Externalities in cane production and environmental best practice

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ABSTRACT

Management of environmental externalities of agricultural production has become a necessity to attain sustainable resource use and efficient use of resources. In this paper we identify sources of externalities in Australian sugar cane production and examine ways to enhance greater environmental compliance by canegrowers who have agreed to a voluntary Code of Practice for sustainable cane production. The rationale for developing best-practice management options to mitigate environmental consequences of cane farming is explored using land management options for cane production in acid sulfate sensitive soils in the northern NSW coastal region as an example. This will form the basis for a detailed investigation of catchment-wide management strategies to mitigate the risks associated with farming on acid sulphate soils.

Key words: Externalities, sugar industry, land management

Introduction

The Australian Sugar Industry is at the crossroads. From its humble beginnings as a Colonial farm venture in 1862, the industry that became a net exporter of sugar in 1923 has since become an important supplier of raw sugar to the world market. This journey of 138 years has taken the industry through many developments, resulting in a significant growth in the number of growers, area planted and the total output of raw sugar. This growth was achieved within a government assisted institutional regime, a central feature of which was a cane area assignment system that regulated the area of cane under production at any given time. Single desk marketing of raw sugar in Queensland, tariff controls and government sponsored research and extension services provided the ancillary support to maintain the regulatory regime. Following a slow growth phase from 1977 to 1990, the industry embarked on an expansionary phase in 1991 following the introduction of the Sugar Industry Act 1991, which provided the basis for targeted area expansion through a decentralised land area allocation regime, and significantly reduced the level of government assistance to the industry.

Sugar cane is one of the highest value agricultural commodities in Australia, and is of particular importance to Queensland and the coastal towns of Northern NSW. In 1997/98 season Queensland produced 5.4 million tonnes of sugar crushed from 38.1 million tonnes of cane harvested off 397 512 ha of sugarcane worth over $2 billion. The sugarcane area in Queensland has increased by 44% since 1990 to around 509 500 ha in 1999, and now represent 95% of Australia's total sugarcane area (Canegrowers 2000). New South Wales produces the most of the balance 5% from a growing area of about 33 000 ha. A fledgling industry in the Ord river region of Western Australia produces a very small proportion of the total Australian raw sugar production. Expansion over the past decade has resulted in an increase of 160,000 ha in the area planted to cane, particularly along the northeastern coast spanning from Grafton in northern New South Wales to Mossman in far north Queensland. A rapid expansion of this magnitude, coupled with a rise to prominence of environmental concerns of development, turned a segment of the population against the industry despite significant national and regional economic benefits brought about by the expanded industry. While community concerns of the environment grew and as ecological sustainability was enshrined in national policy as a guiding principle in development activities, the environmental interest groups became a formidable political force in the mid nineties.

These developments made it imperative for the industry to take an active interest in environmental management. An industry sponsored Environmental Audit (Gutteridge, Haskins & Davey 1996), the appointment of an Environmental Manager and subsequent development of an industry Code of Practice for sustainable cane production (Canegrowers 1998) were major turning points that signalled the environment becoming a major theme in industry development by the late nineties. These developments were facilitated by the creation of a Cooperative Research Centre for Sustainable Sugar Production (CRC Sugar) as a collaborative venture between the Commonwealth, Queensland State Government agencies, CSIRO, three Queensland Universities, and the sugar industry. A major theme of CRC Sugar's 'Protecting the Environment' program was to establish the technical basis for environmental management focussing on environmental best-management practices.

Sugar industry Act 1999 (Queensland) that became effective on January 1, 2000, is the culmination of a series of attempts by the Commonwealth to deregulate the industry to produce an internationally competitive industry that is consistent with the competitive neutrality principle adopted by the government. Although the new *Act* retains much of the provisions of the superseded *Sugar Industry Act 1991* as recommended by the Sugar Industry Review Working Party (1996), which provided the policy blue print for the new *Act*, other Queensland government legislative reform associated with the *Integrated Planning Act 1997, Water Act 2000, Vegetation Protection Act 2000* and the *Environment Protection and Biodiversity Conservation Act 1999* of the Commonwealth will influence the future development of the sugar industry in terms of its environmental obligations.

