Improving water quality in Waikato-Waipa Catchment: Options for dry stock and dairy support farms

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ABSTRACT
Sheep and beef farming industry is probably more challenging than any other industries in New Zealand. Farm costs are rising without corresponding price increases for wool and meat. On top of that is the reality that restoring and maintaining water quality has gone beyond expectations on any one industry alone. As part of a project to study the costs of meeting water quality in Waikato region, sheep and beef, including dairy support farms were surveyed to identify 5 'typical' case study farms/systems in terms of main enterprises and other factors that characterise the farms. The farms were then modelled with different but relevant nutrient loss mitigation practices based on the farms' main enterprises and characteristics. FARMAX® model was applied to investigate biological feasibility and financial implications of the mitigation practices and then OVERSEER® model was applied to estimate the nutrient budgets associated with the mitigation practices. The results show some trade-off, but also, that mitigating nutrient loss is possible even with increased financial net benefits in some cases. However, the socio-economic, cultural and demographic factors that could impact on farmers' decision were not captured with the data used and so those factors have not been considered.

Key words: sheep and beef farming, water quality, nutrient loss, mitigation, farm-level, abatement, mitigation, catchment

[2] Being a paper presented at the 2014 NZARES Conference theme "Farming to Changing Expectations", 28-29 August 2014, Tahuna Conference Centre, Nelson

GENERAL OVERVIEW

As part of the Joint Venture Economic Studies of the costs of meeting water quality in Waikato region, and flowing on from the previous phase in the project where sheep and beef farms was less represented, in this current phase, the main objective is to bridge that gap. Specifically analysis of some nutrient loss mitigation practices for identified ‘typical' farms/systems in order to add to the range of options that farmers would have in mitigating nutrient loss, and how these options would affect farm businesses financially and environmentally. Based on a previously Waikato Regional Council's survey of 450 dry stock sheep and beef farms in the region, we purposely sampled 20 farms to cover the region spatially, and the farm systems clusters identified in the previous 450 farms survey. We collected farm level information, animal transactions information, etc. but we extrapolated regional climate and financial data on the farm data for the purpose of generalisation such that no individual farmer/farm's data will be identified.

Data from 13 case study farms were complete and used to represent 5 ‘typical’ farm systems across the region. The data typify empirical data which contain quality information, but lack statistical properties. The farm-level data were complemented with appropriate data-validating techniques such as literature and expert knowledge from farmers and rural consultants. Based on the some characteristics of the ‘typical’ farms, we have examined some mitigation scenarios that would reduce on-farm loss of nutrients (N and P). We considered different but relevant mitigation options at different levels. Relevant in terms of ‘typical’ farm systems i.e. the main enterprise and the main source of nutrient loss. For example,

- reducing stocking rate on farms characterised by high stocking rate;
- planting steep slope on farm characterised with some steep slope areas as part of their effective areas;
- substituting maize silage cropping with pasture silage for dairy support
- increasing sheep to cattle ratio on farms characterised by low sheep to cattle ratio and
- substituting older/heavier cattle with younger/lighter cattle on farms characterised by older/heavier cattle

These mitigation options were expected to achieve high impact by targeting ‘hot’ practices[3] on-farm in terms of nutrient inputs and outputs, into and from a particular farm practice. For example, AgFirst (2013) has reported some farm practices that have a direct relationship to nutrient leaching and the extent of mitigation option that can yield substantial mitigation effects. These mitigation options were selected from the "menu of practices" to improve water quality. The menu is a product of a joint project between Meat and Lamb New Zealand and Waikato Regional Council (Waikato Regional Council, 2013)[4]. We then ran FARMAX farm models to examine the biological feasibility of the mitigation options in a scenario or sensitivity analysis and what does it cost (or possibly the gain) to implement the mitigation options in an incremental scenarios. It was assumed that for each farm type, the farm would adopt best management practices in the most efficient ways possible. Then we ran

[3], the main enterprise and land use option

[4]. This menu was put together with the collaboration of 10 organisations – Waikato Regional Council, DairyNZ, Beef+lamb New Zealand, Foundation for Arable Research, Ballance, Fonterra, Federated Farmers Waikato, Federated Farmers Rotorua & Taupo, AgFirst, Healands

OVERSEER farm models to arrive at nutrient loss associated with each mitigation option. The results will be used as an input to Waikato-Waipa catchment modelling by developing models of a set of 'typical' sheep and beef farms, which will be combined with similar information about other land uses, along with hydrological information. The catchment-scale economic modelling is being carried out to estimate the effects of water quality scenarios on farmers' income.

Following the case studies of the mitigation options, a half-a-day farmer workshop was held on 30th June 2014 to serve as a focus group discussion involving farmers and professionals. The purpose of the workshop is to provide a quality check on the nutrient loss mitigation practices analysed in the case studies. We also collected feedback from the industry representative to gather some insights. The results of the case studies and summary of the workshop (focus group discussion) are presented in this report.

CASE STUDIES RESULTS

Cluster I: Small lamb finishing farms with some beef finishing operation

- Average farm size range (ha): 50 - 100
- High sheep to cattle ratio: 70:30
- High stocking rate (SU/ha): 10 to 13

