of nitrogen (Lake Taupo Protection Trust, 2013). The target has been achieved ahead of schedule but with 90% of the reduction through purchases by the Trust rather than farmers trading discharge allowances. The price in 2012 was around $NZ300 per kg (OECD, 2015). The outcome has been achieved by taxpayer/ratepayer funds rather than polluter pays.

Because of the time lag of groundwater from past land uses, the goal of achieving improved water quality has been set for 2080. However indications are that a 20% reduction in nitrogen leaching from current land use will be insufficient to reduce the catchment load to meet 2001 water quality levels. Scientific estimates for the exact percentage of the load to come range from 30% to 41% of the current manageable load with other estimates as high as 80% (Hadfield et al 2007). These higher estimates mean greater reductions in nitrogen (and greater cost in purchasing land and NDAs) would be needed to meet the water quality target.

3.2 Mitigation Cost Recovery Charges: Murray-Darling Basin Salinity

An alternative economic instrument that has been successful in achieving improved water quality on a polluter pays basis is the mitigation cost recovery charge approach to address salinity impacts from mainly farming activities in the Murray-Darling Basin.

Salinity of the River Murray has been a major concern in the Murray-Darling Basin, a very large catchment (1,061,469 km^2) involving four states in Australia (Queensland, New South Wales, Victoria and South Australia). A strategy has evolved over the last thirty years to reduce the salinity to achieve the target of 800 EC units at Morgan (the offtake for Adelaide's drinking water supply) for 95% of the time (Murray-Darling Basin Ministerial Council, 2015).

The focus of the Murray-Darling Basin Salinity Strategy is ensuring that for every new action that puts salt in the River Murray and for the delayed salinity impacts of past actions there is another action that reduces the salinity impacts of new actions and delayed effects of past actions by the same amount. A key element of the Strategy is the establishment of two salinity registers: Register A for new actions since the signing of the Murray-Darling Basin Agreement, and, Register B for the delayed salinity impacts of actions prior to the signing of the Agreement.

The Salinity Registers are a credit and debit based salinity accounting system which tracks all actions that are assessed to have a significant effect on river salinity. A significant effect is defined as a change in average daily salinity at Morgan that will be at least ± 0.1 EC by 2100. The salinity registers provide the primary record of accountability for actions that affect river salinity.

Salinity credits (reductions in river salinity) can be achieved by investing in salt interception schemes, improving irrigation management to reduce saline drainage, ceasing irrigation, and increasing environmental flows in rivers. Salinity debits (increases in river salinity) primarily occur through new irrigation development. Salinity impact assessments estimate the average annual salinity debit or credit by modelling the effects of actions over a benchmark period (1975-2000).

Each State is required to prepare annual accounts to demonstrate that there are salinity credits to offset salinity debits. There is also a requirement to meet "end-of-valley salinity targets" for major tributaries, e.g. in Victoria this is a delegated responsibility of Catchment Management Authorities. Salinity credits can be earnt through joint works where all States contribute to the cost of salinity reduction measures (primarily salt interception schemes) or through measures undertaken within the State. While States are responsible for the costs, the cost of the credits is passed on to the beneficiaries of the credits through salinity levies. The financial cost per EC unit is determined annually. For example, in Victoria charges are imposed on new water use licences in salinity impact zones to fund measures that will offset the salinity impact on the river as a result of increased water use. Detailed hydrogeological assessments underpin the salinity impact zones and the capital charges reflect the estimated salinity impact caused by irrigation in the zone.

The implementation of the Salinity Management Strategy has led to a reduction in modelled 95 percentile salinity at Morgan over the benchmark period from 1050 EC in 1988 to 710 EC in 2015.

4. Equity of Allocation of Scarce Water Quality Capacity

A further emerging issue associated with the management of cumulative effects is equity in allocation of nutrient capacity. One type of issue is the allocation between existing users. A second type is between existing and future users: for further land use intensification to occur, existing users have to reduce their cumulative nutrient contribution below the specified limit(s) to create capacity (often referred to as 'headroom'[1]) for future intensification. The approaches taken in the Hurunui-Waiau Zone and the catchment of Wainono Lagoon illustrate the problems that are arising.

4.1 New Zealand Case Studies: Hurunui-Waiau and Wainono Lagoon

Two significant issues have arisen in relation to the setting of nutrient limits in catchments where estimates of current discharges have been assessed to have reached or exceeded desired nutrient limits. One issue relates to the creation of headroom for further land use intensification. This has implications for those responsible for existing discharges as well as new applicants. The second issue is the calculation and allocation of allowances for land uses creating nutrient discharges. This is heavily reliant on data availability and modelling of the effects of land use on waterways. Two examples are considered below: one from the Hurunui and Waiau Rivers, and the other from Wainono Lagoon.

Hurunui and Waiau Rivers

There had been a history of algal blooms from nutrient enrichment in the lower Hurunui River (Ausseil, 2010). Setting nutrient load limits was designed to control land use change that would increase nutrient loads. A change in land use on a property basis was determined as an increase greater than 10% in the long term average release of nitrogen and phosphorus to land which may enter water (Environment Canterbury, 2013)

However the "10% rule" places greater constraints on sheep and beef farmers with low nutrient loss rates (e.g. 5 kgN/ha/y for dryland sheep and beef farms on poorly drained soils which allows 0.5 kgN/ha/y change) compared to an irrigated dairy farmer with high nutrient loss rates (e.g. 61 kgN/ha/y for irrigated dairy farms on extremely light soils which allows 6.1 kgN/ha/y change). Furthermore the 10% rule allowed the Amuri Irrigation Company to expand its irrigated area in the Hurunui catchment by offsetting increased nitrogen loads from converting dryland sheep and beef farms to irrigated dairy farms, against decreased nitrogen loads from irrigation efficiency improvements on high loss rate farms, and secondly in the Waiau catchment by limiting expansion to 6.5% increase in nitrogen loadings (Environment Canterbury, 2015a). Such conversion options were not available to individual sheep and beef farmers under the 10% rule.

