Issues in the Implementation of Pollution Mitigation: A Case Study of Potential Expansion of the Sugar Industry in North Queensland

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ABSTRACT

Research to evaluate economic options to mitigate pollution in Dugong Protected Area's near cane growing regions is hampered by a limited knowledge of biochemical pollution mitigation processes and seagrass ecology. Determining least cost mitigation policies needs to proceed with caution to identify non-regret policies that are most likely to result in net reductions in pollutant loads. Results of some preliminary analysis of pollution mitigation devices are presented in this paper with an examination of the feasibility of linking on-ground work with economic instruments such as water pricing and tradeable permits to encourage greater compliance.

Key words: agricultural pollution mitigation, externalities

1 Introduction

For many reasons governments often find it attractive to encourage agricultural production opportunities. Although agriculture fills many roles, society is placing increasing importance on environmental quality. Future government involvement in inducing agricultural development faces the task of including environmental considerations. The economic analysis of environmental issues at the design stage of new agricultural development could consider efficient allocation and sustainable alternatives. Agricultural effects on the environment might remain unchecked (the status quo) or be subject to a range of mitigation options with the potential to lead to sustainable outcomes.

One approach to address natural resource use problems involving agricultural production is to regulate. This typically involves a government agency taking a hands-on role in setting limits to outputs such as water quality. Such an approach is information intensive and provides no long-term incentives for private research into technological improvements to reduce pollution. The costs of environmental monitoring, policy administration and enforcement are borne wholly by the agency.

We use a case study to incorporate environmental issues in the design phase of an irrigation area development. We propose the integration of a market-based instrument that tries to harness private interest’s to reduce emissions (Stavins, 2001). Costs such as pollution monitoring, policy administration, monitoring and enforcement also occur for market based instruments. One practically feasible method with the potential to reduce environmental impacts is the construction of regional mitigation ponds. If the government were to include construction costs as part of the development costs then alternatives to meet ongoing operating costs merit investigation (wetland mitigation banking is another approach, see (Edmonds, et al., 1997)). Creating a market to use the communal mitigation scheme may be one way to recover some of these costs. Design of the allocation and features of such permits to enhance the net social benefits from the operation of such a market are considered. For example annual auctions, the ability to trade or bank permits, means to reduce transaction costs and penalties for non-compliance are relevant. Implementation issues such as community involvement also warrant discussion.

Analysis of the issue is hampered by insufficient information about the case study area, in particular salinity and groundwater interactions. Such a lack of information is pervasive in many natural resource use situations. Resource managers will inevitably face decisions without the best possible information, undertaking no regret policy measures aimed at sustainable outcomes are the next best alternative. In this paper we incorporate pollution impact mitigation in the planning of a potential new agricultural development area to illustrate the complexities managers face and explore feasible and logically coherent alternatives in dealing with social conflicts.

2 Economic Policy Design

The dominant approach to dealing with natural resource use is to rely on markets to produce efficient resource allocation outcomes. Whilst the demand for agricultural products is often intra and international the production of agricultural goods usually involve regional resource use decisions. Because land use decisions occur at a local scale, efficiency in a partial equilibrium setting requires any new action to result in a net social benefit. However the information requirements for this approach and the need to monetise foreseeable consequences themselves require significant resources and effort (Tietenberg, 2001). Taking a policy stance of do nothing ignores the significant opportunity costs involved. The environmental economics concepts of externalities, public goods and joint production outcomes provide a rationale for intervention in markets (Dasgupta, 2000).

Following Dasgupta (2000), the market does not always capture environmental impacts of agriculture, so called externalities. For example surface water run-off from farm areas may contribute to water quality problems downstream. Where such contributions are not reflected in payments made for farm products or the production costs of the farmer, the market mechanism fails to accommodate such diseconomies and therefore economists consider externalities a source of market failure. The receiving environment may display public good characteristics of collective consumption and non-exclusive consumption which both contribute to under-provision in a competitive setting. Policy intervention is thus regarded as necessary to ensure an adequate supply. In the case of cane farming water quality impacts are often produced as a direct result of cane production (Simpson, et al., 2001). Thus water pollution becomes a joint product of cane farming. These undesireable externalities reduce the social benefit of cane production and the efficiency of resource use in cane farming. Intervention in the absence of the information necessary for optimality is therefore based on the notion of sustainable natural resource use (Tietenberg, 2001). An environmental target is set and alternatives for achieving that target are examined.