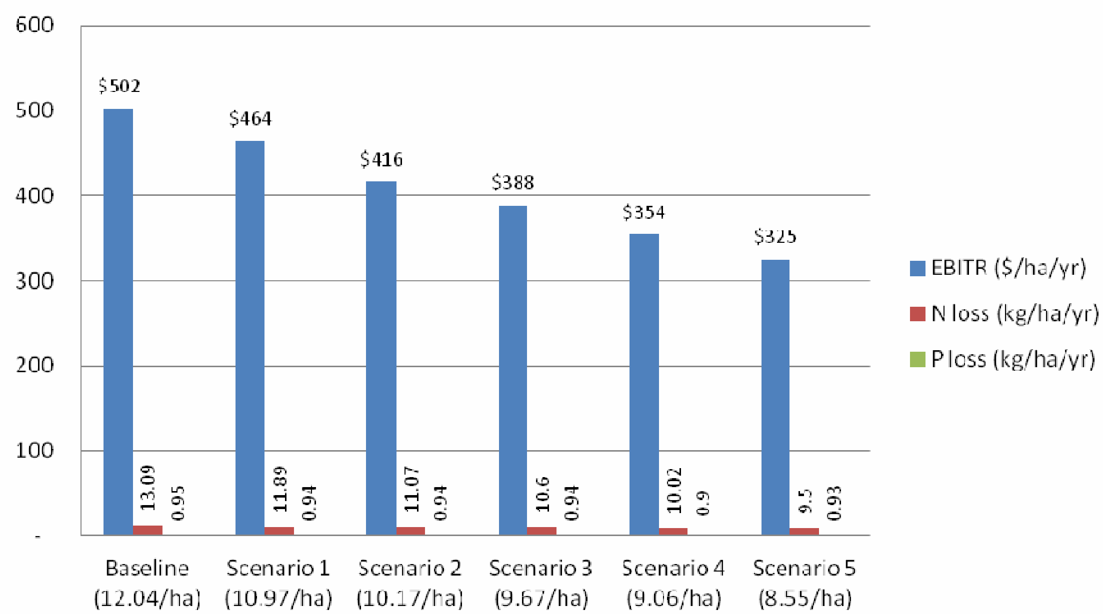
Mitigation

- Reduce stocking rate

Results

This mitigation means lower net revenue with decreasing stocking rate because the rate of revenue loss is greater than the rate of cost saving as stocking rate reduces. This could be as a result of some overhead costs and not pushing the farm to optimum pasture utilisation, although additional revenue from selling extra pasture and reduced costs as a result of a reduction in N fertilizer used has been captured in the results. As stocking rate reduces, both N and P loss reduce because of less stocking pressure From Figure 1, a typical farm in cluster 1 can mitigate nutrient loss by up to 3.6kgN/ha/year and 0.02kgP/ha/year at a cost of $177/ha/year (EBITR). This implies an annual cost of about $50/kg/ha of N mitigated and a relatively massive $8,850/kg/ha of P mitigated.

Figure 1: Cluster 1, FARMAX Mitigation (reduce stocking rate) scenarios results



Cluster II: Traditional hill country with lamb finishing

- Traditionally large farms (ha): 165 - 450ha
- High sheep to cattle ratio: 70:30
- Low stocking rate (SU/ha): 8.5
- High male to female cattle ratio: 70:30
- 10% of effective area in steep slope

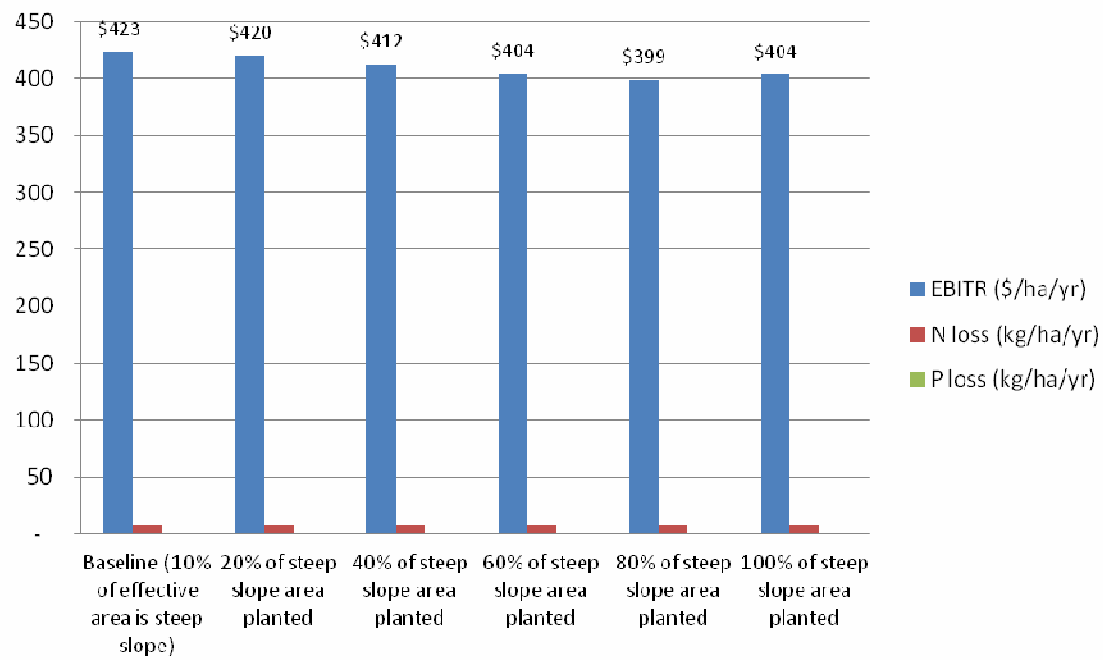
Mitigation

- Plant less productive area (steep slope area) of farm in trees

Results

This mitigation means the added income from on-farm forestry enterprise is marginal and less than the loss in sheep and beef income associated with this option planting the less productive land into trees. The annualised forestry income at a plantation scale was estimated at approximately $200/ha (Harrison & Yao, 2014). This income is lower ($150/ha) at on-farm small-scale level (Yao & Harrison, 2014). The lower forestry income has been used in this analysis. This is to capture some of the socio-economic and demographic factors that could discourage on-farm tree planting. As less productive area is planted in trees, both N and P loss reduce because of less stocking pressure per whole farm area. From Figure 2, a typical farm in cluster II can mitigate nutrient loss by up to 0.28kgN/ha/year and 0.15kgP/ha/year at a cost of up to $19/ha/year (EBITR). This implies an annual cost of about $70/kg/ha of N mitigated and $130/kg/ha of P mitigated.

