Benefit-cost analysis of addressing rural diffuse pollution through the FarmFLOW Extension Framework

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Abstract. Since the early 1980s the international community and government at all levels have become increasingly aware of the off-site impacts of agriculture. It has been argued that concepts of stewardship are insufficient to drive practice change and that the underpinning economic and social drivers for farm management practice need to be considered. This article argues that increased public investment in voluntary extension programs that target high risk agricultural sub catchments is an economic efficient intervention to reduce rural diffuse pollution. The analysis assessed the economic impact of investing in the FarmFLOW area-wide management framework in coastal South East Queensland. This approach focuses on voluntary adoption within an integrated catchment management context. The study modelled the impact of reduced off-farm flows of sediment and nutrients based on anticipated increased adoption of a limited number of recommended best management practices. The study showed that a voluntary extension approach supported by incentives and investment in on-farm trials, demonstration and action learning would have a positive internal rate of return of 13.4% from the ongoing investment by government with a benefit-cost ratio of 1.61.

Key Words: benefit-cost analysis, natural resource management, public goods, sustainable, environmental and ecological economics, agricultural policy.

Introduction

Concerns regarding the off-site impacts of agriculture came to prominence in the early 1980s. In Australia the early impetus for current action was driven by the investigations of the Advisory Committee on the Effects of Agricultural Practices on Coastal Zone Ecosystems (1992). They suggested that the responsibility for, and costs of, minimising downstream effects should not fall disproportionately on the rural sector and recommended appropriate and equitable forms of compensation to farmers and agricultural industries.

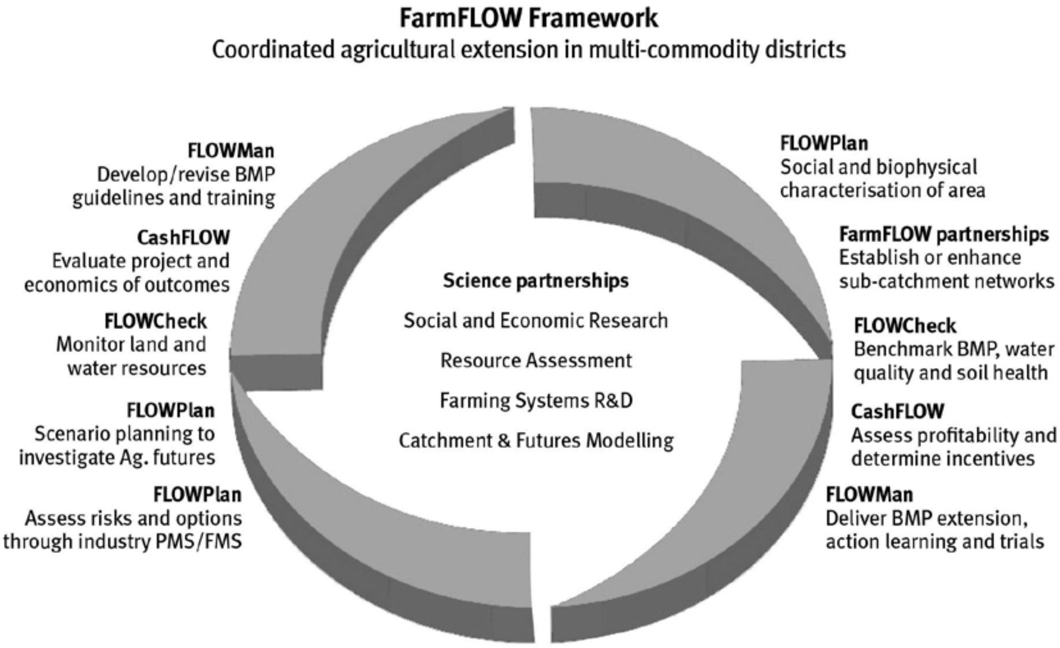
Over the last twenty years Australian governments have introduced a range of policies and incentives to address the 'spill-over effects' of agriculture through stewardship programs such as Landcare and then integrated catchment management programs (Burton 1991; Dawson 1993; Mitchell & Hollick 1993). Lawrence et al. (2003) argue that concepts of stewardship are insufficient to drive practice change. Consequently, it has been broadly argued that the key to achieving ecologically sustainable primary production is to develop and implement systems that contribute to desirable social and economic outcomes for the whole community while minimising environmental harm.