Society is becoming increasingly wary of the environmental effects of economic activity, especially agricultural pursuits. The complex basis of this rising concern is reflected in the multifaceted role of agriculture. Agricultural pursuits have economic, environmental, social and cultural aspects. The interconnectedness of these roles is often ignored in policy analysis of natural resource use. We attempt to consider economic and environmental aspects in policy analysis of pollution mitigation. We assume the decision making process provides avenues for broader socio-cultural considerations and preference expression.

2.1 Economic policy options

When considering economic policy options the site-specific nature of likely impacts and environmental processes involved could narrow the range of alternatives. In the presence of uncertainty over the effect of pollution economic policies need to specifically address the effectiveness of pollution mitigation to provide appropriate incentives to improve environmental performance. Mitigation is concerned with containing the effects of pollution or trying to minimise the impact of pollution. Pollution mitigation policy aims to target at least one aspect of pollution; transport, delivery or availability. Mitigation aimed at reducing transport of pollutants such as soil erosion in overland flow includes practices such as green cane trash blanketing. Mitigation aimed at reducing the delivery of pollution might involve vegetated filter strips near drains and waterways.

The characteristics of specific situations where analysis is required to address identified diseconomies can invoke a range of economic responses. Economic policy options include direct regulation, market based instruments (taxes and permits), incentives and information approaches. Each situation requires analysis of which policy instruments are feasible and will result in environmental benefits (Claassen, et al., 2001).

All policy options are designed to raise awareness in the polluter but differ in the way of motivating the polluter.

The incentive to change behaviour may be non-compulsory, such as in most information type approaches. Information dissemination through education, extension and/or technical assistance employs moral suasion to affect behaviour. For example Queensland's Rural Water Efficiency Initiative is aimed at voluntary irrigation efficiency improvements (CANEGROWERS, 2001).

2.1.1 Choice of instruments

Policy approaches may be compulsory with no compensation where the protection of common goods is required. Regulatory requirements such as clearing native vegetation, taking protected flora and fauna and regulated waste contain set procedures in order to comply with a set standard. These command and control policies have historically been a measure employed after a resource is severely threatened. There is currently no explicit regulation of sugar cane production, as it is not listed as a relevant activity in the *Queensland Environmental Protection Act 1994.* All activities have a general duty of care to avoid undue damage to the environment (see (Mallawaarachchi, et al., 2002) for a discussion of progressive self regulation options).

Between these two extremes of behavioural incentive approaches lies a continuum of motivational tools ranging from payments for the provision of environmental services to the creation of markets for environmental goods. Market based approaches are economic instruments that attempt to facilitate changes in individual motivation through price or quantity intervention to result in environmental improvement. Market based instruments effectively create new markets so that producers have incentives to control pollution at socially desirable levels (Ribaudo, et al., 1999). Whether market based instruments are efficient depends on the agri-environmental setting and the details of the program design (Claassen, et al., 2001).

Price based instruments seek to provide incentives through changing the cost structure of production functions (introducing a cost of polluting). Taxes are designed to increase the marginal cost of pollution to result in marginal benefits. Thus taxes place a burden on the polluter internalising an increase in environmental quality. Where information allows taxes can be set to equate the marginal cost with marginal benefits. At this equilibrium level the socially optimal quantity of pollution is not likely to be zero. Although taxes seek to use prices to signal more fully the opportunity costs, the lack of a direct linkage between the magnitude of environmental damage and prices reduces the desirability of possible outcomes. If some limit to the level of pollution is desirable, then quantity based economic instruments can be used to create incentives for private action. Similarly to taxes, a financial outlay to acquire a pollution allowance brings an upfront cost to pollution externalities.