Most sugar production in the world is consumed domestically and the world trade represents largely a residual supply. Australia, Thailand and Brazil are notable exceptions to this norm and together contribute nearly half of the internationally traded sugar. Therefore, the world sugar market is highly volatile reflecting supply and demand imbalances in both producing and consuming markets. Existence of highly protected markets of the European Union and the US makes the world sugar market one of the most complex of all commodity markets. Increasing volatility in the global sugar market resulting from production increases in particular in Brazil and India, and successive crop losses resulting from severe weather has eroded the profit margins of the previously highly profitable Australian sugar industry in current times. The expected returns to Queensland cane growers for the 1999/2000 crop, based on a pool price of $250 per tonne of raw sugar, is likely to be less than the 'break-even' price for many growers. Such low prices, coupled with a production downturn are threatening the viability of some cane enterprises, particularly those in marginal production areas. Recent analysis indicates that, if such low prices were to be sustained, over one third of existing cane land in regions such as the Lower Herbert would be withdrawn from cane production in an optimal planning strategy, in the absence of reductions in costs or other adjustments to farming systems (Mallawaarachchi and Quiggin forthcoming). Both the industry and the government are concerned with this commercial vulnerability of the industry, and the Sugar Industry Assistance Package announced in August 2000 by the Australian government seeks to encourage the industry to ensure its long-term viability through structural reform.

Development of sustainable farming practices that are both economically feasible and environmentally viable is the challenge confronted by the industry in responding to reform pressures to ensure long-term viability. These entails the development and implementation of smarter, more efficient ways of managing environmental externalities that may threaten the resource use efficiency and business competitiveness in the maturing sugar industry.

The other option available to the industry is to disregard calls for effective strategies to mitigate environmental impacts of industry activities. This unlikely option could expose the industry to grave consequences in terms of retaliatory action by a growing sector of the population both in Australia and overseas. Such action may possibly trigger domestic regulation under the *Environmental Protection ACT* and similar legislation governing industry practice. On the other hand, given Australia's firm position on free trade, it is unethical for Australia to be seen as providing implied subsidies for sugar production through a lack of effective environmental regulation. Such perceptions may lead to potential trade boycotts in the international market for creating environmental harm on World Heritage assets such as the Wet Tropics and the Great Barrier Reef, and pressure for countervailing measures to mitigate the implied cost advantages faced by the Australian industry in not having to mitigate environmental costs. While these are largely potential threats, and are of questionable legality under current WTO rules, they are increasingly becoming realistic in a market that has faced a global oversupply in recent times.

The objective of this paper is to examine the sources of externalities in Australian cane production and to identify opportunities for managing such externalities in the national interest, while meeting commercial viability considerations of cane growers. We present an outline of a detailed investigation to mitigate the externality risk of developing acid sulfate soils for commercial agriculture using best management options.

Environmental externalities in Australian sugarcane production

Externalities represent a wide variety of costs and benefits, which are not normally included in prices and charges. Some environmental externalities associated with sugar industry land use, also shared with other intensive agricultural industries, include the diffuse source pollution problems arising from run-off of pesticides, fertilisers and mill effluent (Mary Maher and Associates 1996; Johnson et al. 1997; Rayment and Neil 1997). Mallawaarachchi (2001) identifies two sources of externality associated with cane production in Australia: expansion of production area; and increase in production intensities on existing areas.

Expansion of the sugar industry following 1991 partial deregulation led to a growing number of environmental disputes, and attracted publicity amongst a fast-growing urban population in the region. Mary Maher and Associates (1996) and Johnson et al. (1997) identify a number of environmental issues connected to the sugar industry. The most pressing issues arise from an expansion of the area of land assigned for cane farming. In the absence of careful planning, expansion can create problems such as: altering the existing drainage regime, including wetlands, poorly drained coastal plains and coastal waterways; clearing of critical habitat and significant vegetation communities; disruption to aquatic life, water flows and fish breeding grounds; and fragmentation of previous integral native habitat.

Recent studies indicate that the balance of community view favours greater environmental care by the sugar industry, and that the loss of environmental value due to cane area development in cane growing regions can be significant and possibly exceed the benefits achievable from cane production. For example, choice modelling studies in 1998 indicate a high willingness to pay for preserving wetlands and riparian areas ($2100/ha) in major cane farming regions such as Herbert (Mallawaarachchi and Quiggin forthcoming). The preservation value of unique or rare vegetation in the smaller cane growing regions around the urban fringe, such as the Sunshine Coast region was estimated to be around $1300/ha (Mallawaarachchi, Morrison and Blamey 2001). These values attributable to environmental management arise due to the externality impacts of the sugar industry that affect community's use and non-use values of the environment.