Figure 2: Cluster II, FARMAX scenarios results



Cluster IIIa: Hill country with maize silage cropping for dairy support

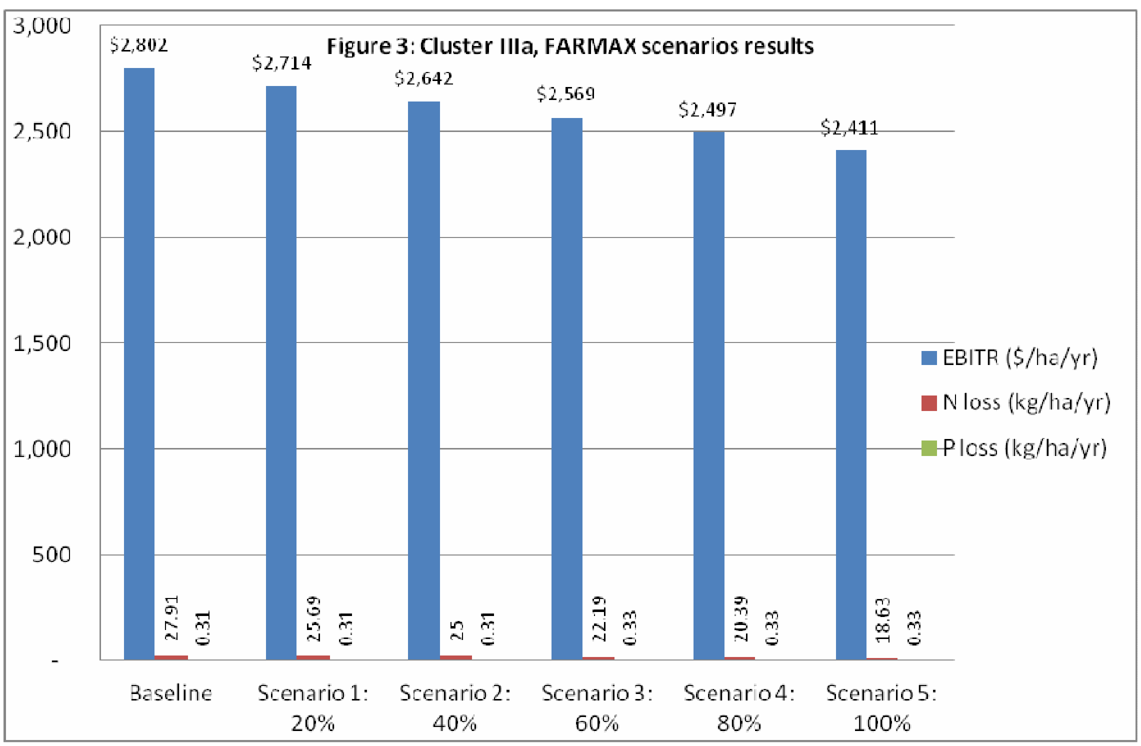
- All cattle
- Average farm size: 35 - 250
- High female to male cattle ratio: 80:20
- Low stocking rate: 8.6
- Wintering dry dairy cows/dairy heifer grazing
- Beef breeding with dairy support operation

Mitigation

- At constant stocking rate, substitute maize silage cropping for pasture silage

Results

This mitigation means revenue loss from less maize silage and additional fertilizer cost of restoring previously planted area to pasture. As less area is cropped, N loss reduce because of less N application per whole farm area but P loss increase marginally as more of maintenance/nutrient loss replenishment fertilizer application increases when returning cropped area into pasture. The cash flow impacts have been considered especially in forestry although the risk management impact of maize silage cropping on contract has not been considered. From Figure 3, a typical farm in cluster IIIa can mitigate N loss by up to 9.28kgN/ha/year while P loss increases marginally by up to 0.02kgP/ha/year at a cost of up to $391/ha/year (EBITR). Similar study (AgFirst 2009) has also reported that limiting fodder cropping has potential to mitigate N loss on a farm. This implies an annual cost of about $40/kg/ha of N mitigated and, however, at $19,550/kg/ha of P loss rather than loss mitigated. The risk management impact of maize silage cropping through contract has not been considered.



Cluster IIIb: Hill country with pasture-based dairy support

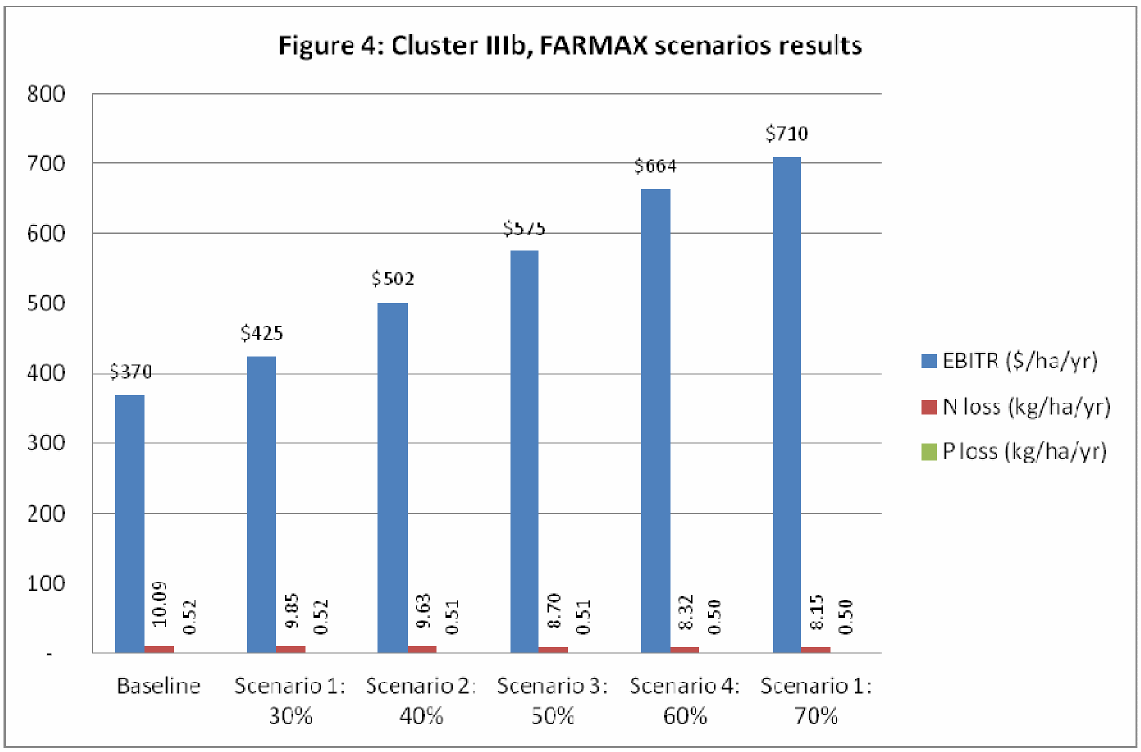
- All cattle
- Average farm size: 35 – 250ha
- High female to male cattle ratio: 80:20
- Low stocking rate: 8.6
- Wintering dry dairy cows/dairy heifer grazing
- Mainly beef breeding with dairy support operation

Mitigation

- Increase sheep to cattle ratio at a constant stocking rate

Results

This mitigation means per ha revenue of a sheep enterprise is higher than per ha revenue of a beef enterprise with increasing sheep to cattle beef ratio. As sheep to cattle ratio increases, both N and P loss reduce because of less stocking pressure per whole farm area. From Figure 4, a typical farm in cluster IIIb can mitigate nutrient loss by up to 1.94kgN/ha/year and 0.02kgP/ha/year at a gain of up to $340/ha/year (EBITR). This implies an annual cost of about $175/kg/ha of N mitigated and $17,000/kg/ha of P mitigated.