As a quantity based instruments, tradeable permits have been widely deployed to target various environmental objectives such as access to fisheries, air pollution control (Tietenberg, 1999) and salinity (Environmental Protection Agency, 2001). The essential feature of a permit scheme appropriate to the case at hand involves an agency setting a cap on pollution. The cap being the total quantity (expressed in an applicable unit) of pollution acceptable, within spatial or temporal limits. A permit is then a property right to allow emission of a quantity of pollution in a given time period and a spatial boundary. The permit is an access right to a common good and can then be allocated (for example by auction). Rights may be transferable or bankable.

Heterogeneity of natural resources has often been overlooked by policy. Firm heterogeneity is the source of efficiency gains of permits over traditional approaches. Social costs are minimised as heterogenous firms with differing marginal control costs trade to maximise profit. In an efficient setting high marginal cost of abatement firms will purchase permits off low marginal cost of abatement firms. By introducing an agricultural production cost for a level of pollution the producer has an incentive to change practices to reduce pollution because unused balances have value. The importance of low friction markets in generating minimum social cost of meeting a given level of pollution is to maximise private benefits. Features of trading schemes such as requiring agency approval have been found to increase the transaction costs and reduce the number of trades. One way to encourage low transaction costs is to provide public information on prices (Tietenberg, 1998).

Traditionally tradeable permits have had a limited application to nonpoint source pollution, the type of pollution usually generated by agricultural activities. Point source trading schemes have featured the ability to transact with nonpoint sources, usually for mitigation credit. The uncertainty of nonpoint source management measures reduces the attractiveness of such trading and ratios are usually much higher than 1. However modern irrigated area design involves controlled drainage with one drainage point from each farm. This provides the means to monitor individual pollution loadings.

3 The Analytical Approach

The characteristics of the environmental problem determine the success of the approach employed. It requires careful economic analysis (and a great deal of luck) to sufficiently understand the cause of the environmental problem to identify the type of incentive needed to change individual behaviour. Prioritising competing societal objectives leads to an integrated economic and environmental planning approach. An integrated economic – environmental analysis seeks to identify the geophysical resource and natural resource use characteristics, agricultural production capacity and economic viability of a particular natural resource issue. This approach encompasses economic and environmental facets within the purview of a single decision making basis – value. Environmental goods have value because of the opportunity cost of foregone benefits (Pearce, 1983).

Agrochemicals enhance the productivity of natural resource use yet artificial inputs may exceed crop requirements and soil absorption capabilities leading to off-site impacts. These unintended consequences increase the risk of accelerated environmental change. Policies to reduce these consequences acknowledge that users of resources will bear costs of altered production techniques and possibly reduced production. The rationale for investigating cost sharing is that the benefits of policies will accrue to the broader community. Exploring cost sharing arrangements for private costs as well as mitigation costs is central to economic policy analysis. Economic analysis frames mitigation policy options to manage downstream effects in the absence of specific and detailed information about environmental effects. Environmental impacts often involve time lags and linkages amongst actions spread over vast areas to produce cumulative pollutant loads that trigger observable ecosystem reactions following prolonged exposure at or above critical limits.

3.1 Linking ecosystem impacts

Dugongs (*Dugong dugon*) are marine mammals that live for about seventy years. Adult dugong consume approximately 25 kg of seagrass per day. Dugong Protection Areas were introduced in 1998 to protect declining dugong numbers by recognising important seagrass habitat areas. Seagrasses have many other functional values that would be affected by pollution impacts such as fisheries habitat. However the myriad of possible reasons for variation in fishery harvest have the potential to mask the linkages. As Dugong are not commercially valued habitat degradation invites managers to employ risk management strategies. The Great Barrier Reef Marine Park Authority risk assessment of Dugong Protection Areas (Schaffelke, et al., 2000 (Unpublished)) underscored the nature of pollution threats – delivered by water. Pollutants such as nutrients, pesticides and suspended sediment have the potential to affect the species composition of seagrass and the extent of seagrass beds. These effects can occur via sediment smothering, light inhibition, by creating conditions that give a competitive advantage to algae and by carrying adsorbed and dissolved compounds (such as pesticides).