More recently, the Queensland and Australian governments have invested in both voluntary and regulatory measures to improve water quality flowing both to the Great Barrier Reef Lagoon and Ramsar listed waters of Moreton Bay (GBR Reef Protection Interdepartmental Committee Science Panel 2003; Healthy Waterways Partnership 2007; Anon 2009; Stockwell 2010). The relative efficacy of voluntary versus regulatory approaches (e.g. Weaver et al. 1996), compulsory Pigovian taxation versus voluntary incentives (e.g. Sun et al. 1996) and market based instruments (e.g. Clowes 2004) are a recurring topic for analysis in resource economics literature. Equally, the relative effectiveness of different models of farmer engagement to drive practice adoption is a frequent subject of concern to rural social scientists (e.g. Pannell & Vanclay 2011).

It is within this context that the FarmFLOW extension framework (Figure 1) was designed to address the problem of sediments, nutrients and pesticides running off and leaching from rural land into waterways, aquifers, estuaries and bays (rural diffuse pollution). It was developed with the social, economic and landuse characteristics of peri-urban agricultural catchments of South East Queensland (SEQ) in mind. FarmFLOW is a voluntary adaptive management approach underpinned by rapid rural appraisal and multi-commodity extension processes that use a range of social and economic techniques (e.g. decision support tools, grants and incentives) to reduce the impediments to the adoption of best management practices by commercial producers. The framework also features paddock and subcatchment scale monitoring of land and water resources and annual benchmarking of practice uptake to evaluate the impact of the intervention.

This article firstly reviews the economics underpinning initiatives to address the downstream impacts of agriculture and then assesses the costs and benefits of implementing voluntary, area-wide management program at a sub-catchment scale based on the Phase 1 implementation of the FarmFLOW Framework (Stockwell 2009). The benefit-cost analysis sought to quantify both the on-farm and the external impact of agricultural production and projected improvements in management practices over the subsequent sixteen years, and to analyse the return on government and industry investment from a proposed second phase of this project. This research found that increased public investment in voluntary extension and incentive programs that target producers in high risk sub catchments is an economic efficient intervention to reduce rural diffuse pollution.

Figure 1. Conceptual diagram depicting major elements of adaptive management cycle in the FarmFLOW Framework



Source: Stockwell et al. in press

Literature review

The environmental effects of agricultural activities result from an integration of economic decisions, private-good production practices and biophysical processes that involve both the long-run and short-run production decisions of farmers (Weaver 1996). There is also a role for economics in quantifying the environmental costs and benefits that occur outside the private entities that produce them. Sediments, nutrients and other pollutants that move off farms frequently lead to downstream water quality problems, or rural diffuse pollution, which is a common externality of agriculture.

In the short to medium term, non-sustainable agriculture can lead to inflated profitability in agriculture derived from the cumulative depreciation of the environmental asset reserves. Sediment and nutrient loss from farms is a good example of a cost that is external to agriculture that may not have immediate impacts on the producer's bottom line but comes at a public cost. In Australia, cropping and grazing are significant contributors to nutrients and sediments in inland waters and coastal pollution (Hamilton & Haydon 1996; Wason et al. 1996, National Land and Water Resources Audit 2001).

Tietenberg (1992) argues that the creation of negative externalities (pollution) by privately owned agricultural production entities, can be linked to the following factors (or the perception of them):

- The output of the agricultural product is too high because the external costs are not borne by the primary producer; hence, too much pollution (soil and nutrient loss) is generated.