Sugarcane farming is an intensive land use activity. Production is increasingly dependent on the use of chemical fertilisers to augment land quality, which has deteriorated following long years of monoculture. Fertiliser, in particular nitrogen and phosphorus, used on sugarcane can pollute rivers and waterways through soil erosion and subsoil leaching, and create costs to the users of the wetlands and water bodies (Rayment and Neil 1997). These pollutants have the potential to impact on the Great Barrier Reef World Heritage Area, creating vast social costs (Driml 1994; Wachenfeld, Oliver and Morrissey 1998). The canegrower who contributes to this pollution, as an indirect result of acting to maintain a productive cane crop, nevertheless does not pay for the 'use' of the waterway as a 'waste sink'. The presence of the externality leads to an economic inefficiency, because the full cost of the fertiliser management is not borne by the canegrower. Over-use of fertiliser, relative to the level that is economically optimal, will result. Moreover, cane production costs are undervalued to the extent of the 'free' use of the waterway, leading to the production of more sugarcane than that is economically optimal. In this case, the market has failed to avoid an inefficient practice resulting in public costs, and measures to mitigate the externality are required (Jacobsen and Mallawaarachchi 2001).

The system of industry regulation developed in Australia in the early twentieth century involved restrictions on where cane could be grown, on where the cane grown on any given piece of land could be processed, and on the terms and conditions under which growers and processors negotiated prices. The object of the assignment system is to allocate land to match existing mill capacity. However, the system is based on an implicit assumption that yields are constant, both spatially across lands and over time periods. In practice, growers are free to vary their production levels on assigned land by altering agronomic management, notably through the application of nitrogen fertiliser to augment land quality. Mallawaarachchi (1998) details the history and policy background of the sugar industry from a single user of natural resources in a region to a current multi-user setting and their implications on industry planning and management.

The regulatory system in Queensland[1] as a whole was designed to limit the total area used for cane production and to restrict the reallocation of land from cane production to other agricultural activities and vice versa. Moreover, the combination of inflated returns and restricted areas of land meant that intensive production techniques were more profitable under regulation than would have been the case otherwise. In environmental terms, there is a trade-off between increases in area and increases in production intensity. Incentives for intensive production tend to increase the severity of problems such as soil erosion and nutrient run-off. However, more intensive production techniques reduce the need for land clearing. Hence, the gradual relaxation of regulation since 1991 has yielded both environmental benefits and environmental costs. A responsible industry that aims to enhance its economic standing thus needs to improve the resource use efficiency in both the agricultural and environmental sectors by aiming to minimise undesirable activities. In this respect, it is prudent to identify the sources of inefficiency associated with current resource management systems and to examine ways of minimising such inefficiencies.

Sources of inefficiency in the use of natural resources in the Australian Sugar Industry

Factors that affect the level of aggregate demand and the aggregate supply determine the level of employment of a resource in the economy. Technological change, demand for final products, and the availability of cooperating and competing factors cause shifts in demand. On the other hand, wealth, social trends and legal context (institutional setting), investment and accumulation, and demography are important parameters of factor supply (Hirshleifer 1980). When markets operate freely, prices for goods and services generally indicate their value to society, and the allocation of resources between uses follow changes in supply and demand. Various forms of inefficiencies in the market, which are collectively known as market failure, lead to a situation where the social costs and private costs differ. The extent of this divergence reflects the level of uncompensated costs to the society of decisions made by individuals seeking their own utility and firms seeking to make profits. This discrepancy can result in resource allocations that bring higher private

[1] There is no statutory regulation of cane production in NSW. The production system in NSW is based on renewable mill-grower agreements.

benefits but represent costs to the society. Such allocations are inefficient, because a reallocation amongst alternative production and consumption opportunities could bring higher social benefits and more sustainable outcomes.

Market failure problems revolve around, and/or are reflected in, imperfect and asymmetric information, risk and uncertainty, incompletely specified property rights, externalities, collective or public goods, economies of scale and monopolies, all of which influence the functioning of the market as a means for allocation of resources. The Australian sugar industry displays all the above forms of market failure. The prime source of inefficiency, however, is related to the existence of production externalities associated with its land use.

In the case of the Australian sugar industry, the externalities are both direct and indirect. In the expansion of cane area, it can create a direct negative externality if the environmental values of the existing land uses are not considered. These can be generally regarded as land use change. In addition to opportunity costs imposed due to the forgone benefits of the existing land use, an extra hectare of land brought to cane production yields indirect externalities to the community. The latter arises through increasing the demand for remaining environmental assets, such as by contributing to congestion in national parks, wetlands, and the like. It can also lead to other indirect externalities, if activities of cane production or processing lead to uncompensated costs or benefits to individuals other than the cane grower. They may also include erosion and sedimentation affecting the ecology of waterways adjoining cane land, contribution to water quality problems through nutrient run-off, and run-off of pesticides and harvest residue from cane fields. The sugar processing also creates externalities, such as smoke stacks, mill effluents, emissions and noise, which under certain circumstances can be significant.