Possible extension of an irrigation area to a site closer to the near shore marine environment necessitate investigating the costs of feasible pollution control measures as the first step in managing the uncertainty of off site impacts. The least risk approach to protecting Dugong habitat is to reduce the impacts of pollution. In the context of agricultural pollution targeting the concentration of pollution and timing of delivery via detention ponds is a feasible alternative. Because of the failure of current regulations to protect this ecosystem any improvements will increase community benefits.

4 The Case Study

Milled sugar from cane produced in the Burdekin area accounted for 28.8% of the sugar produced in Queensland (CANEGROWERS, 2001). Of the 74 729 hectares in the Burdekin region dedicated to sugar production around 46,000 ha is supplied by the Burdekin River Irrigation Area. The economic benefits suggested by agricultural activity are not without environmental costs. Agricultural activity in the Burdekin River catchment (including extensive agriculture) delivers on average 2.4 million tonnes of sediment per annum (Great Barrier Reef Marine Park Authority, 2001).

The Burdekin River Irrigation Area storage currently services limited areas to the south of the Burdekin River. Potential development between Rocky Ponds Creek and Molongle Creek is called the Molongle block. The small potential irrigation development that is the subject of this case study would be an additional source of pollution among a myriad of contributions from intensive and extensive agriculture and other sources. Given that seagrasses have over the last 15 years persisted in Upstart Bay (Department of Primary Industries, Unpublished), a relevant question is will the pollution contribution from a small increase in the area of intensive agriculture be important? This aspect of the economic analysis touches on potentially the largest impediment to implementation from a political science perspective. Will the interest groups involved readily allow regulation of an activity similar to nearby activity that is not regulated?

The Molongle Block is adjacent to remnant seagrass beds declared a sanctuary for Dugong (Upstart Bay Dugong Protected Area). The nature of intensive agriculture and the sensitive location of the potential development, adjacent to remnant seagrass beds has the potential to directly impact on the health, distribution and species composition of seagrass. Introducing dry season flows and increasing the delivery of pollution directly onto remnant seagrass increase the risk of disrupting seagrass health. Aiming to mitigate this new threat is a no-regret policy to protect a highly valued marine ecosystem. Location specific factors dictate the mitigation option most likely to provide a minimum standard of ecosystem protection. Given the nature of dry tropical biochemical interactions containment of irrigation wastewater for disposal during subsequent high flow events is the least uncertain mitigation option. The critical pollutant loads in irrigation wastewater are dry season flows and first flush type events.

4.1 Assessment of mitigation options

Constructed wetlands have been used to treat wastewater, however the pollution characteristics in the case study area suggest limited long term benefits. Firstly fine suspended sediments typical of soils in the area can remain in suspension for long periods (Fleming, et al., 1981). Secondly over a long time frame, pathways for phosphorous transformation or attachment are limited (Faithful, 1997). Constructed ponds to retain wastewater flows may mitigate dry season impacts on remnant seagrass beds. The rationale is to contain combined nutrients and suspended sediment, especially dry season flows and initial runoff events. Initial runoff from the first major rain events of a wet season contain high amounts of suspended sediment, nutrients and herbicides (Simpson, et al., 2001). Thus mitigating the highest risk polluting process mitigation is likely to offer high social benefits.

Yet as seagrasses are adept at trapping sediment and a pollution transport pathway includes attachment to sediment, simply lowering the concentration of suspended sediment may not provide long-term ecosystem protection. In addition impacts on groundwater and salinity require further investigation. A combination of policy tools and flexibility are likely to be required as further information comes to hand.