- The price of agricultural products is too low, as they do not include the external costs, creating greater demand (consumption) through imperfect market signals.
- The failure of agriculture to 'internalise' external costs leads to underinvestment in the search for ways to reduce the external costs.
- Recycling & reuse of the items or materials causing the external costs is discouraged.

Mitigation of soil loss is expensive and fertiliser is a relatively cheap method of replacing lost nutrients. Although sediment loss represents a cost to producers in the form of some lost production capacity, and perhaps an increase in fertiliser costs, the overall cost to the business is minor and usually ignored. Damage caused downstream by soil loss is not borne by the agribusiness and therefore the impetus for practice change is minimal. Trapping and recovering sediment that depreciates the environmental asset and creates the external cost is discouraged, hence, there is underinvestment in possible solutions (Tietenberg 1992). Yet the cost paid by water users on the streams, rivers and oceans of the world can be significant. This cost is paid as a loss of amenity, reduced recharge of aquifers, higher filtration costs for water users, algal blooms, reduced fish stocks, loss of habitat, and reduced recreational and/or business opportunities (e.g. Blamey 1992; Sun et al. 1996; Wossink & Osmond 2002).

The valuation of ecosystems services affected by soil erosion and nutrient leaching can inform the estimation of non-market valuation of externality costs. For example, Brenner et al. (2010) estimated a value for soil formation in cropping land to be $7 USD per ha/year. While dated, the most relevant research was a case study of the Willamette Valley in Oregon USA, which estimated the off-site costs of soil erosion from agriculture (Moore & McCarl 1987). That analysis estimated the annual average erosion costs to municipal water treatment, road maintenance and navigation channel maintenance of $6.50 USD per hectare of agricultural land per year (present value 2010). This figure was used as the basis for estimating societal benefit in this study.

Paton and Grice (2004) suggest that much of the emerging sustainability in agricultural effort is driven by the desire of producers to meet industry best practice, to have minimal environmental impacts, to be economically viable and to be acknowledged by the broader community as effective land managers. The drivers for practice change internal to private entities involved in agricultural production will take one of three forms, or a mix of all three:

- Profit Driver – A demonstrable economic benefit is derived from the implementation of the practice change to the private business.
- Risk Reduction Driver & Associated Social Benefit Driver – Practices which can be shown to reduce risks to the enterprise and/or the desired social attributes of the family farm, including workplace amenity.
- Subsidy Based Driver – Practice change is facilitated through payment of subsidies to compensate the private business to undertake 'public benefit practices' in the absence of real or perceived private economic benefit accruing from the change.

While the adoption of recommended Best Management Practices (BMP) is promoted as an effective mechanism to reduce the externality costs of agriculture, there are rational reasons for farmers not to adopt BMPs that reduce rural diffuse pollution. Rolfe (2002), for example, points out it is not always financially attractive for landholders to pursue sustainability goals when there are long lead times involved in future production losses.

From a sociological perspective, adoption of BMP is a dynamic learning process strongly influenced by personal, social, cultural and economic factors, as well as the intrinsic characteristics of practice or innovation. Adoption more readily occurs:

- When there is a perception of a net benefit or contribution (i.e. relative advantage) to the achievement of personal / end goals that include economic, social and environmental values.
- When practices/innovations are easy to test and learn about prior to their adoption (high 'trialability') (Pannell 2006).

Marshall (2008) found that scale in extension delivery was important, identifying that subregional natural resource management groups have been more successful than regional bodies in motivating voluntary cooperation from farmers in adopting practices because of their ability to engage effectively and establish trust from their farmer constituents such that they come to follow reciprocity strategies.

Sun et al. (1996) found that due to specific production practices, a particular group of farmers within their study area could reduce nitrogen leaching and runoff more efficiently than others. Their economic simulation of expected returns suggested that a government cost-sharing program that provided incentives to farmers for voluntary adoption of economically efficient and environmentally acceptable BMPs would be superior to an alternative scenario of regulating/penalising all producers in the watershed using a tax on fertilisers. Clowes (2004) also point out that there are several constraints to imposing regulatory controls on non-point source pollution such as the difficulty in establishing liability in enforcement processes. This is complicated further by the technical difficulty in establishing the timing of the initiation of the problem and the responsible individual/ entitywhen property rights can be transferred. He also suggests that the challenge of monitoring compliance at a reasonable cost is a primary concern.

