SOME BENEFITS AND COSTS OF IMPLEMENTING SOIL CONSERVATION PRACTICES ON FARMS ON THE NORTH COAST OF KWAZULU-NATAL

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Abstract

The soils of the north coast of KwaZulu-Natal are subject to erosion when inadequately conserved. The SA Sugar Association Experiment Station CANEGRO model was used to simulate sugarcane yields from various soil depths. Losses in revenue from predicted sugarcane crops when soil depth is decreased by erosion of the topsoil, are shown. The costs of carrying out conservation measures are investigated, as are the losses in revenue from the reduced area cropped following the construction of conservation structures.

Introduction

There is an obvious need to conserve soil to ensure agricultural production into the future, and the Conservation of Natural Resources Act (1983) (the Act), requires all farmers to implement adequate soil conservation measures to protect the soil from erosion (Anon., 1984a). However, some cane growers regard as wasteful the use of productive land for conservation structures. This paper attempts to show that there is sufficient economic incentive to apply the necessary conservation measures. It also highlights the need for further research into the economic benefits to the farmer and the community if all land is conserved.

On certain cane farms on the North Coast of KwaZulu-Natal, efforts have been made in the past to persuade growers to implement the necessary conservation measures, including minimum tillage and strip cropping (Hulbert, 1990). An initiative by the Lower Tugela Conservation Committee (LTCC) started with farm assessments to determine whether individual farms on the coastal belt complied with the requirements of the Act (McFarlane and Maher, 1993). It was found that relatively few farms complied fully with the requirements of the Act where the stability and capacity of grassed waterways and the protection of larger water courses were concerned. More recently, efforts have been made to give priority to these problems. For example, the sugar industry's Local Environment Committees (LECs) have held a number of field days and demonstrations on wetland and water course management.

This paper looks at examples of erosion occurring in field, water course and roadway situations on certain farms on the North Coast. In each case the situation is reviewed by the presentation of descriptive and calculated data. In addition, an estimate of the cost of appropriate conservation measures is provided.

Results and discussion

Infield erosion

Continuous cropping of sugarcane on erodible soils without the implementation of adequate soil conservation measures can lead to a decline in yield caused by a limited rooting depth. Yield loss is difficult to quantify from field records as yield decline is a long term effect, and several factors such as rainfall, agronomic considerations and management standards also influence comparisons.

To quantify the loss in yield caused by reduced rooting depth, the SASA Experiment Station (SASEX) CANEGRO model was used (Inman-Bamber et al, 1993). A crop growing at Darnall on a Milkwood soil form with a 12 month cycle from mid-September to mid-September, was simulated for the years 1971 to 1992. A Milkwood soil can be regarded as shallow, having a rooting depth of between 300 and 700 millimetres (Anon., 1984b). In the simulation an initial rooting depth of 650 mm was selected and yields determined. Three further simulations were done progressively, reducing the rooting depth by 100 mm. The results of these simulations and the gross margin analysis for sugarcane grown on each soil depth are presented in Table 1 and Appendix 1.

Table 1

Results of CANEGRO simulation and gross margins

Soil depth (mm)	Average sucrose yield/ha for 1971-1992	Gross margin in Rands per hectare	Difference in gross margin R/ha
650	9,90	5 587,82	-
550	9,00	4 973 80	614,02
450	7,46	3 917,22	1 056,58
350	4,22	1 712,05	2 205,17

While it is unlikely that losses to the extent of 100 mm soil would occur over a short time, there is evidence that, over longer periods, such losses have occurred. For example, tropical cyclones Demoina and Imboa in 1984 and the Natal floods in 1987 showed the dramatic effects that heavy rains have on unprotected soil. Specific examples of soil loss from sugarcane fields and the banks of streams can be found in the Shakaskraal area along the Umhlali river and its tributaries (Stranack, 1992). Large deposits of sediment over a considerable distance can be found on the bed of the Umhlali river in its lower reaches. The estimated average rate of soil formation on arable land is 12,5 tons soil/hectare/annum, or about 0,8 mm per annum (Hudson, 1971).