Cluster IV: Bull and prime beef finishing

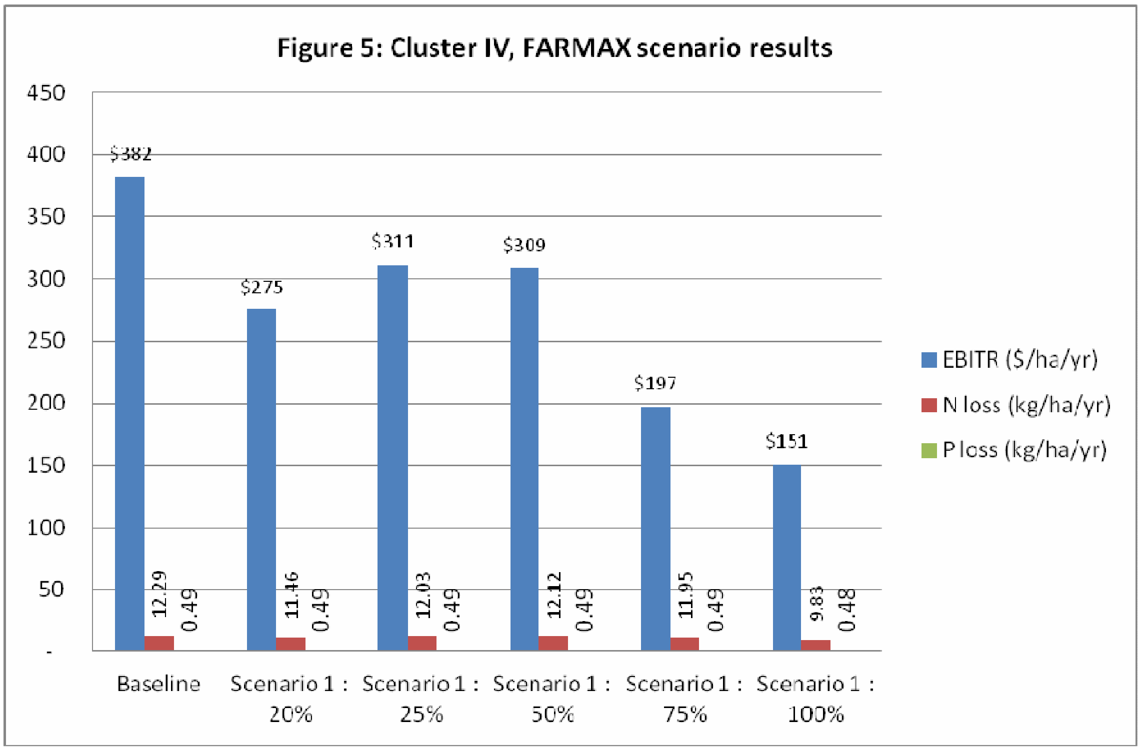
- Mostly all beef cattle
- Average farm size: 35 – 250ha
- High male cattle ratio 100%
- High stocking rate: 11.75
- Mainly finishing operation and purchase replacement stock rather than bred

Mitigation

- Substitute older/heavier cattle for younger/lighter cattle.

Results

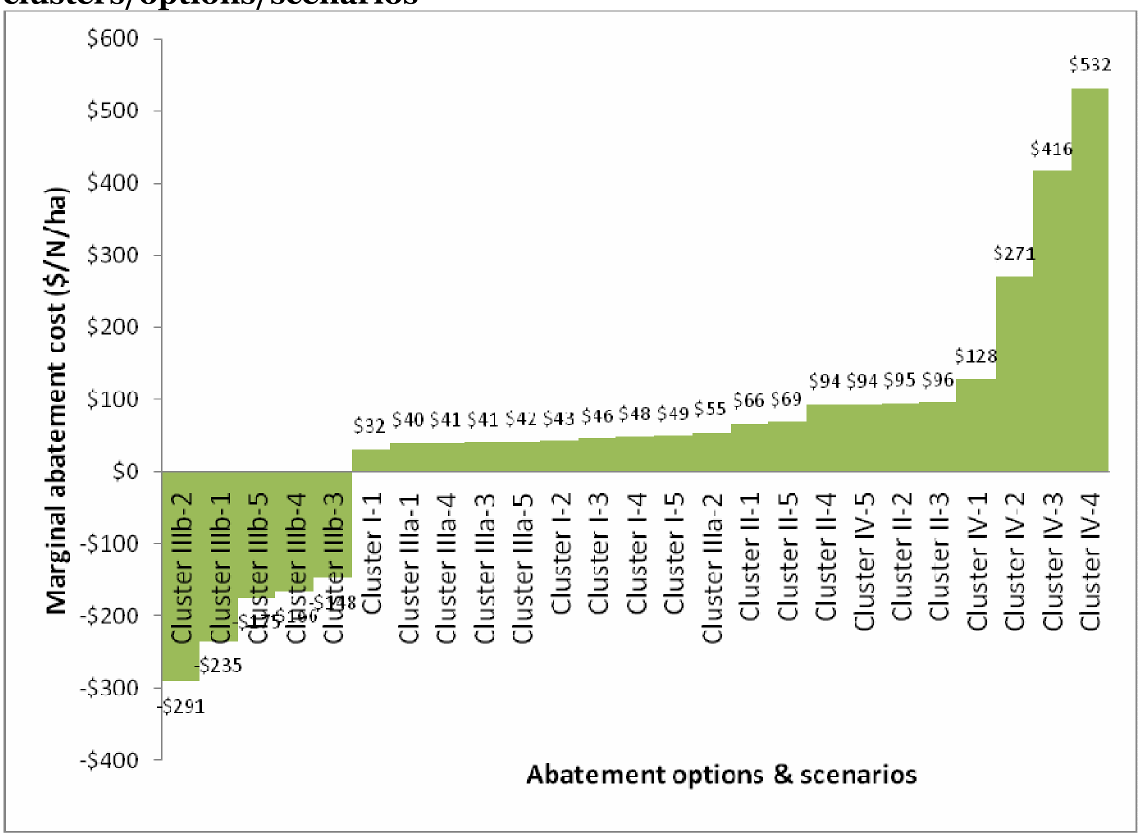
This mitigation shows a general decline in revenue by replacing the proportion of older/heavier animals with younger/lighter ones. As older/heavier animals are replaced with younger animals, both N and P loss reduce because of less stocking pressure per whole farm area. From Figure 5, a typical farm in cluster IV can mitigate nutrient loss by up to 2.47kgN/ha/year and 0.01kgP/ha/year at a cost of up to $231/ha/year (EBITR). This implies an annual cost of about $90/kg/ha/year of N mitigated and $23,000/kg/ha/year of P mitigated.