The area has sodic duplexes, grey cracking clays, black earth and various sandy lenses (Donnollan, 1993). Soils in the areas typically have high fractions of fine particles (silt and clay). Agronomic characteristics can be used to determine the costs of amelioration and to explore the nature of environmental risks. Land capability classifications will be used in production functions and to indicate environmental risks based on best available agronomic knowledge. For example sodicity at particular depths is usually associated with soil type and agronomic amelioration has different costs depending on the depth and level of sodicity. Other limitations such as complexity and susceptibility to surface erosion also inform production costs.

Attempting to include impacts on production and the environment sets the parameters for estimating the total costs of damage mitigation. Modelling for the study area will be developed using estimations of fertiliser response from nearby production area. Functions for pollution risk and pollution mitigation will be added to compare scenarios. Farming blocks will be grouped according to the topographic feasibility of constructing retention ponds to capture wastewater. Designating appropriate risk classes based on soil type (relating land capability) and location for mitigation works and pollution risk allow capital cost allocation. Mitigation also includes pollution monitoring costs. Monitoring farm level wastewater pollution allows for subsequent examination of the desirability of using tradeable permits to re-allocate the costs of maintenance and management amongst polluters.

Analysing the case study will entail the development of a module for production costs and environmental risks for use within a regional production framework such as in (Mallawaarachchi and Quiggin, 2001). By expressing production and environmental impacts in the same analytical context we create a transparent tool for decision-making. This approach explores resource availability and allows examination of alternative institutional settings for policy implementation.

4.2 Issues in the Implementation of Policy Options

The appropriate level of government to deal with a policy issue is related to the confluence of benefits and costs and the agency best equipped to administer the program. The marginal benefits from mitigating agricultural pollution in Upstart Bay from new development include commercial and recreational fishers, the Great Barrier Reef Marine Park Authority (as managers of the marine protected area), the local community and the broader community (State, country and worldwide indicated by world heritage status). If farmers place some value on recreation in Upstart Bay then they may suffer a negative externality from any decrease in environmental quality. This partial self-interest may provide an amenable reception for resource protection measures. Because sugar industry participants are only a subset of all beneficiaries, then a State or Commonwealth agency can represent the full set of beneficiaries. The public marginal costs of mitigation policy include monitoring, administration, operating and enforcement costs. The private marginal costs will include the costs of obtaining a permit for the land developers. Given that feasible and least risk pollution mitigation involves regional retention ponds we explore cost sharing arrangements.

The level of government in a position to influence the diseconomy is the state level. In order to determine which policy is best we need to investigate alternatives for cost sharing. COAG irrigation water pricing guidelines provide one avenue to recover the cost of maintaining mitigation ponds. As retention seeks to minimise an externality the cost is directly relevant to the cost of supply.

5 Applying the Framework

We assume that government would undertake the irrigation area development and that mitigation devices would be installed. An agency will be responsible for the administration of permits to use the mitigation device. Some apportionment of the costs of monitoring, maintenance, administration and enforcement may be achieved through the sale of permits. Initial permits will be allocated to purchasers of land as an entitlement attached to the title. Agricultural producers within the development area thus face permit costs based on land area, and an annual licence fee to use the mitigation facility. The amount paid by agricultural producers represents a transfer to society as a contribution towards the costs of avoiding uncertain environmental impacts. The annual fee will enable partial recovery of ongoing costs.

Production areas, having different soils and production limitations (represented diagrammatically by different shading), will be able to employ different management actions to produce cane and an amount of pollution as a joint product. Agricultural producers will be expected to act to minimise pollution subject to marginal costs. This action produces marginal benefits (of a public good) accruing to society at large. Some producers will have the ability to produce less pollution and some will require additional capacity to mitigate pollution beyond the access given by existing permit. If the permits were tradeable, and if the transaction costs were kept to a minimum, then producers will trade their pollution permits to maximise their returns. While this will offer a useful mechanism to share ongoing costs of the mitigation facility, the problem of apportioning the capital costs of establishment between industry and government needs further investigation.