The socio-economic context of BMP adoption, as outlined in the above review, was overtly considered during the design, piloting and implementation of the FarmFLOW Framework in South East Queensland, Australia. That framework was developed to respond to the persistent water quality problems identified by a long-term Ecosystem Health Monitoring Program in South East Queensland. This socio-economic context guides interpretation of the costs and benefits of investing in voluntary programs that target agricultural producers in high-risk sub catchments.

Study Area

Long-term monitoring of the catchments of SEQ has shown that a significant contribution to the loads of pollutants entering Moreton Bay originate from the rural landscape (73% of sediments, 36% of Nitrogen) (WBM 2005). In addition, annual evaluations of the major agricultural catchments in the region consistently show poorer freshwater and estuarine water quality than those where primary production is only a minor activity (EHMP 2004, 2005, 2006, 2008).

In 2006 the Queensland and Australian governments jointly prioritised rural diffuse pollution in the revised Regional Water Quality Improvement Plan (Healthy Waterways Partnership 2006). Since then they have provided significant funding for the implementation of the FarmFLOW as a key element of the response. Evaluation of best-practice adoption and economic and biophysical analysis of the impact of this intervention has shown promising results in reducing the threat to downstream environments posed by sediments and other nutrients known to be driving blue-green algal blooms in the Pumicestone Passage (Hannigton 2007; Stockwell et al in press).

To date, estimation of the value that the SEQ community places on maintaining and rehabilitating wetlands and waterways has been undertaken through citizen's juries, surveys and choice modelling (Clouston 2001; Robinson, Clouston & Suh 2002, Binney 2010). However, more robust analyses are required by decision makers about the cost efficiency of investing in specific interventions that aim to protect or enhance these communal environmental values.

In 2010, the authors undertook a benefit-cost analysis investigating the implications of further government investment in the FarmFLOW framework to inform policy and investment decisions within government. The analysis assessed the economic impact of expanding the FarmFLOW approach from the coast sub catchments of the Pumicestone Passage to all coastal sub-catchments identified as high risk by Pointon et al (2008) in terms of their relative contribution of nutrients of concern to algal blooms in the region. This assessment showed that the coastal components of catchments within 150 kilometres north (Sunshine Coast and Pumicestone) and south (Logan-Albert) of Brisbane had the highest level of hazard. Our analysis of Queensland Government GIS databases indicated that high-risk sub catchments on the Sunshine Coast, Pumicestone and Northern Gold Coast featured approximately 9,200 ha of horticulture and cane production.

Method

The study modelled the impact of reduced off-farm flows of sediment and nitrogen based on an anticipated increase in adoption of a limited number of recommended BMP. The analysis aimed to:

1. Estimate the net benefits and costs that would be incurred internally (on farm) in minimising the environmental impacts of excessive soil erosion and off-site flow of nutrients.
2. Provide an estimate of the environmental/public benefit that would accrue if adoption of practice change increased across relevant industries in the target region and environmental outcomes were improved.
3. Analyse the 'return on investment' of increased public funding for the FarmFLOW extension framework as a delivery mechanism.

The analysis was based on a scenario of increased government investment in the FarmFLOW framework for an additional eight years in order to achieve a target of 80% of farmers adopting recommended BMP. However, on-farm costs and benefits were estimated out to the 2026 time horizon of the SEQ Healthy Waterways Strategy (Healthy Waterways Partnership 2006). In estimating the on-farm costs and benefits of implementing practice change, the study considered all identifiable parameters affected by implementing practice change, such as yields, inputs (fertiliser, pesticides, labour) and capital investments (e.g. fencing, machinery).

