Landcare Research
Manaaki Whenua
POLICY BRIEF

Sharing the Pie: The dilemma of allocating nutrient leaching between sources

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KEY FINDINGS

There is no universal 'best' approach to allocate nutrients to landowners. In an analysis that compares different allocation approaches in two catchment settings we find that the efficiency and equity implications of the various approaches differ based on existing land use, land characteristics, and the stringency of the regulation.

To move past the current impasses and debates on allocation, decision-makers should recognise that different stakeholders are likely to prefer diverse approaches. The *a priori* identification of criteria to compare allocation approaches is needed to focus discussions. Efficiency and equity in these dialogues will be important as these relate to the size of the costs and benefits and who bears the costs. Policy can be designed to improve efficiency and to compensate, where necessary, those most affected.

BACKGROUND

The National Policy Statement for Freshwater Management (NPS-FM) provides a framework that directs how councils are to set objectives, policies, and rules about freshwater in their regional plans. They must do this by establishing freshwater management units across their regions and identifying the values (for example, irrigation, mahinga kai, swimming, etc.) that communities hold for the water in those areas. A key outcome of the NPS-FM will likely be that many regional councils will have to place limits on the nutrient loads in catchments under their jurisdiction. As part of the limit-setting process, the total catchment load (i.e. a cap on nutrients) may have to be allocated between all resource users, including diffuse sources such as agriculture and forestry. This is typically done by issuing nutrient discharge allowances (NDAs). Thus, the question in this situation is how best to allocate these limited resources, i.e. the amount of nutrients allowed to be discharged into a waterbody by a given entity is a critical question to address and one to which there is no easy answer.

The tenor of debate can be contentious when establishing a nutrient reduction limit. Catchment caps or targets set at existing (or even slightly higher) discharge levels have implications for potential new entrants and future growth, and for potentially maintaining the longer-term financial viability of landowners as costs increase but their ability to intensify to maintain profitability is limited. A more stringent cap that requires a reduction from existing discharge levels has immediate financial implications, and may endanger the viability of some impacted operations. Therefore, where 'clawback' or a lower cap is set, the allocation debate is likely to be more controversial.

With diffuse sources like agricultural and forestry operations, the debate becomes even more challenging as soil characteristics, rainfall, topography, and how the land is managed can play a large role in the amount of nutrients that reach a waterbody. This means nutrient losses need to be estimated on an individual farm basis and there is frequently wide variability in discharge levels across a catchment.

There are two common aims when setting policy, including freshwater policy. One is that policy is implemented at least cost or minimum loss to society, i.e. the policy is efficient as it maximises total net benefits. The other relates to the distribution of an economy's resources, i.e. the policy's impacts are perceived to be equitable by all stakeholders involved. Equity is particularly challenging as the definitions of equity are subjective and involve value judgements that can vary between people. Defining principles for what stakeholders wish to achieve through the policy can help equity judgements. One consideration many stakeholders frequently wish to understand when judging equity is where the cost burden of the policy lies.

Both efficiency and equity are important considerations and the design of an optimal policy and may involve a trade-off between efficiency and equity objectives. This is often the case with a regulatory approach that involves the allocation of a catchment cap between sources as typically there is no 'right' allocation approach that maximises both objectives for all affected stakeholders. Rather it is a decision on how to weight questions of efficiency and equity and how equity is being judged. The debate on the appropriate allocation approach to use is often heated, with various sources arguing about who loses the most today and who loses the most in the future, i.e. about questions of equity.

While economic analyses can help identify the most efficient allocation approach with the lowest overall financial burden (i.e. impact on net farm revenue), it can only provide insights on some of the equity implications, which are then considered by the decision-maker(s). In the following analysis, equity implications are considered in terms of how costs are distributed under different allocation approaches.

APPROACH

Comparing the Hinds and Selwyn catchments in Canterbury (see Fig. 1) allowed us to demonstrate the efficiency and equity (as defined above) implications of six different approaches to allocate non-point source nutrient discharges under three nitrogen (N) reduction scenarios. The assessment used the New Zealand Forest and Agriculture Regional Model (NZFARM) to assess the economic and environmental impacts to reduce N loads from the agricultural and forestry sectors. The spatially explicit agro-environmental economic model estimates changes in land use, agricultural output, farm management, and environmental impacts at the sub-catchment level. Based on this assessment we can draw some general conclusions on the applicability of allocation approaches for non-point source discharges based on efficiency and equity grounds as we compare the approaches across catchments and the stringency of regulation. More details of the model, catchments, management practices, and initial nutrient allocation are outlined in an accompanying technical document.[1]