Since 1977, the SASEX Farm Planning Department has been recording soil loss from selected catchments at La Mercy, and from other small run-off plots situated on SASEX field stations in the sugar industry (Platford, 1979). A rainfall simulator (Platford, 1987) has been used to compare the effects of conventional and minimum tillage systems on soil loss. Platford (1987) reported that measurements from these sources indicate that 85 to 90% of soil loss occurs during crop re-establishment. For example, soil loss from catchment 104 in area 10 at La Mercy, was measured during one rainfall event in March 1987, when 103 mm of rain was received over three days, with a maximum intensity of 37 mm in 26 minutes. Catchment 104 was fallow at the time of the rainfall event, and the measured soil loss at the end of the three days was 35 tons per hectare (1Platford, unpublished data). Catchments with varying degrees of crop cover recorded considerably less soil loss.

On the north coast the practice of ploughing and harrowing fields before crop re-establishment has for many years, contributed significantly to soil erosion, particularly on steeper slopes. Calculations of soil loss using the Universal Soil Loss Equation (USLE) show that on a moderately erodible soil with a 15% slope, a 'blocky' field layout and using conventional tillage, 64 tons of soil per hectare per annum can be lost (Platford, 1987). This is equivalent to 4,2 mm of soil lost each year.

Minimum tillage is one of the most effective methods of reducing soil loss from sugarcane fields. In the situation mentioned above, soil loss can be reduced to 13 tons per hectare per annum if minimum tillage is practised. Following the removal of the patent rights to 'Roundup' (glyphosate) in 1994, a range of similar glyphosate products became available (Leibbrant, 1994), and resulted in a lower price for the product, which in turn reduced the cost of chemical minimum tillage (Stead, 1995).

Cost

Situated at Darnall on the north coast, farm 'A' has an annual replanting programme of 140 hectares. If crop eradication and land preparation were done by conventional means, 420 tractor hours for ploughing and 378 hours for harrowing would be required. The total cost of these operations would be R48 720. A similar programme using chemical minimum tillage would cost R25 480 (Appendix 2). If a combination of manual removal of sugarcane stools (hand chipping) in winter and chemical minimum tillage in summer were used, the cost would be somewhat higher at R38 494.

Erosion of water courses

The protection of stream banks is essential if severe erosion is to be avoided during heavy rains. In 1984, a survey by the Lower Tugela Soil Conservation Committee identified a distance of 22 of the 50 kilometres of the Umhlali river catchment where sugarcane was planted within the 10 metre boundary along the river bank (Lower Tugela Soil Conservation Committee, unpublished data). The Act requires that no cultivation be practised within 10 metres of the one-in-ten-year flood line on any river or stream (Anon., 1984a).

An investigational report by the Institute of Natural Resources (INR) on the Umhlali river catchment proposed guidelines for the protection of water courses in that area (Anon., 1993). The guidelines concentrate on the importance of stable, grassed waterways, and the establishment of plugs of vegetation at strategic points to encourage wetlands to develop which would slow the flow of water and reduce the impact of flood waters on areas downstream.

Farm 'A', having soils of the erodible Cartref form, is an example of the damage that can be done by flood waters. Run-off following the heavy rains in September 1987 resulted in the enlargement of a poorly protected waterway on the farm. This waterway increased from a width of 3,2 to 5,7 metres at the widest point, and depth increased from less than one metre to an average of three metres. The catchment area of this waterway, measured to the point where it joins a stream, is three hectares in extent. Damage resulted from a lack of sufficient soil cover in the waterway at the time of the heavy rain. Run-off from the catchment was supplemented by discharge from a road and a number of buildings. Where there was adequate cover over part of its length, the original width of the waterway was maintained, with only slight damage being evident.