This study commenced with capturing baseline data and refining study parameters including:

- Identifying the high risk sub-catchments to be targeted for potential expansion based on the hazard assessment of Pointon et al.(2008).
- Consulting with relevant extension officers to determine the industries and practices (BMPs) of relevance to individual sub-catchments.
- Collating data from trial results reported during Phase 1 of the Healthy Country FarmFLOW project that quantified soil and nutrient savings from specific BMPs (see Factsheets at Anon 2010a).
- Accessing government GIS land use databases to determine the spatial extent of each industry (cane, strawberries, pineapples) in each catchment, the average farm size for use in gross margin analysis, and the number of farms for use in the adoption profile.

These data were used to refine existing gross margin and partial budgeting economic analysis tools (e.g. the Cane Farm Economic Assessment Tool described by Stewart (2010)) and to construct a benefit-cost analysis spreadsheet for calculating both the aggregate on-farm costs and benefits of practice adoption, and the average biophysical impact of this per farm (e.g. sediment and nutrient savings).

The SEQ ABCD Classification System (Anon 2010b), which is a system based on the method originally developed by Drewry et al. (2008), was used to establish relevant BMP and to?? benchmark practice adoption. The benefit-cost model utilised partial farm budget comparisons to assess the financial impact of farmers moving away from dated practices (Class D) and conventional practices (Class C) to currently recommended best practices (Class B) and in the case of cane, one Class A practice (GPS guided minimum till). These data, together with an estimate of the envisaged project operating costs required to apply the FarmFLOW framework across all high-risk sub catchments in coastal SEQ, were used to estimate potential returns on investment. A discount factor of 6% was applied to determine the present value of future anticipated cash flows.

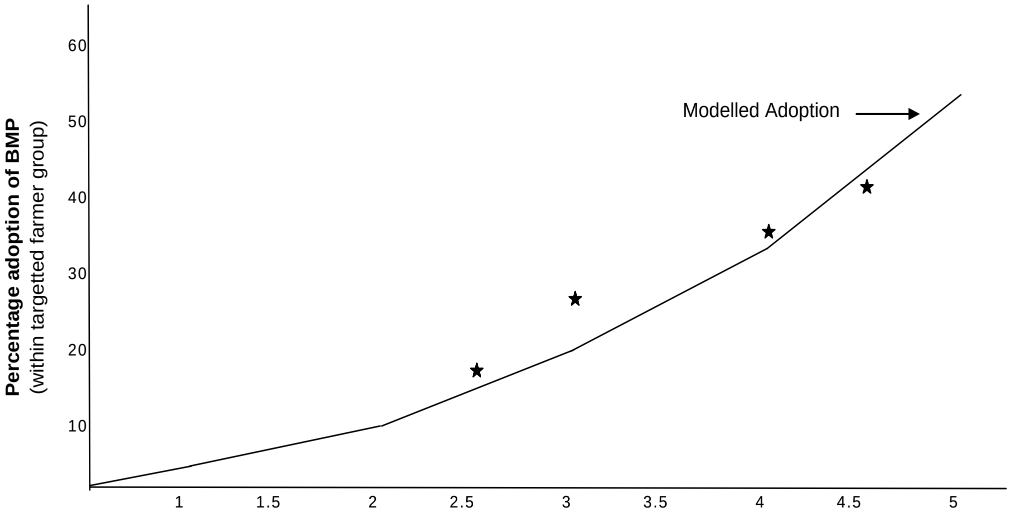
The Revised Universal Soil Loss Equation (Renard et al. 1997) was used to estimate the soil loss from a 'typical' strawberry, pineapple and cane farm scenario in the farm partial budget model. Once in-field sediment loss rates were calculated, the net amount of sediment moving off farm and into waterways was estimated based on the effectiveness of riparian areas in filtering sediments from overland flow. The analysis was founded on Class D and C farms having poor to moderate riparian vegetation which would filter 50% of sediments, while Class B and A farms would have good riparian vegetation capable of filtering 90% of horticultural sediments (80% for cane).