The focus of this paper is on these indirect externalities that are associated with pollution. Pollution can arise in the act of bringing land into cane production, in the continued use of land for cane production, and in the process of sugar manufacture. These include the impacts of accentuating natural hazards such as exposing acid sulphate soils that could cause harmful consequences through strong acid release. The damage caused by the pollutant (sulphuric acid) is determined by the concentration of the pollutant, and as long as the rate of release is less than the rate of assimilation or absorptive capacity of the environment, these pollutants, generally referred to as *fund pollutants* do not accumulate and become harmful (Tietenberg 2000). This class of externalities may also include the effects of excessive use of water, such as irrigation salinity and drainage problems; using fires for pre-harvest burning of cane, mill effluents running into waterways, etc.

Once the concentration of these fund pollutants exceed the assimilatory capacity of the environment, then they become similar in effect to *stock pollutants*, for which the environment has little or no absorptive capacity. Stock pollutants accumulate over time, and in some circumstances, can cause irrevocable damage, such as, when concentrations exceed certain biophysical thresholds. Heavy metals, soil salinity, soil acidity and persistent synthetic chemicals such as dioxins are some examples of stock pollutants that may be associated with sugar production. Both phosphorus and nitrates can become stock pollutants at higher concentrations, and efficient management objectives should entail restricting concentrations reaching such harmful levels.

Both these classes of pollutants cause externalities in cane production. When the first-best policy of avoiding the externality is not feasible, these externalities may be mitigated by appropriate land management practices. The policy problem, however, is ‘how to promote efficient land management?’, when the correction of the externality may involve direct costs to the grower and yield nonexcludable public benefits to many.

Options to manage externalities in the public interest

Traditional approach

The traditional approach to address externalities was the intervention by governments through imposition of taxes to limit the externality generating activity (Pigou 1932). However, mere existence of the externality itself does not warrant government intervention (Coase 1960), because of the possibility for bargaining. Hence providing information to enable participants achieving beneficial outcomes was encouraged as a solution to externalities. For most externality problems however, negotiation is costly, and is almost infeasible as a solution, as the number of parties adversely affected can be large, and it is difficult to isolate the contributor. In this regard, Coase (1960) stressed that market failure would not occur in the first place if property rights were properly defined. He argued that in a world with full information, low transaction costs, and strict enforcement of contracts, the distortions resulting from an externality could be resolved by the clear definition of property rights. His analysis indicated that nonattenuated property rights that are fully specified, enforceable and transferable would lead to socially efficient allocations of resources.

While these principles formed the economic basis for developing market based instruments such as quota arrangements and tradable entitlements, collective exchange opportunities such as voluntary restrictions, offset schemes such as land swapping, and proof of liability arrangements are becoming more widely considered in recent times (OECD 1999; Brunton 1999; Tietenberg 2000).

Recent developments

The general thrust of these arrangements today is to develop systems that are consistent with the changing community attitudes. The community is increasingly more informed of environmental consequences of developments, and there is a growing scepticism about public institutions. The general call is for greater involvement of stakeholders in decision-making. As a result, the command-and-control policies of the past are increasingly being supplemented with policies that allow greater participation of decision agents in voluntary management regimes that are linked to achieving agreed objectives (Department of Environmental Protection 1996; Environmental Protection Agency 1998). Resource management therefore reflects strategic management as against focus on reactive management that characterised penalty-dominated past management regimes. This emerging multi faceted approach aims to promote greater compliance through incentive structures, reward mechanisms and the role of regulatory exclusions and penalties are delegated to second place to be used as instruments of last resort.

In view of promoting compliance and greater participation, externalities can be seen as reflections of existing regulatory and incentive structures that deliver a set of goods and services in a particular combination, involving desired and undesired attributes (Cornes and Sandler 1996). Mitigation of the externality therefore entails examining alternative arrangements for delivering goods and services in a manner most acceptable to all stakeholders. Within this view, the aim of the sugar industry therefore would be to seek ways of producing sugar in the most efficient manner. The efficiency of production must match the quality of natural resources at its disposal, technological constraints that define the flexibility of altering the condition of natural resources to enhance productive capacity, and to minimise external costs, and be consistent with the way in which institutions have evolved, reflecting individual preferences and the distribution of those preferences (Cornes and Sandler 1996).

With communities seeking greater environmental responsibility from industries, and governments endeavouring to address this concern within budgetary constraints, and information deficiencies to set targets for environmental achievement, it is opportune for governments to encourage and facilitate communities and industries wishing to take greater environmental responsibility.