Deriving the Marginal Abatement Cost Curves for the clusters

The next question to policy makers is what is the most efficient and sustainable allocation of mitigation level and costs among the different farm types? Different farm clusters contribute to the regional water pollution through on-farm leaching at different rate and level of mitigation and different costs, (meaning each cluster has a different marginal abatement cost curve). Therefore, finding the efficient amount of abatement required of each farm type is by combining these curves to find an overall marginal cost curve for water pollution abatement at catchment level. The catchment level marginal abatement cost curve is the horizontal sum of the individual abatement cost curves of the clusters. The abatement costs curves from each cluster can be derived from figure 1 to 5 above. For catchment level mitigation to be efficient that is, at minimum cost to the sheep and beef farming sector, the allocation to mitigate nutrients among the clusters could be the same. The individual cluster marginal abatement cost curves are lumped together in increasing order of cost as in Figure 6.☐

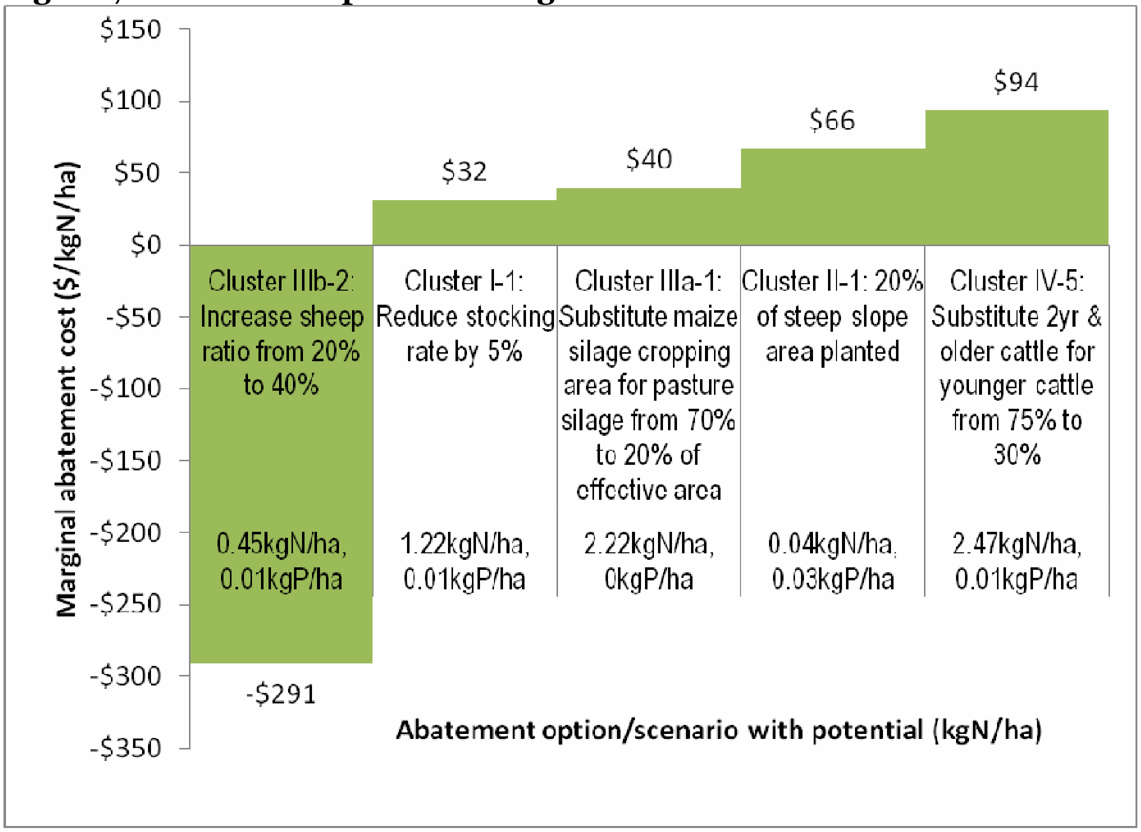
Figure 6: Farm-level marginal abatement cost curve by clusters/options/scenarios



This gives the overall cost curve for water pollution abatement when the abatement is allocated efficiently across clusters. Based on Figure 6, Figure 7 was extracted to present the most efficient abatement scenario for each cluster. Figure 7 is the marginal abatement costs for each cluster where the cost is minimum of the scenarios we have tried in this analysis. This will be the most efficient level of mitigation if a firm is considering the option to mitigate the next unit of leaching.