To determine the flow of costs and benefits over time, an adoption profile was required. The adoption profile was created using the system dynamics model developed by Sterman (2009). This model adapts traditional theories on the dissemination of innovation based on the relative abundance of innovators, early adopters, early and late majorities and laggards (Rogers 1995). It uses two coefficients, one for innovators (p) and one for imitators (q) to generate adoption curves. The dynamic simulation runs in discrete time steps (annually) and shows that the behaviour of the system would be to have growth in adopters that follows the classical s-curve shape. Benchmark data on BMP adoption over the first three years of FarmFLOW projects was utilised to refine the coefficients such that the rising slope of the s-shaped curve closely reflected actual results from the project to date (Figure 2). The line of best fit was achieved with the innovation coefficient $p= 0.06$ and imitators $q=0.5$.

Results

Analysis of government and industry statistics suggests that there are approximately 383 horticulture and cane farmers in the targeted high-risk agricultural sub-catchments of the Sunshine Coast, Pumicestone and Northern Gold Coast (Table 1). The modelled target was to achieve 80% of farms adopting the relevant best management practices identified in Table 2. These variables together with the collated data on the general topography of production areas and the average size of farms in the area were used to generate 'per farm' soil loss data relevant to adoption or non-adoption of the practices in Table 2.

Figure 2. Plot showing modeled BMP adoption curve and data points from FarmFLOW BMP Benchmark Surveys



Time since FarmFLOW extension project started (years)

Legend: ★ Stars indicate results of BMP Benchmarking from 3 different FarmFLOW projects in South East Queensland

Table 1. Estimated number of farms and adoption benchmarks in 2009

Industry	**Class D**	**Class C**	**Class B**	**Class A**	**Total**
Strawberry (surveyed)	15	90	30	15	150
Pineapples (surveyed)	70	50	25	0	145
Cane (estimate)	8	72*		8	88
Total	93	212	55	23	383

* Note: Figure is an estimate of combined Class C & B growers

Table 2. BMP used in the determination of costs and benefits of adoption

Class B Practice	**Industry Applied**
Mulch in the interrow during establishment of crop	Strawberry Pineapple
Drainage management (reprofiling and armouring)	Strawberry Pineapple
Use of improved nutrient products and application (slow release, targeted)	Strawberry Pineapple
Matching nutrient application to crop need through leaf/ sap analysis or soil analysis	Strawberry Pineapple
Improved soil management (reduced tillage)	Strawberry Pineapple
Reduced fertiliser usage - soybean crop in rotation	Cane
Moving from conventional till to minimum till with GPS guidance *	Cane

* Note: This is a Class A practice

The systems dynamics adoption profile suggests that if the current trends in adoption continue then the target of 80% adoption of target BMPs could be achieved by 2018. The adoption curve is based on a scenario of enhanced region-wide investment for the delivery of the FarmFLOW framework of $672,000 - $866 400 per year from 2011 to 2018. It includes investment in agricultural extension and economics officers ($878,000), conduct of farm trials ($132,000), demonstration farms ($432,000), workshops and training (including Industry Farm Management Systems) ($211,200), BMP adoption incentives ($435,900) and evaluation and monitoring ($244,000). Incentives to date have featured a mix of matching grants and a competitive nutrient and sediment reduction 'tender'.

Variation in farm size may affect the economics of adoption, however, this is not thought to be significant considering the generally small property size in SEQ. Contemporary data from regional producers were used to analyse the economic impact of adopting the above practices across an average sized farm using partial farm budgets developed in collaboration with growers in Phase 1. This showed that adoption of the above BMPs increased the gross margin of strawberry production by $1,453 per ha, pineapples by $646 per ha and cane by $612 per ha.