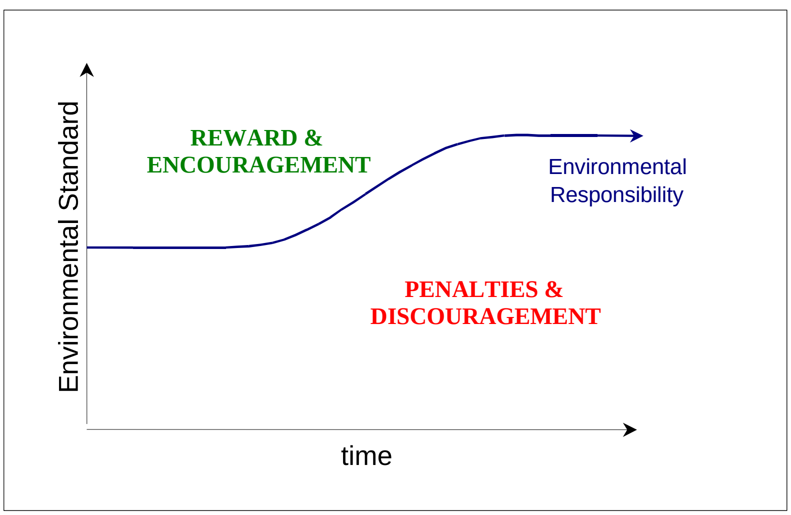
Following the environmental audit in 1996, the industry endorsed an environmental management strategy in 1997 and developed a Code of Practice for Sustainable Cane Growing in 1998 (Canegrowers 1998). The Code is aimed at mitigating the adverse environmental effects of on-farm practices. The Code is voluntary, and it is aimed at a general level of compliance within the guidelines available in existing legislation for land clearing, soil conservation, environmental protection and waste management.

In a global level, business-led environmental initiatives are increasingly common in industry, although new to agriculture. Business firms are motivated by either a desire to lower costs and improve profits while striving to achieve environmental compliance requirements (or, *regulatory push*), or/and a desire to respond to consumer demands for more environmentally sound processes and products – the *consumer push* (Batie and Ervin 1999). This applies equally well to the sugar industry, because, while complying with the Code is a voluntary decision for individual cane growers, deviation from compliance may carry the risk of litigation by affected individuals in cases where liability can be established. Moreover, state legislation such as the *Queensland Environmental Protection Act 1994* defines a duty of care responsibility for all land users to manage land in a sustainable way. Extensive non-compliance could result in the imposition of special conditions by the state to ensure sustainable sugar production, such as a condition attached to the cane assignment. Having brought the Code in place, an issue that needs addressing to ensure wider compliance is the availability of appropriate information, in particular regarding the efficacy of acceptable management practices to mitigate harmful externalities.

Strategic environmental management – incentives for best practice

The environmental impacts of the sugar industry depend both on the long and short run production decisions of cane growers. In the short run, production decisions are made and implemented within the constraints of weather conditions, available technologies and incentive regimes reflected in prices and policies. In the long run, investments are made in new technologies enabling improvements in productivity and production capacity. While in the short run, the focus on environmental policy is on the mitigation of harm, the focus must move to prevention as a strategic response over the long run.

Figure 1: A framework for the definition and identification of externalities and the signals necessary to encourage "efficient" resource use



Source: Young 2000

As environmental policies pursue higher levels of environmental quality in industry operations, or higher environmental standards over time, reward systems and encouragement can play a significant role in promoting environmental responsibility.

Whereas, over the long term, continued achievement of environmental responsibility may require greater emphasis on penalties for 'wrongdoers' and discouragement of non-compliant practices through market based mechanisms and planning controls. This is just, because industry has had the time to invest on new technologies to overcome constraints for compliance in the interim. Such a policy regime illustrated in Figure 1, following Young (2000) is comparable to the infant industry argument for tariff protection for emerging industries, applied across many industries in the post-war period. In place of tariffs that were granted to infant industries, assistance for promoting environmental responsibility generally includes technical assistance and investment subsidies (Lichtenberg, Strand and Lessley 1993). Moreover, best practice environmental management approaches have emerged as an effective response by industries aiming to maintain a competitive position in the face of advancing environmental policy (Environmental Protection Agency 1995).

Best management practices (BMPs)

Rationale

Best management practices (BMPs) represent a practice or combination of practices currently determined to be effective for preventing harmful impacts of production. BMPs are a means of preventing or reducing the amount of harm or pollution generated by production units by operating within stated management objectives. For example, best Management Practices (BMP's) are those fertilizer, water, crop and land management practices which lead to increased land productivity, greater fertiliser efficiency, minimum loss of inputs and maintenance or increase in crop yield and quality.