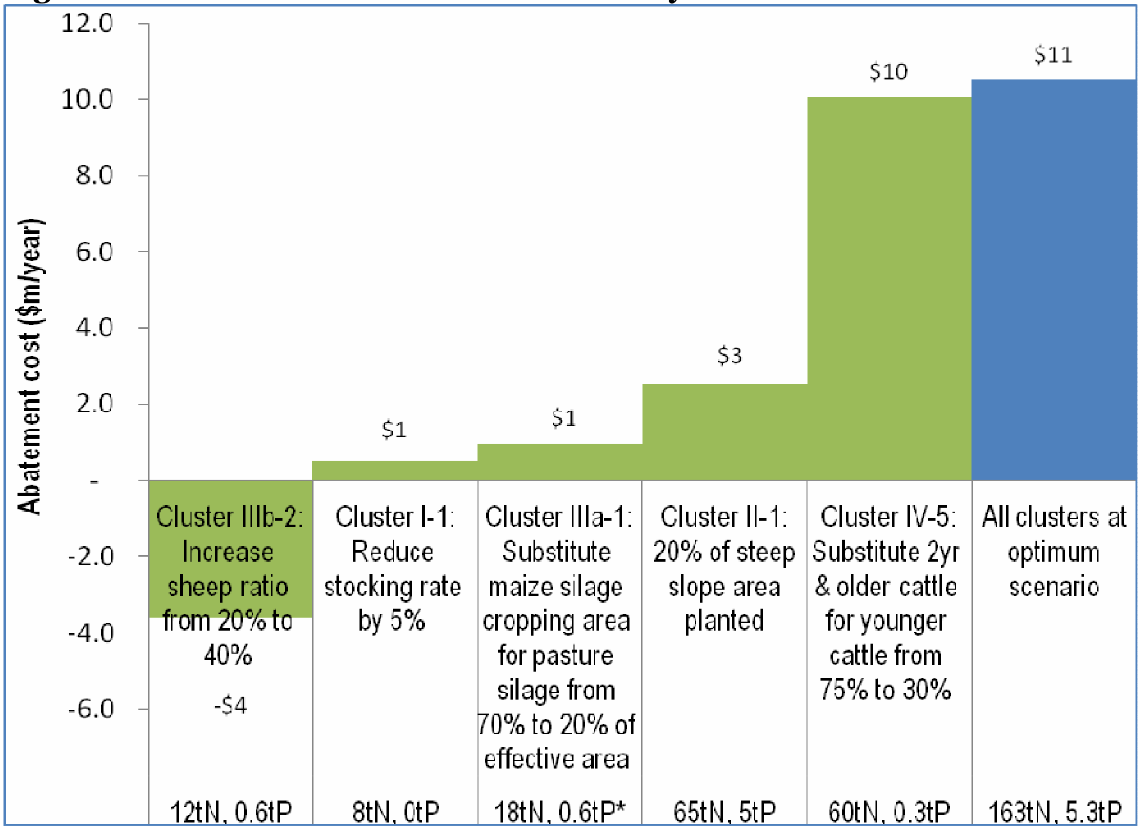
If a catchment wants to mitigate up to 2.47kgN/ha and had to decide how to allocate it between the clusters, Figure 7 shows the marginal cost of a kgN/ha abatement from each cluster.☐

Figure 7: Farm-level optimum marginal abatement cost curve



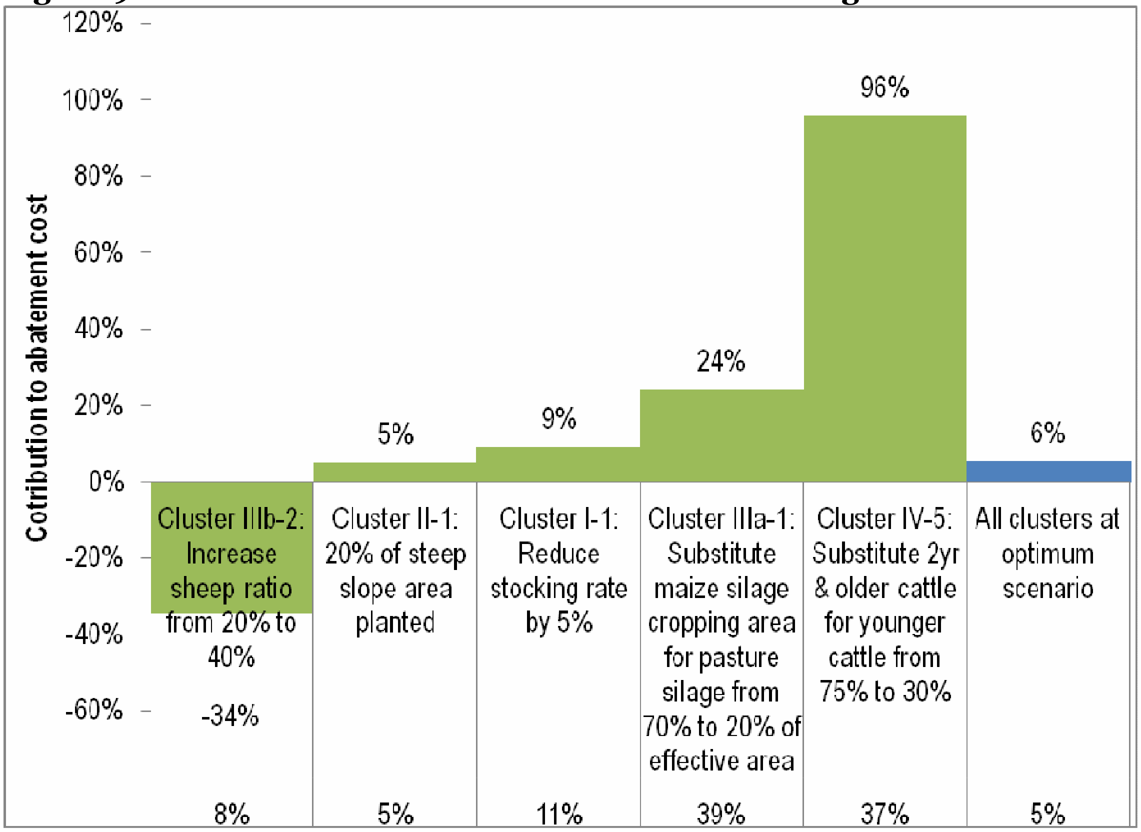
Cluster IIIb practicing scenario 2 can mitigate up to 0.45kgN/ha at an additional gain of $291/kgNN/ha. That is a cost of $132/ha for that cluster. If the catchment wants to mitigate further, the next cluster will be cluster 1 practicing scenario 1 (reducing stocking rate by 5%). This cluster can mitigate 1.20kgN/ha at a rate of $32/kgN/ha, which is a cost of $38/ha for cluster 1 farm type. Next in the line is cluster IIIa practicing scenario 1. The marginal cost for this cluster is $40/kgN/ha and can mitigate up to 2.20kgN/ha. The most costly option is cluster IV practicing scenario 5. However, it has the highest mitigation potential at 2.47kgN/ha but at a cost of $94/kgN/ha. This cluster sets the maximum level of abatement cost that any of the clusters can be expected of any of the clusters. Based on the land distribution under the clusters, Figure 8 shows the potential mitigation at minimum costs for each cluster.