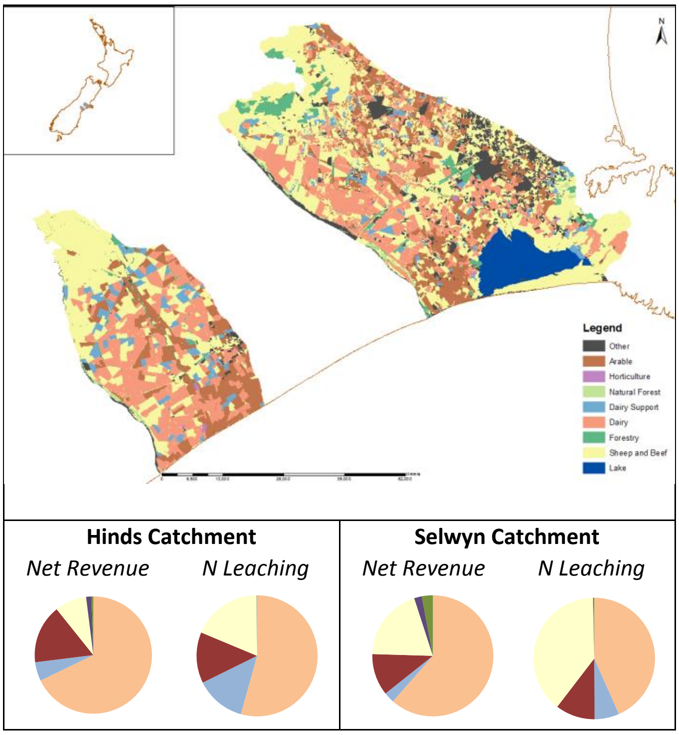

Figure 1 Hinds and Selwyn Catchment baseline land use, net farm revenue and N leaching distribution.

ALLOCATION APPROACHES

The different allocation approaches are derived from approaches proposed by regional authorities, industry bodies, and researchers. Four of the approaches are based on existing land use and two are based on land characteristics (see Table 1).[2] To help achieve their limits farmers can also implement a number of nutrient mitigation practices. In all cases it is assumed that existing land uses can continue as long as they operate within their allocated NDA, but any change in land use must be within the property's existing discharge allowance. Included in the comparison is a least cost option to demonstrate the most efficient outcome for the catchment. This can be interpreted as a catchment having a single landowner who is making the optimal economic decisions for the whole catchment.

Table 1 Modelled allocation approaches

Allocation	Description
Grandparent	NDA based on N leaching rates during a baseline or benchmarking period and proportional to reduction target.
Natural capital	NDAs are allocated based the physical quality of the land, soil and environment. Land use capability (LUC) is used as a proxy for natural capital, and more NDAs are allocated to higher class land.
Catchment average	All landowners are given the same NDA regardless of land use and this is the average of total N discharge from land-based sources.
Land cover average	Landowners managing a specific land cover (e.g. pasture, forest, arable) are given the same NDA.
Sector average	Landowners within the same sector (e.g. dairy, sheep and beef) are given the same NDA.
Nutrient vulnerability	NDAs allocated based on the nutrient leaching capacity of the soil. More NDA would be allocated to land with lower 'vulnerability'.

ILLUSTRATING THE ALLOCATION DILEMMA

To illustrate how the different allocation approaches work we outline a stylised example of a catchment with four farms:

- Two are irrigated 160 ha dairy farms that produce net returns of about $4,000/ha/yr. Dairy farm A is located on land use class (LUC) class I land with predominantly very light soils that currently leach about 68 kgN/ha/yr.
- Dairy farm B is located on LUC class III land with predominantly medium soils that leach 37 kgN/ha/yr.
- The third farm is a 250 ha dryland sheep and beef (S&B) enterprise on LUC VI land with light soils that leaches 12 kgN/ha/yr and returns $500/ha/yr.
- The fourth farm is a 120-ha mixed arable cropping system on LUC IV land that leaches 27 kgN/ha/yr and nets $1800/ha/yr.

As all four farms are located on different types of soil and LUC, they will receive different N leaching or discharge levels for each allocation approach, as shown in Figure 2.

[1] http://www.landcareresearch.co.nz/publications/factsheets/policy

[2] This is not an exhaustive list of possible allocation approaches.