BMPs may be regarded as a logical short run alternative, given the informational deficiencies that surround non-point source pollution. However, its emerging emphasis on prevention, rather than control, makes it a more strategic and long-term response to pollution management (Stanley 2000). Moreover, practice of BMP promotes greater environmental performance, and is also regarded as an insurance against future liability for environmental damage, or adhering to duty of care, as required by most environment legislation. In particular, the rationale for BMP is guided by the following advantages of greater environmental performance as summarised in Department of Environmental Protection (1996):

1. As carrying capacity limits of receiving environments are approached or exceeded, possible expansion and in some cases continued operation of industry can be constrained.

2. With urban encroachment towards industrial areas and rising community concerns in relation to environmental quality, improved environmental performance is critical to public acceptance of industry.

3. Poor environmental performance can incur financial liabilities in fines, clean-up costs, compensation payments as well as negative market reaction.

4. There is growing consumer demand for cleaner products made by cleaner technologies; and,

5. contaminant levels in production inputs are increasing as industries use up better quality raw materials, requiring industries to improve pollution control performance to stay within emission [or discharge] requirements.

As a strategic management tool, one of the most important steps in developing BMPs should be the setting of objectives. Objectives must be achievable, relevant to problem being addressed and delineate a resource-dependent context, so that the manager can see that the enterprise can achieve them. Objectives must integrate production and environmental considerations of firms' practice, permit the entrepreneur to make the full use of available resources and capabilities, and encourage seeking innovations to accomplish higher goals. Without this emphasis BMP's will be seen as an approach that does not effectively signal the need for new R&D (Ervin and Schmitz 1996). Objectives must lead to tactical and operational goals, and flow into decisions and actions, whose achievement should advance the attainment of objectives (Forster and Browne 1996). To be successful, the industry must embrace an attitude of proactive and continued improvement, rather than, a reactive approach limited to compliance with changing environmental standards. Such resource-dependent and action-oriented strategies can be successfully linked to incentive mechanisms and reward system to facilitate greater voluntary participation.

BMPs for cane growing on acid sulfate sensitive soils

Having located in the coastal region, sugar cane farms run the risk of exposure to acid sulphate soils which may occur in low lying land below 5 m AHD[2]. Acid sulphate soils (ASS) are the result of long-term bacterial activity in organic rich sediments now underlain by varying thicknesses of later alluvium. These soils are generally found in low-lying areas along the coastline, estuaries and estuarine flood plains throughout sugarcane areas of NSW and Queensland. In NSW, extensive deposits have been identified in the Tweed, Richmond and Clarence regions of north coast, which are important cane growing areas.

ASS do not pose an environmental threat when left undisturbed beneath the water table. However, when ASS are excavated or drained, oxygen enters the soil, oxidising the sulphide compounds (mainly pyrite), and produce sulphuric acid. Acid so formed can leave the sites of oxidation during and following heavy rains, causing severe soil

[2] Australian Height Datum

acidification and pollution of local waterways. In turn, the acidification mobilises metallic ions such as aluminium, iron, manganese and cadmium. Therefore, run-off and drainage waters from areas of acid sulphate soils can cause sudden increase in acidity in water bodies and disrupt aquatic communities and result in fish kills. Prolonged exposure to acidity may bring about habitat degradation, ecosystems decline and loss of recreational and commercial opportunities (Ahern, Powell and Eldershaw 1999). It can lead to further costs by damaging built structures, particularly made of concrete, ferroconcrete, iron, steel and aluminium that are found in bridges, building foundations, pipes and cables.

Oxidation of ASS soils is a natural process and occurs in undisturbed woodlands, grasslands and wetlands as watertables rise and fall. However, any activity that alters the existing condition of acid sulphate soils can trigger an accelerated oxidation process. For instance, increasing pressure for improving productivity has resulted in greater emphasis on farm drainage, thus increasing the risk of exposure of pyritic material.

Acid sulphate soils became a significant environmental issue for the NSW sugar industry following a major incident in the Tweed River in 1987, which led to significant disruption of fishing habitats and local community outrage. Having traced the incident to acid flowing from areas developed for cane production, in 1993, the NSW industry adopted new guidelines for drain construction and maintenance in acid sulphate soils. Strategic management of acid sulphate soils in NSW was initiated with the formation of the Acid Sulphate Soils Management Advisory Committee (ASSMAC) in 1994, to advise government on the management of acid sulphate soils, to coordinate research and management initiatives of government agencies, and to develop generic guidelines and principles for effective management at a local level.

A National Strategy for the Management of Coastal Acid Sulfate Soils was promulgated in 1999, by the National Working Party on Acid Sulfate Soils, on behalf of the Standing Committee on Agriculture and Resource Management (SCARM) and the Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ). The strategy offers a blue print for the management of coastal and estuarine acid sulphate soils to minimise social costs through a coordinated whole-of-government approach (AFFA 1999).