Figure 8: Catchment level abatement cost by cluster



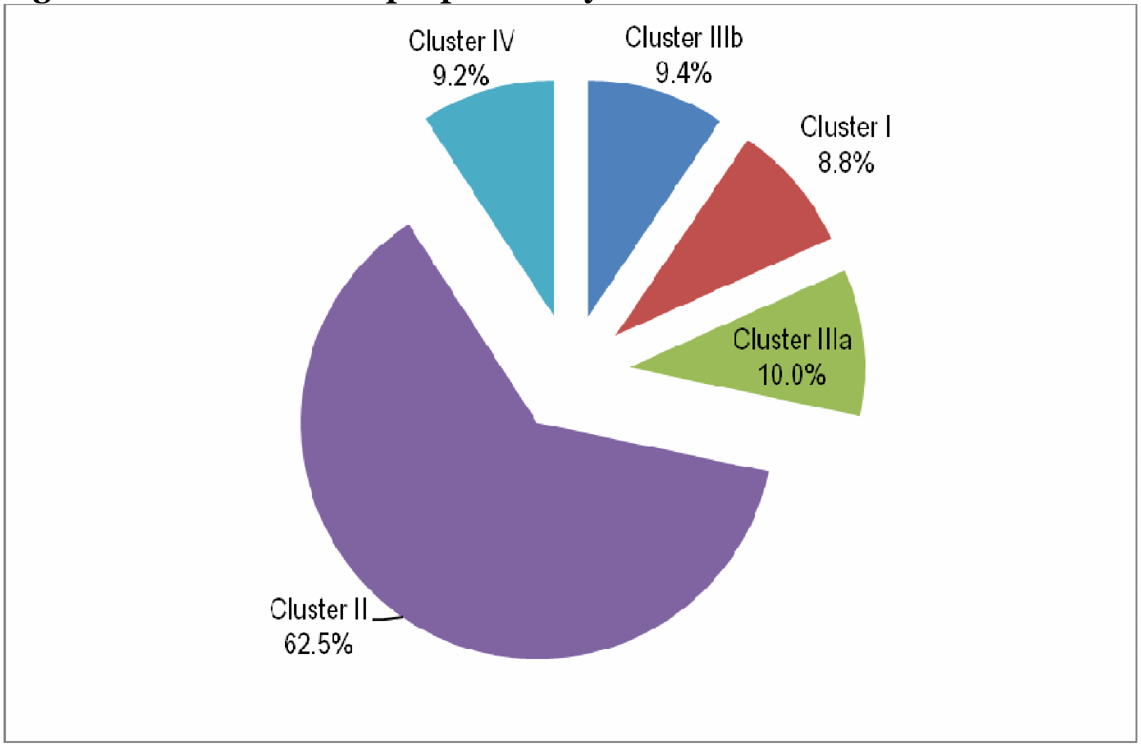
This implies farms in cluster IIIb should be the first target where more money can be made at the same time mitigating N and P up to 12ton/year at a gain of up to $4m. This is followed by cluster 1 farms mitigating up to 8tN/year but at a loss of $0.5m/year. Farms in cluster IIIa practicing scenario 1 can mitigate up to 18tN/ha at a cost of $1m. It becomes a little costlier with Cluster II farm type practicing scenario 1 as it cost $3m to mitigate 65tonN/year. The most expensive option is Cluster IV practicing scenario 5 where it costs up to $10m to mitigate 60tonN/year and 5.3tonP/year. In summary, the catchment can mitigate up to 5% of the Nitrogen loss at a cost of up to 6% loss in catchment income from drystock sector (Figure 9).

Figure 9: Distribution of cluster contribution to N mitigation



As previously explained, Cluster IIIb farms practicing scenario 2 is the only win-win option to mitigate up to 8% of the catchment level mitigation with added gain of up to 34% loss in income at catchment level. Cluster IV practicing scenario 5 is an efficient option as the farm type can mitigate though up to 37% of the catchment level mitigation but at a loss of up to 96% of the loss in catchment income. This is followed by Cluster IIIa practicing scenario 1 which can mitigate up to 39% of the catchment level mitigation but at a cost of up to 24% of the loss in catchment level income. This distribution is as a result of land area distribution among these farm types as presented in Figure 10.

Figure 10: Effective area proportion by cluster



SUMMARY OF THE FARMERS' WORKSHOP

Following the case studies of the mitigation options, a half-a-day farmer workshop was held on 30th June 2014 to serve as a focus group discussion involving farmers and professionals. The purpose of the workshop is to provide a quality check on the nutrient loss mitigation practices analysed in the case studies. There were two groups of participants – the first group comprises of scientists, researchers, research extentionist, rural consultants who were to help in translating the *science*, technology and knowledge behind the mitigation options. The second and main group comprises of farmers who are to be informed of the mitigation options before their views are been gathered. The workshop presented information to let farmers learn about the investigated nutrient mitigation options. It also gathered information about farmers' views of these options in terms of why and why wouldn't they adopt it and what other information can better inform their decision to adopt the options. The participants provided information through written responses and discussion in small groups. This process was repeated before and after the mitigation options with corresponding assumptions, financial and nutrient budgets were presented to the participants. The discussion was designed to gather information from the farmers in regard to the following outcomes:

- To understand how farmers perceive the mitigation options in meeting their both environmental and financial needs
- To understand what would motivate adoption of the mitigation options and what would prevent an adoption of the mitigation options
- To under what more information would influence adoption of the mitigation options

Participants' backgrounds

Twelve participants took part in a focus group - six in farmers group and 6 in researcher, rural professional group. The farmers were sample of the case studies farmers that were invited and could make the workshop. The professional group comprised of a farm system scientist, a rural consultant, a fertilizer industry representative, regional council extentionist. All the participants are well knowledgeable of the contexts – nutrient loss mitigation and financial impacts.