[1] Headroom is available when the current load is lower than the load limit. Headroom is equal to the difference between the load limit and current load.

The sheep and beef farmers expressed concern that the 10% rule did not provide sufficient flexibility for “normal” variations in sheep and beef farming, such as increased planting of fodder crops which could trigger the land use change rule. This led the regional council to issue an advice note that normal dryland farming changes would not be considered a change in land use under the 10% rule and that the regional council does not intend to undertake enforcement action against dryland farmers for normal variations in farming practice (Environment Canterbury, 2015b).

Wainono Lagoon

Water quality in the Wainono Lagoon has a Trophic Level Index (TLI) of 6.5 and a goal of achieving a TLI of 6 has been set (Canterbury Water, 2014). To achieve this there was a need to reduce the nitrogen loading in the catchment of the lagoon. Under the proposed Land and Water Regional Plan in catchments of lakes like Wainono Lagoon existing users would be constrained to their nitrogen baseline (the mean discharge of nitrogen below the root zone for the years 2009-13 calculated by a model called Overseer®), or for low emitters to 10 kg/ha/y.

However a group of farmers expressed dissatisfaction with the nitrogen allocation framework in relation to the equitability of the framework for low emitters compared to high emitters. The concern was not about the need to set catchment load limits to achieve environmental outcomes but the method of allocation (Norton et al., 2014). The Nitrogen Allocation Reference Group (NARG) was formed comprising farming interests, rūnanga representatives and general community interests.

Grandparenting of current discharges (the Land and Water Regional Plan proposal) was rejected. A cornerstone of the agreed framework was the requirement for all land users to achieve a minimum of Good Management Practice with respect to nutrient discharges so that poor performers were not rewarded with high nitrogen allocations. With allocations based on first-come, first-served under the RMA there is no incentive to minimise discharges or maximise efficiency beyond the minimum requirements of consent conditions.

The main area of negotiation was the need to create headroom from improved management by high emitters to enable flexibility for nitrogen load increases by low emitters. “Maximum caps” were to be placed on high emitters according to soil type (35 kg/ha/y for light soils, 25 kg/ha/y for medium soils and 20 kg/ha/y for poorly drained soils) and that they be given a time period to adjust. “Flexibility caps” were set for low emitters. Initially these would be set at 10 kg/ha/y (excluding steep hill country farmers who would be assigned 5 kg/ha/y). (Norton et al., 2014).

The agreement by the NARG was accepted and was incorporated in the proposed plan change to the Land and Water Regional Plan (Environment Canterbury, 2015c).

However since the preparation of the proposed plan change there has been a revision of Overseer® (the model used to estimate nitrogen loss rates for farms), adjustments to the leaching rates from the Look-Up Tables (the basis for estimating nitrogen leaching rates from farms with different soil types), concerns about the assumptions about denitrification in poorly drained soils, and revisions to soil mapping in the Wainono Lagoon catchment. The changes affect the calculations of catchment loads and maximum caps and thereby the flexibility caps. Interested submitters on the plan change were asked to caucus on the implications of these changes (Whiting et al. 2015). While there is agreement that the changes need to be addressed, the discussions reignited the debate about the appropriate nitrogen allocation methodology and the fairness of the allocations (Environment Canterbury, 2015d).

4.2 Reallocation Process under Scarcity: South African Water Act

In areas where water quality or quantity is at sustainability limits, there is a need to consider water allocation on the basis of merit rather than 'first-in/first-served' in relation to consent applications. There is also a need to deal with water use efficiencies and discharge management performance that may have been acceptable in the past but now constrain improvements in resource productivity and sustainable management. A good example of a policy approach that addresses these issues is the South African Water Act 1998 which has a provision (section 43) for the responsible water authority to undertake compulsory licensing of any aspect of water use for existing and new users in areas of water scarcity. The process can be undertaken (a) to achieve a fair allocation of water which is under water stress or to achieve equity in allocations; (b) to promote beneficial use of water in the public interest; (c) to facilitate efficient management of the water resource; or (d) to protect water quality. In the reallocation process the responsible water authority can consider a wide range of factors including existing lawful uses, investments already made, redress of past discrimination, socio-economic impacts, catchment strategies, effects on the resource and other users, water quality objectives, strategic importance of use, reserves for future use and international obligations, and duration of use.

This approach provides a systematic framework for addressing issues related to equity in allocation while incorporating provisions for improving water use efficiency and discharge management for both existing and new users.

5. Concluding Comments

This paper has identified three issues in relation to developing policy to address the management of cumulative effects of diffuse sources from agricultural land use intensification. Using the analysis of case studies from New Zealand to identify deficiencies in current policy and alternative policy approaches from other jurisdictions the paper concludes that:

- Policy on assessment processes requiring development to demonstrate compliance with a regional sustainability strategy is a more effective approach than environmental assessment of development to ensure effects are less than minor.
- Policy for economic instruments based on mitigation cost recovery charges is more likely to ensure polluters pay for water quality remediation than a cap-and-trade approach.
- Policy for resource allocation when sustainability limits are reached adopting the reallocation of available water or water discharge capacity among existing and future users is a more effective approach than reliance on first-come, first-served allocation and existing use rights in achieving equity among users, resource productivity and sustainable management.

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