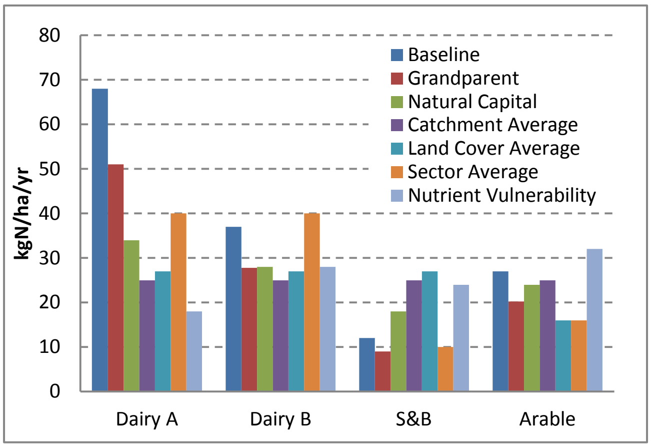

Figure 2 Illustrative distribution of allocated N leaching rates for baseline leaching and 25% N reduction target.

From Figure 2 we can see it is unlikely that any one allocation approach would be 'preferred' by all farmers because of the differing impacts of each allocation approach on farm profitability, both between and within sectors (i.e. each farmer will prefer the option with the highest allocated leaching rate as it is likely to result in the least impact to farm profits). Based on farmers preferring an approach with least (or no) financial impacts, the S&B farmer is likely to prefer the land cover or catchment averaging approaches because they provide an opportunity to expand their operation, while the arable farmer would prefer nutrient vulnerability. The preferred allocation approach even varies between the two dairy farmers. Dairy A would prefer the grandparenting approach as it requires the least reduction in their N leaching, while Dairy B would prefer the sector averaging. Given that many catchments in New Zealand contain hundreds of landowners, this illustrates why allocation decisions can be contentious and complex.

IMPLICATIONS OF DIFFERENT ALLOCATION APPROACHES IN TWO CATCHMENTS

We now consider a more complex set of policy scenarios where landowners in the Hinds and Selwyn catchments must cumulatively reduce their N loads by 10%, 25% or 50% below the no-policy baseline. For context, the average baseline N leaching is 32 kgN/ha in Hinds and 18 kgN/ha in Selwyn. As with the stylised example, the catchment-level assessment demonstrates that the preferred allocation approach for each land use differs between catchments and stringency levels. The discussion below looks at both policy efficiency and implications for the distribution of costs (for assessing equity) to illustrate the challenges involved in these decisions.

Efficiency

Efficiency of the different allocation approaches can be judged by comparing net revenue impacts with the lowest reduction in net revenue for a given N reduction target being the most efficient. From Table 2, the allocation approach in Hinds whose change in net farm revenue is closest to the least cost option is grandparenting for the 10% and 25% targets and natural capital for the 50% target. For the Selwyn, sector averaging is the most efficient allocation option regardless of the N reduction target. However, natural capital, for the 50% N reduction target, has the same level of efficiency as sector averaging.

For the Hinds catchment, the nutrient vulnerability approach is estimated to be the least efficient as it allocates a high proportion of NDAs to enterprises on low vulnerability soils (i.e. low baseline N), thereby requiring many landowners operating on high vulnerability soils to make changes that have significant impact on their profitability. In Selwyn, natural capital is the least efficient for the 10% N reduction target, natural capital and catchment average are least efficient for the 25% target, and for the 50% target it is grandparenting and nutrient vulnerability. These findings indicate there is no most or least preferred allocation option based on efficiency criteria across reduction targets and catchments.

Table 2 Estimated impacts of N reduction policy scenarios

Scenario/ allocation approach	Net Revenue (M$)	N (tonnes)	Net Revenue (M$)	N Leaching (tonnes)
	Hinds Catchment		*Selwyn Catchment*	
Baseline	$246.1	4,443	$294.6	4,266
10% Reduction Target				
Least cost	−1%	−10%	0%	−10%
Grandparent	−2%	−10%	−2%	−10%
Natural capital	−7%	−27%	−11%	−38%
Catchment average	−9%	−35%	−10%	−36%
Land cover average	−9%	−34%	−9%	−35%
Sector average	−5%	−21%	−1%	−10%
Nutrient vulnerability	−10%	−36%	−9%	−34%
25% Reduction Target				
Least cost	−4%	−25%	−3%	−25%
Grandparent	−4%	−25%	−7%	−25%
Natural capital	−9%	−32%	−13%	−42%
Catchment average	−12%	−41%	−13%	−42%
Land cover average	−12%	−40%	−11%	−39%
Sector average	−9%	−31%	−4%	−25%
Nutrient vulnerability	−13%	−43%	−12%	−39%
50% Reduction Target				
Least cost	−14%	−50%	−14%	−50%
Grandparent	−19%	−50%	−24%	−50%
Natural capital	−17%	−50%	−15%	−51%
Catchment average	−21%	−56%	−20%	−54%
Land cover average	−21%	−56%	−19%	−52%
Sector average	−21%	−50%	−15%	−50%
Nutrient vulnerability	−24%	−60%	−24%	−58%