An estimate of the societal benefit for savings in off-site loss of soil was calculated using Moore and McCarl's (1987) valuation as a base and converting it to cost per tonne of soil lost using the Revised Universal Soil Loss Equation. Using this method the non-market value of costs avoided by adoption of BMP on farms was estimated at $1.98 per tonne (AUD 2010) of soil conserved within the property. Expected reduction in nutrient loss through leaching was estimated from changes to fertiliser regimes. The social value of these savings was estimated as being equivalent to the cost of fertiliser saved. These are considered to be a conservative estimate of benefit as they does not, for example, include the benefit of enhanced commercial and recreational fishing from reduced algal blooms (Savige 2006).

Based on the above assumptions and a discount factor of 6%, implementing the FarmFLOW Area Wide Management Framework at a cost of $4,700,000 from 2011 to 2018 would have an Internal Rate of Return (IRR) 7%) and a Benefit-Cost Ratio (BCR) of 1.4 when only the costs and benefits on farm were considered out to 2026.

The net present value (NPV) was converted to a yearly figure (annualised) as a measure of average annual returns generated over the life of the project (expressed in today's dollars). The analysis showed that without any valuation of societal benefit flowing from the reduced diffused source pollution, the program would have a NPV of $1,030,556 accruing to industry at an average annual return of $101,976.

When the non-market value of benefits are included in the analysis, the expansion of the project to target the three high risk agricultural catchments in SEQ was found to have IRR of 13%. Similarly when the societal benefit flowing from reduced diffused source pollution is included, NPV of the proposed program of activity increases to $5,330,713 at an average annual return of $527,485. When the flow of total benefit is considered the investment in FarmFLOW breaks-even in year 12. The analysis suggests that expanding the FarmFLOW framework to all catchments assessed as having a high level of hazard as a result of nutrients sourced from agriculture driving coastal algal blooms has a BCR of 1.6.

The biophysical impact of farmer adoption of the best management practices summarised in Table 2 is sizeable. The per hectare rate of reductions in off-site flow of sediments and nutrients utilised in the benefit-cost analysis are outlined in Table 3.

Table 3. Estimated Soil and Nutrient Loss from Production

Industry	**Average Farm Size**	**Sediment Loss**	**Nitrogen Loss**	**Phosphorus Loss**
	(ha)	(tonnes/ha/year)	(kg/ha/year)	(kg/ha/year)
Strawberries	5.0			
Class D/C		44.64	22.32	0.83
Class B		1.49	0.74	0.03
Pineapples	31.03			
Class D/C		69.75	34.88	1.29
Class B		2.23	1.12	0.04
Cane	52.04			
Class D/C		17.86	8.93	0.33
Class B/A		1.19	0.6	0.02

Discussion

The Tietenberg theory suggests that excessive erosion creating sediment loss above the social optimal occurs via excessive production which occurs because farmers do not pay most of the external cost. Profitability is therefore over-stated and leads to production in excess of the optimum. While the actual cost has not been calculated in this study, it was estimated that the difference in cost to the community between non-sustainable farm management practices and adoption of recommended best practices for soil management was in the order of $802,000 per year for the estimated 9,200 hectares of cultivated land in SEQ. This represents an externality cost of $87 per ha of production.

In our study the mix of private and public investment required to move to 80% adoption of best practice did not break even until after year 15 if only the on-farm benefits were included. Social benefit-cost analysis factors in the environmental spill overs from private decisions and in this analysis consideration of off-site societal benefits brought forward the break-even point by three years. This study has supported the argument of Tisdell (1996), who suggested that when societal benefits and costs are considered, more sustainable forms of agriculture tend to have a higher benefit-cost ratios in relation to other practices.

The FarmFLOW framework was designed to actively address profitability, risk reduction and subsidy drivers. Partial farm budgeting demonstrated that the suite of BMPs recommended and analysed in this study all had a marginally positive benefit on farm gross margins ($612-$1,435 per ha) with the need to acquire machinery determining the length of time required to increase the annual profit of the enterprise. Over a decade of active catchment management in SEQ has led to a high level of community awareness in regard to the link between agriculture, diffuse rural pollution and downstream impacts such as coastal algal blooms. In Phase 1 of the FarmFLOW project, engaged farmers were not only made aware of this linkage but also were involved in obtaining and considering real-time local data which clearly demonstrated this link. This, together with an understanding that increased exposure of production to non-farming neighbours in the peri-urban zone increased the potential for the surrounding community to impose 'a social licence to farm' through political activity, has resulted in practice adoption as a risk management measure.