Costs

To stabilise this waterway, which has vertical and actively eroding sides, a 3,5 metre wide area free of sugarcane on either side of the waterway is necessary. This will allow the area to be established to grass, with enough space for the banks to settle to an angle of 45 degrees, providing the stability required. The waterway is 95 metres long, so the area occupied by the enlarged waterway, once it has been stabilised, will be 1045 m^2 (Appendix 5). A cost of R602,28 will be incurred by planting a suitable grass species such as *Stenotaphrum secundatum* (coastal buffalo grass) and appropriate indigenous trees, in the damaged area (Appendix 5).

This waterway can be compared with a watercourse on the same farm on similar Cartref form soils. In this example the catchment is 16,6 hectares in extent. Although only 4,3 metres wide for most of its length, this watercourse remained stable due to the presence of a thick cover of grasses and sedges in its base.

A comparison of the cost of land lost to production over an equivalent length in the two waterway situations, is given in Table 2.

Table 2

Comparison of stable and damaged waterways, farm 'A'

Condition of waterway	Width (m)	Length (m)	Area (ha)	Revenue lost (R)	Repairs (R)
Stable	4,3	95	0,04	156,69	
Damaged	11,0	95	0,11	430,89	602,28
Difference	6,7	-	0,07	274,20	

Conservation layout

SASEX Land Use Plans (LUPs) provide a layout of conservation terraces, specify the size and position of grassed waterways, and identify wetland areas. These are not widely accepted as necessary by all growers in the region, who argue that conservation structures occupy land that could be planted to sugarcane. Farms 'B' and 'C', adjacent properties in the Tinley Manor area, are an example of diverse strategies in this regard. Farm 'B' has a traditional 'blocky' field layout with the minimum number of roads and few grassed waterways. Farm 'C' has a network of contour terraces and grassed waterways and is generally regarded as one of the best conserved farms on the north coast.

Costs

Table 3 gives a comparison of the areas occupied by roads and waterways on the two farms (see Appendix 3). The cost that these areas represent in terms of lost revenue per hec-

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Table 3

Area of roads and waterways, farms 'B' and 'C'

Farm	Area of farm (ha)	Area of roads (ha)	Area of waterway (ha)	Roads and waterways/ha of farm (ha)	Loss in revenue/ha of farm (R)
B	164	3,37	0,25	0,02	78,34
C	144	10,89	2,16	0,09	352,55
Difference				0,07	274,21

tare/annum is shown for each farm. The gross margin analysis for a 62,5 ton cane/ha/annum crop is used to calculate the loss in marginal revenue (see Appendix 1).

In the example used, the initial cost of constructing the structures has not been considered. If waterways and terraces are correctly constructed, their capital cost can be depreciated over a long period.

The annual cost of maintaining terrace roads and waterways includes mowing of the grass in these structures. Farm 'C' has 13,1 hectares of grass to mow each year. Four mowings per summer would cost R6 130,80 (Anon., 1994), adding a further R42,57/ha to the total negative cash flow for farm 'C'.

Erosion from roads

Inadequate drainage has in the past caused considerable erosion of farm roads by channeling and concentrating run-off water, thereby increasing the velocity and the erosive power of the water (Anon., 1974). If the water course into which this water is eventually discharged does not have adequate cover and channel capacity, erosion will occur, particularly if the soils are sandy.

For example, a crest road on farm 'A' had inadequate side drainage, which resulted in water being channelled along the road instead of being safely led off into the fields at intervals. The continuous erosion of the road surface has resulted in it becoming entrenched, making it impossible to lead water off the road. The channels on either side of the road have also become entrenched, eroding the adjacent fields and increasing the area of non-productive land.

Costs

As the crest road on farm 'A' is a haulage route, the surface needs to be maintained and in fair condition. The erosion of the surface material results in resurfacing having to be done on a regular basis at a cost, per operation, of R9 260 per 1 000 metres of road (see Appendix 4). The cost of this maintenance is additional to the loss in income from the reduced area of productive land on the sides of the road.