We also see that for many of the allocation approaches, the aggregate reduction in N leached is higher than the specified reduction target. This is because some landowners are allocated more than they currently leach. Therefore, they can maintain their current operations and still have NDAs in reserve to use at a later date. This is one situation where a market-based flexibility mechanism such as trading has benefits. If this option were available, landowners would also be able to sell their excess NDAs to other farmers in the catchment who might find it more profitable to leach more than their initial allocated allowance. This enables those landowners to increase their discharge levels while others decrease their discharges by an equivalent amount. Therefore, the efficiency of the policy will improve as the overall cost of meeting or managing within a limit is reduced.

Equity

While the cumulative change in net catchment revenue can be used to compare the efficiency of the different allocation approaches, additional information is needed for stakeholders to assess the relative fairness or equity of each approach. Provided the N reduction target is set at a level that achieves societal goals, we can implicitly assume that the benefits of the policy to the wider community are accounted for. Regardless of how equity is defined, the distribution of benefits and costs across affected parties needs to be understood. This will be useful during deliberations on equity as it demonstrates how the potential costs differ between sectors. We do this by disaggregating the catchment net revenue effects to the various sectors. The impacts of the 25% N reduction target are shown in Figure 3. We also acknowledge there are within-sector distributional impacts that are not shown in this analysis. What we are illustrating is that the distribution of costs varies between sectors and allocation approaches, and this is why challenges arise.

Figure 3 shows that the financial impacts can vary widely and are not consistent across the two catchments, even for the same reduction target or allocation approach. For nearly all allocation approaches, there are greater impacts on sector net revenue in Selwyn than in Hinds. This is influenced by Selwyn's larger catchment size, and the distribution of existing land uses, which results in a lower mean N leaching rate for that catchment. Forest and horticulture revenues and area are generally estimated to expand much more in Selwyn relative to Hinds because the Selwyn catchment already has some infrastructure for those sectors and hence can more easily support sector expansion.

There are some key observations across the different allocation approaches. For example, the relative and directional impact on arable profits changes significantly depending on the allocation approach, especially in Hinds. Generally, arable farmers stand to lose more under the land cover and sector averaging approach because they have higher leaching rates relative to other enterprises in the catchment (with the possible exception of some dairy and dairy support, which have more cost-effective mitigation approaches available), and thus must mitigate a relatively higher amount of N.

Dairy stands to lose the largest net revenue in nearly all cases. This is expected because dairy is by far the highest earning enterprise and contributor to N losses in each catchment (Fig. 1). However, despite dairy having a relatively high baseline leaching rate it has a range of feasible mitigation approaches available to meet their individual limit.