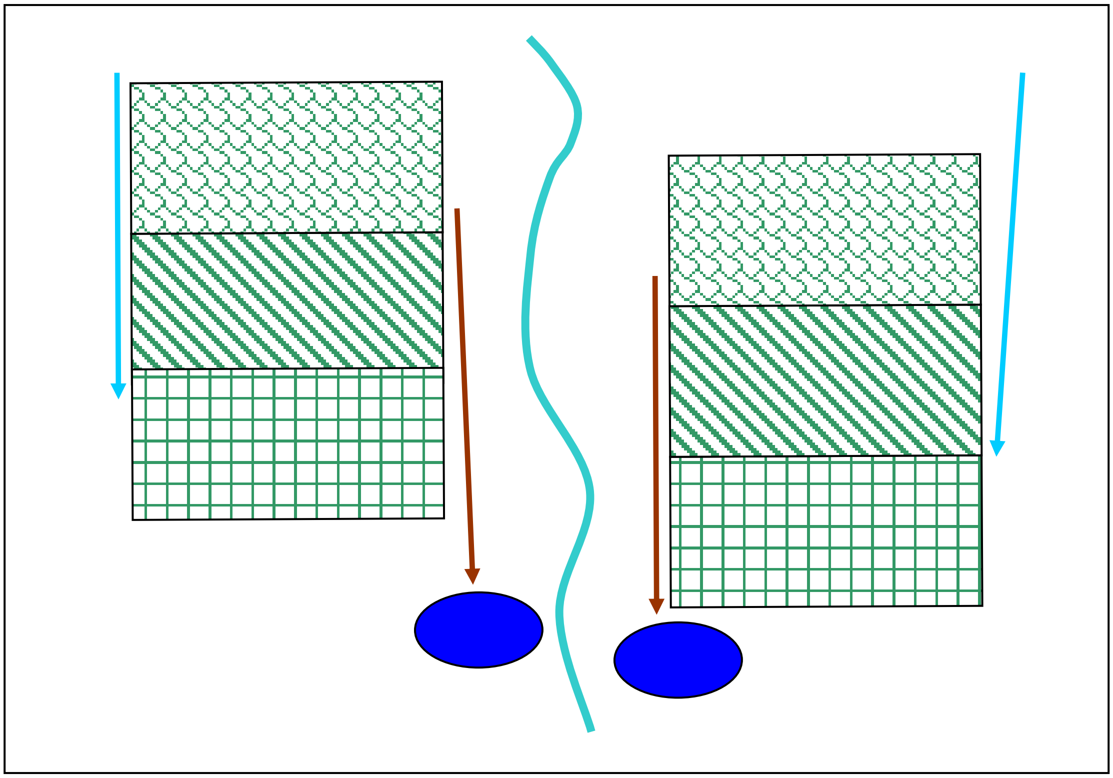

Figure 1 – Schematic Representation of Mitigation Design

6 Conclusion

Society faces alternatives for resource use. While current technology may leave some areas undeveloped it is useful to explore the way managers might deal with the trade-offs between agricultural activity and environmental impacts. An evaluation of the benefits and costs associated with human-induced changes to the environment recognises the opportunities foregone. Without estimates of the broader community benefits from maintaining environmental quality within Dugong Protection Areas economic analysis attempts to assess the least social cost of practically feasible policy choices. Implementing such a policy recognises that if such a policy is not undertaken, the implied social benefits are less than the cost. The costs of mitigation define the minimum level of benefits decision makers should attribute to development. It is likely there are other benefits from minimising water quality degradation accruing to the community.

Policy instruments such as tradeable permits facilitate the convergence of farmers' private interests with societal interests by rewarding pollution reductions. Economics provides a useful framework for conceptualising the trade-offs between agricultural production and natural resource use. When full information about the environmental impacts of agricultural production is not available or is too costly to obtain, decision makers can incorporate likely effects into planning and design stages. The research approach adopted in this paper offers some flexibility to explore uncertainties to aid efficient decisions on resource management.

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