The Strategy is consistent with the principles of externality management discussed earlier and focus on:

1. Objective assessment – to gain an understanding of the extent of coastal ASS in Australia;
2. Prevention -- avoid disturbance of coastal acid sulphate soils where possible;
3. Mitigation -- mitigate impacts when ASS disturbance is unavoidable; and
4. Rehabilitation -- rehabilitate disturbed ASS and acid drainage.

The implementation of the national strategy rests largely on the hands of state governments, local authorities and landowners, and various policies, programmes and statutes have been designed, at various levels of the government, both in association and independent of the national strategy (Queensland Government 2000). These activities, in particular, identify the importance of collecting information on the distribution and extent of ASS at both catchment and property levels. While the information will help improve the awareness of the problem, risk maps showing potential distribution and depth of acid sulphate soils can also be used as a resource to persuade land managers and developers in identifying and adopting best practice principles and technologies. Where an excessive risk prevails, planning and development controls can be used to minimise the risk of disturbing ASS and to provide appropriate preventive measures without excessive cost. The strategy recognise the old adage ‘prevention is better than cure’ in that the investment of time and effort in measures that avoid or prevent disturbance of ASS will provide a much greater return than measures designed to treat or rehabilitate areas after disturbance.

A program of research sponsored by CRC Sugar strengthened this process by developing a testing procedure for potential acid sulphate soils (Neilsen and Rayment 1998), for use in tandem with farm scale mapping of acid sulphate soils risk (Naylor et al. 1995), and investigating on-farm practices to minimise the impacts of acid sulphate soils on the environment (Wilson, White and Melville ; White et al. 1997; CRC Sugar 1999). This program of activity facilitated and endorsed by the NSW sugar industry has enabled the industry to gain self-regulation status for managing acid sulphate soils under best management practice. Research into best management practice for drain maintenance and water table management is in progress (Cook et al. 2000a; Cook et al. 2000b). Yet, affordable treatment technologies must be refined and extended to industry for adoption into routine practice. Measures must be adopted at a hydrological catchment scale because of the interdependence between catchment hydrology and effective practice. This requires economic studies to evaluate the effectiveness of best practices applied as an integrated land and water management regime at a catchment scale. In the following section, we examine the basic features of an effective BMP scheme for acid sulphate soils and outline a case study to evaluate the effectiveness of such a BMP strategy being investigated in a NSW sub-catchment.

Effective management of acid sulphate soils

Presence of acid sulphate soils should not preclude development; however, their use requires specific management to minimise social costs. Development involves changing land use from an existing state to a more beneficial use, as perceived by the developer. This conversion is socially beneficial when the social cost of new land use is less than the benefits achievable. The social cost reflects the full economic cost of changed land use and is defined as “the sum of money which is just adequate when paid as compensation to restore to the previous level of utility all who lose as a result of the output in question” (Pearce 1978). The output in question here is cane production, which is unambiguous and easily measurable. Those who lose, in terms of money spent, labour committed, and given up current land use are largely cane farmers, but can also include others, if in particular conversion of natural land uses are involved. Yet, counting them is relatively straight forward, and at the highest level they include the community. Determination of "the previous level of utility" is much harder to quantify, and may involve difficult assessments of non-use benefits.

Assuming that all costs can be measured, the costs in this case includes the cost of investment and maintenance costs for both production *and* pollution abatement. This also assumes that the level of acid discharge from current land uses is within the assimilatory capacity of the environment and poses no threat of degradation. Since it is not likely to be the case, and if the development is likely to increase environmental status, such improvements must be counted as benefits together with the benefits of cane production. The objective, therefore, is to determine profitable land uses when the costs of pollution abatement are fully regarded as costs of development. Then, such land use change would be socially desirable.

The following case study of the Tuckean Swamp is designed to assess the economic feasibility of using potential acid sulphate areas for cane farming under best practice management to mitigate pollution hazard. Since the case study is in its early stage, we give below a brief outline of the activities designed on the basis of the rationale for best practice management discussed earlier in this paper.

Tuckean Swamp case study

Tuckean Swamp is backwater of about 9 000 ha of coastal floodplain on the lower Richmond River near Broadwater in Northern NSW. Once a significant wetland, an important feeding and nesting ground for waterbirds and a significant fisheries habitat, this small subcatchment of the Richmond River has been largely reclaimed over the past hundred years. Once profitable dairying and beef cattle grazing land have more recently been targeted for conversion to sugar cane. In i996 there were about 7200 ha under pasture including 500 for dairy and 5700 for beef, while the area under cane was around 1000 ha (Read Sturgess and Associates 1996). Remaining areas include nature reserves and small holdings used as hobby farms. Past development has involved investment in drainage and flood mitigation to improve potential land productivity. The Bagotville tidal barrage erected in the 1960's protects the swamp from tidal inundation and saline inflows.