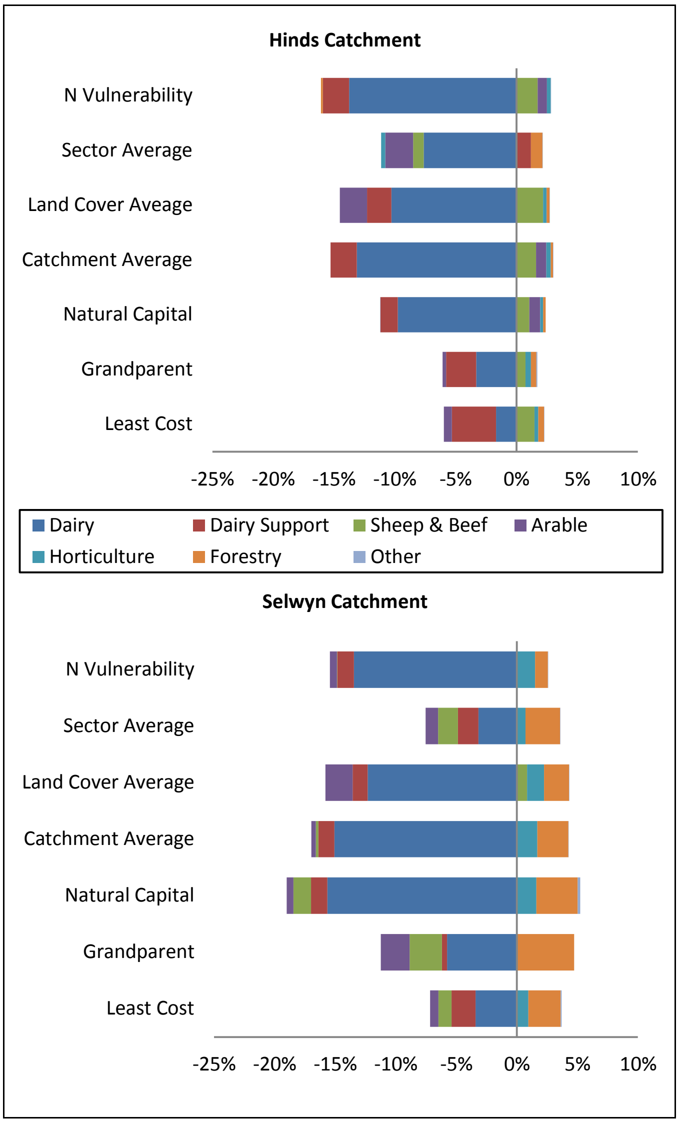

Figure 3 Estimated catchment net revenue change from baseline (% change from baseline total), by enterprise, 25% N reduction target.

Summary

The findings from this analysis demonstrate the challenges that confront decisions to allocate N discharge levels to landowners. There are a number of instances where the most efficient allocation approach also aligns with a particular sector's likely preferred approach in terms of lowest sector losses. For example, for the 25% reduction target in Hinds the most efficient modelled allocation approach is grandparenting, which has the lowest impact on dairy and horticulture revenues. However, grandparenting also has the largest reduction in revenue for dairy support and thus may be a potentially contentious option for some landowners. Thus, more than just catchment-wide policy efficiency may have to be incorporated into the decision-making process.

The process and logic to decide which approach to apply when allocating a catchment cap between sources may therefore involve:

- stakeholders agreeing on the principles of equity that will be used to underpin the decision on the allocation approach. This should be done before identifying what allocation approaches to compare and any economic analyses being undertaken, and is to facilitate a more objective discussion based on these principles
- identifying allocation approaches to consider
- estimating the catchment revenue impacts of each allocation approach to compare the relative efficiency of each approach
- evaluating the distributional impacts of each approach on different land uses
- identifying appropriate policy mechanisms or design. This could, for example, be focused on improving efficiency (e.g. through trading or some other flexibility mechanism) and/or compensating those who face the highest costs or have the least options to mitigate.

CONCLUSIONS

Clean freshwater is one of the resources currently at greatest risk in New Zealand and national policy directions are being defined to maintain or improve the overall quality of freshwater in the different regions of New Zealand.

One of the policy responses to address declining water quality is to regulate the loss of nutrients coming from diffuse sources. This is when the quandary of how to allocate an overall catchment cap (or nutrient load limit) to individual landowners arises. There is some debate that has focused on how to define a common approach across the country. We have demonstrated, however, the role that heterogeneous land uses and land characteristics within a catchment play in these decisions, the importance of efficiency and equity considerations, and why these decisions are so challenging.

Our analysis demonstrates that the most efficient allocation approach and the cross-sector distribution of costs when limiting N discharges will differ between catchments because of differences in existing land use and land characteristics, and the stringency of the regulation. We use an economic modelling approach to show that there is no universal 'best' allocation approach. While it seems that at lower regulatory stringencies the approaches related to existing land use do appear more efficient this does not hold at higher stringency levels. Therefore, debates should focus on which approach to choose based on, at least, efficiency and equity grounds and then to design policy to, for example, improve efficiency and/or compensate those most affected. Compensation could take many forms such as direct compensation for losses or extending compliance periods.

Economic analyses provide key pieces of information to understand the implications of the various allocation approaches and are necessary but not sufficient to determine which allocation approach to implement. Economic analysis can help identify the most efficient allocation approach but can only provide insights into which sector (or which landowners within a sector) bare the greatest costs. Therefore, it is the purview of the decision-makers to decide which approach, and potential compensation and flexibility mechanism, is best suited to the land uses and land characteristics in any given catchment and for the people within that catchment, based on concerns for an economically efficient and equitable outcome.

FURTHER READING

Daigneault A et al. 2013. Evaluation of the impact of different policy approaches for managing to water quality limits. Report to the Ministry of the Environment, Wellington, New Zealand. www.mfe.govt.nz/publications/fresh-water/modelling-economic-impacts-nutrient-allocation-policies-canterbury-hinds

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Kerr S, Lock K 2009. Nutrient trading in Lake Rotorua: cost sharing and allowance allocation. Motu Working Paper 09-09. www.motu.org.nz/publications/detail/nutrient_trading_in_lake_rotorua_cost_sharing_and_allowance_allocation

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