The subsidy based driver is implemented within the framework and costed in the analysis through the full funding of trials and demonstration farms which allow 'early adopter' farmers to demonstrate the production, economic, environmental and social costs and benefits of change to themselves and their peers ($564,000 budget in CBA). In addition, provision was made for devolved grant and market based instruments (e.g. tender systems) for farmers seeking government assistance for adoption of recommended practices ($435,900 budget in CBA). While this study did not analyse the costs and benefits of a regulatory alternative, it clearly showed that a voluntary extension approach supported by incentives and investment in on-farm trials, demonstration and action learning would have a positive return on the ongoing investment by government (IRR 13.4% and BCR 1.6) generating an average off farm social benefit of $425,509/yr.

Another alternative avenue for government investment is in schemes focussed purely on stream bank erosion. Riparian restoration is frequently posited as an efficient and effective mechanism to achieve reduction in diffuse rural pollution. The results of this study suggest BMP adoption achieves similar BCR and IRR to the average results from Sillar Associates' (1998) analysis of nine case study dairy and beef enterprises that rehabilitated degraded stream banks in the Mary Valley. Their analysis of on-farm costs and benefits indicated an average IRR of 15.9% and an average BCR of 1.9. However, BMP schemes could be more reliable in the achievement of positive benefits, with 55% of case study riparian restoration farms in that study achieving a BCR of less than 1 and an IRR of 0 or below.

The principles of the FarmFLOW methodology have now been adopted as part of the Education and Extension Strategy for the Reef Water Quality Protection Plan (Stockwell 2010) with a $1.4 million pilot in the Johnstone and Herbert Catchments of North Queensland. The government has invested both in a voluntary extension and incentives approach, and in a regulatory approach in the highest risk catchments and industries. A benefit-cost analysis which compares voluntary and regulatory approaches would provide valuable insight into this ongoing area of economic and rural sociological research. Similarly, future research that compares the efficiency and effectiveness of investments in programs that directly target adoption of BMP with investments in broader programs, such as catchment improvements, re-vegetation, urban stormwater management and wetland protection, is warranted.

Conclusion

The personal, social, cultural and economic 'context' within which farmers operate has a major influence on the success or failure of rural engagement projects targeting rural diffuse pollution. This benefit-cost analysis shows a positive societal benefit flowing from the enhanced adoption of best management practice as a result of continued investment in the FarmFLOW area-wide management extension framework. This framework has been designed to reduce the impediments to adoption by specific extension, agricultural economics, and catchment management techniques which respond to the specific industry and sub-catchment contexts in coastal peri-urban SEQ.

The results of the CBA support the continued investment in an area-wide approach to agricultural catchment management based on an incentivised voluntary framework. An investment in the proposed program of activity over eight years, including agricultural extension and economics officers ($878,000), conduct of farm trials ($132,000), demonstration farms ($432,000), workshops and training (including industry Farm Management Systems) ($211,200), BMP adoption incentives ($435,900) and evaluation and monitoring ($244,000) was shown to have a NPV of $5,330,713 at an average annual return of $527,485 and an internal rate of return of 13% and a BCR of 1.6.

The use of contemporary real world farm data generated in Phase 1 of the FarmFLOW project increases the reliability of the costs and benefits of adoption. The validity of the predicted flow of benefits over time, however, will be reliant on how accurately the Sterman's system dynamics model (2009), used to generate adoption curves, simulates actual BMP uptake as a result of this program. This will require evaluation in the future.

While the benefit-cost analysis includes a conservative estimate of the social benefits of the modelled adoption curve ($425,509 per year), the study shows that increased government investment in the program can be justified on the long-run benefits to industry alone (IRR 7% and BCR 1.4).

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