It is however, recognised that drainage exacerbates the oxidation of acid sulphate soils and increases the potential for acid export to the Richmond River estuary. During and following rainfall events, barrage acts as a reservoir for collecting acid laden run-off, thus permitting concentrations to reach harmful levels. On the other hand, the neighbouring farmers believe that the barrage impedes the passage of water during major floods

(Baldwin 1997). Landholders are encouraged to adopt farming practices that are less reliant on drainage.

Therefore drainage management, flood control and crop management are important land and water management issues facing the Tuckean Swamp community.

Case study outline

The economic basis of the assessment method is to manage the acid sulphate soils problem as a potential fund externality explained earlier. The management approach is to assess the acid sulphate soils risk and to determine appropriate management strategies to management units falling under each risk category. Given the interlinked nature of drainage, hydrology, landscape and soil attributes, the aim is to understand the linkages at the subcatchment and property levels to guide management strategies. The economic assessment will determine optimal management strategies that meet the environmental and economic viability considerations.

The study involves three interconnected segments:

1. Production risk assessment for sugar-cane and other crops;
2. Assessment of management options to rank their suitability to mitigate risk;
3. Determining economic feasibility of management strategies.

The best practice management options developed will be aimed at:

a. avoiding significant environmental impact;
b. recognising the interest of the community and other stakeholders;
c. promoting system scale solutions to land and water management; and
d. seeking a commitment to continual improvement in performance.

Recently completed Tuckean Swamp Land and Water Management Plan (Baldwin 1997) and associated studies {Read Sturgess and Associates 1996 #10410} will set the general direction for the study and provide the primary source of information. This information will be supplemented with those from CRC Sugar, NSW Government agencies, Richmond River County Council and other relevant sources.

Production risk assessment

The NSW Department of Land and Water Conservation has mapped ASS risk at 1:25,000 scale as part of the regional resource inventory program. This information will be linked with other technical information in a Geographic Information System (GIS) to assess the suitability of land for cane production.

GIS analysis

Given the heterogeneous nature of the risk, GIS analysis will be used to identify management units with homogeneous character with respect to known attributes. These management units will then be used as the unit of focus for exploring different options for managing the acid sulphate soils risk under best management practice.

Assessment of management options

This will involve the matching of existing agronomic and land management practices to the respective risk categories of different land units that are classified on the basis of risk assessment. These options will include exclusion, mitigation and treatment strategies to minimise the acid sulphate soils risk. GIS analysis will also be used to explore other management options such as flood gate management: An automated system to open floodgates to allow tidal water to mix with acidified drainage waters may be used to improve water quality. This tidal mixing neutralises acid to prevent concentrated acid being discharged directly into receiving waters. It also offers an escape route for fish and other aquatic organisms, which might otherwise be trapped within the floodgates as acid waters accumulate.

Economic feasibility

The economic feasibility of management options will be assessed both at the farm (or management unit) and the subcatchment level. Farm level assessment will incorporate whole farm accounting to determine long-term financial viability, using a farm-level modelling tool, CANEPLAN (Qureshi et al. 2001), calibrated with site specific parameters.

Regional assessment of viability will be made using the regional allocation model CLAM (Mallawaarachchi and Quiggin 1999), adapted to local conditions based on GIS analysis.

Implementation of this study requires the cooperation and commitment of the landholders, the sugar industry, local authorities and the technical experts dealing with different aspects of the problem. While the approach presented provides a mechanism to integrate inputs from all parties, its successful completion will also rests with our ability to gather required funding.

Concluding remarks

The purpose of environmental policy is to guide firms and individuals towards more sustainable production and consumption activities. The basis of these policies is social regulation and involve: (1) rules or standards prescribing responsible behaviour; (2) enforcement agents and auditors to deter deviation from compliance; and (3) sanctions applied to those who violates the rules. More recently, the focus is moving on incentives to promote compliance, as a more cost-effective and strategic policy instrument.

To achieve sustainable development sugar industry must improve its environmental performance by more effectively integrating environmental considerations into its strategic planning activities. Cane production area assignment system is the current mechanism for allocating land for cane farming. Attaching environmental performance requirements to assignment criteria is an effective instrument to ensure compliance by canegrowers with best practice to mitigate harmful externalities. Economic assessment of best practices can provide information to enhance compliance as well as to exclude those land units that are not likely to be viable in the first place. The analytical methods being developed in this study will enable the examination of incentive structures to promote compliance.

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