General feedback on the case studies options and results

The results of the case studies were presented to the participants with the caveat that despite they were case studies, a number of regional extrapolation have been applied to the case study data in order to fairly generalize the results. That means the results are better to be interpreted in terms of direction rather than magnitude effects.

The experts from the professionals include the following: The dollar trade-off and reduction if nutrient loss of the options varies between the options with the fourth option having a win-win solution which is not surprising. However, they reckoned optimizing the options could improve the results. For example, for the maize silage cropping case study, the livestock system could be optimized to baled pasture silage; case study IV could run a good system with light cattle at 70 to 30 per cent cattle to sheep ratio. In addition, considering the long-term implications of the results may carry different messages to the farmers. The typical nitrogen loss from a typical dry stock farm range from 8 to 12 kg per ha per year. So the results are within the range and nothing to worry about. Getting soil type right is critical to the results of nutrient budgets. OVERSEER modelling can account for fencing in Nitrogen budget but not for phosphorous budget. Mitigator is another nutrient budget model that can account for the impact of fencing in phosphorous loss. It is also capable of informing the right amount of fertilizer that gives best results. However, OVERSEER uses long-term average data, so it is not useful at predicting impacts of a specific event (eg. rainfall). It is important to take a good audit of soil situation to ensure best data goes into the modelling.

Farmer views of the case studies options and results

For most of the results, the farmers were concerned that there is a big cost per level of nutrient loss mitigated and also that the level of nutrient loss mitigated is marginal. However, these options suggest a higher level of mitigation at a lower cost with some win-win option compared to options analysed by AgFirst (2013) in the first phase of the economic joint venture project.

In terms of the outcomes being sought from the discussion, the summary of farmers' responses and discussion suggest the following:

Reduce stocking rate

The farmers view reducing stocking rate as an option to allow them increase stock performance per unit such as concentrating on prime lands; step back into lifestyle operation when old age sets in. They would reduce stocking rate to achieve those purposes. However, they would not want to reduce stocking rate because this option would have a negative financial impact especially on a small farm. To make a better decision, however, they would need information on the soil test, weed and pest issues, fencing and ultimately any financial incentives.

Plant trees on steep slope

The farmers view planting steep slope in trees as an option to optimize fertilizer use, prevent erosion, diversification of income and also as a plan for retirement. They would plant steep slope area in trees if the area is large enough to achieve those purposes. However, they would not want to plant trees as it can encourage pests and weeds and for lack of good cash flow and long term risk and uncertainty. To make better decision however, they would need information on different types of trees and certainty of financial returns on trees.

Substitute maize silage cropping for pasture

The farmers view maize silage cropping as a practice to take advantage of speculative high maize silage return and better spread of and cash flow of farm income. In terms of the results presented, the farmers were expecting a higher reduction in phosphorous loss. They would consider this option if they're labour constrained. However, they would not consider this option because they would lose the better cash flow income advantage of maize silage cropping compared to pasture silage. To make a better decision however, they would need information on a financial benefit especially the difference between input costs and labour requirements, terms of grazing contracts. ☐

Increase sheep to cattle ratio

The farmers view this option as a means to manage weed and pugging and also to spread enterprise risk. They would carry a higher proportion of sheep to achieve those advantages in addition to having a flexible grazing management and control pests/parasites. In terms of the results, the farmers did not expect the level of *income gain from this option because they are concern that profitability can vary quite significantly from farm to farm depending on the kind of the country. However, they would not want to increase sheep proportion because of higher labour requirements, need to fence and increase shed size. Some also have personal preference, eg. Want big animals, don't like sheep, etc. To make a better decision however, they would need information on the financial analysis that include the cost of infrastructure and labour availability.*☐

Substitute older/heavier cattle for younger/lighter cattle

The farmers view heavier cattle as prime cattle which offer less cost per stock unit and reduce financial margin on buying and selling cattle. This takes care of uncertainty in income. Similar to the third mitigation option (substituting cropping area for pasture), the farmers expected a higher reduction in phosphorous loss. They would consider this option if they have heavy and or damaged soil. However, they would not want to start with younger/lighter animals unless they can realize same financial return or better. To make a better decision however, they would need information on animal age groups that give best financial margin, their soil type, slope, and aspect.☐

Workshop summary

There is an indication from the responses and discussions that the farmers value the ability to compare these options with other options that they are already practicing especially fencing waterways. This implies the farmers would like to see a range of options in order to be able to consider each option in light of their personal preferences rather than just financial and environmental benefits. In summary, and putting the popularity of the options (for each case study) on a scale of 1 to 5 where 1 is least popular and 5 is most popular, reducing stocking rate is the least popular while increasing sheep to cattle ratio which suggests a ‘win-win' outcome is most popular according to the farmers' response.☐

GENERAL CONCLUSIONS

Considering that the mitigation options were chosen with a focus on the ‘hot' practices, the results are different compared to previous studies (AgFirst, 2009, 2013) in a number of ways:

- The options yielded expected results in terms of nutrient loss mitigation
- The options suggested higher level of N loss mitigation
- The options suggested lower cost per nutrient loss mitigation
- The options also suggest some win-win solutions
- Its more expensive to mitigate P than N

The forestry option, however, suggests similar results (highest P loss mitigation effects) compared to previous studies (AgFirst, 2013). During the focus group discussion, reducing stocking rate is the least popular while increasing sheep to cattle ratio that suggests a ‘win-win’ outcome is the most popular despite its challenging labour requirement. If a range of options are combined as appropriate, depending on a farm specific situation, the level of mitigation could be higher especially for P that has shown marginal results. The highest mitigation potential is 2.47kgN/ha among cluster IV farm type at a cost of $94/kgN/ha. This sets the maximum level of abatement cost that any of the clusters can be expected of any of the clusters. However, the socio-economic and demographic factors that could impact on farmers’ decision were not captured with the data used and so these factors have not been considered. Further work would be necessary to answer specific questions in terms of are the mitigation options practicable and adoptable and what would make them more or less adoptable in terms of socio-economic and demographic factors?

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