General discussion

The results of the CANEGRO simulations illustrate the importance of preserving soil depth, particularly if the soil is not deep to begin with. For example, there are approximately 20 000 hectares of soil on the north coast that are derived from Dwyka tillite parent material (Anon., 1984). This represents about 13% of all soils on the north coast. The most commonly occurring is the Glenrosa soil form, which has a rooting depth of between 300 and 500mm, similar to that of the Milkwood form. The CANEGRO simulation indicated that productivity on these shallow soils would show losses if adequate conservation measures, particularly minimum tillage were not practised. As some north coast farmers continue to use conventional tillage on these unsuitable soils, it is probable that the original yield potential of cane crop has been substantially reduced on their farms. It has been shown that basic soil conservation measures are cost effective to the grower. For example, the practice of chemical minimum tillage is currently the cheapest method of crop eradication. It also provides good cover at time of planting and conserves moisture as well as soil, thereby increasing yield potential.

The presence of a good vegetative cover is crucial to withstanding severe pressure from run-off in water courses, particularly on erodible soils. The stability of stream banks is improved by the planting of suitable indigenous trees at pressure points, and removing sugarcane from the banks of streams to the required distance will reduce erosion in these areas. The distance needed to adequately protect stream banks has been debated, despite the Act being specific in its requirement that no cropping take place within the area of 10 metres of the one-in-ten-year flood line. The policy adopted by many farmers is to remove sugarcane from visibly unstable areas adjacent to the banks of streams and to allow indigenous vegetation to return by natural seeding.

The 1987 Natal floods caused significant widening of some water courses and led to instability of stream banks. The width to which these water courses have since settled and begun to stabilise, can often be related to water courses on similar soils and of similar size which are protected by natural vegetation. This enlarged area indicates the area which should not have been cleared of indigenous vegetation for cropping.

Erosion caused by poor road drainage is a common occurrence and better siting, together with correct construction, are essential to stop this damage.

Further benefits from conservation measures that are more difficult to quantify are those accruing to the community beyond the borders of a farm. Cleaner and less erosive run-off water reduces the possibility of damage to properties downstream. Lagoons and estuaries would receive less sediment and function more effectively. A slower release of water from upstream farms due to the presence of stable wetlands will benefit the water supply to water users downstream during times of drought and flood. Indigenous vegetation along streams is a source of seed material for the area and also provides habitat for fauna. A well conserved farm is less likely to place demands on state funds for assistance in times of natural disasters such as floods and droughts. These benefits need to be measured in an exercise in resource economics.

Finally, a well conserved farm is likely to command a higher market value.

Conclusions

The implementation of conservation measures includes the capital cost of construction, an annual maintenance cost, and an annual sacrifice of revenue. However, these annual recurrent costs are seen to be lower than the predicted long term reduction in yield that may occur if conservation is not practised and soil depth is reduced. This is particularly true where soils are already shallow or highly erodible. The land taken up by conservation structures must not be considered lost to production but should be seen as the cost of maintaining yields on the farm in the long term. Viewed as a form of insurance, these costs are more easily justified, particularly as this cost must be related to the entire area of the farm. More work is needed to measure soil loss from sugarcane fields over a long period of time.

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APPENDIX 1

An 'A' Pool gross margin/hectare analysis for farm 'A' at Darnall

Sucrose % cane - 12%
Price of A Pool - R830/ton of sucrose (1994/5)
Direct costs of commercial cane production in R/hectare

Planting costs depreciated over nine harvests	234-33
Fertiliser	426-00
Labour fertiliser application	38-00
Herbicides	190-00
Labour herbicide application	57-00
Hand weeding	221-12
Subtotal	R1 166-45

Harvesting and haulage costs in R/ha for each soil depth in the yield simulation:

Soil depth (mm) Tons suc/ha	650 9,9	550 9,0	450 7,46	350 4,22
Tons cane/ha @ 12%	82,5	75	62,5	35,2
Harvesting cost	637-73	579-75	483-13	272-10
Haulage cost	825-00	750-0	625-00	352-00
Total harv + haulage	1 462-73	1 329-75	1 108-13	624-10

Gross margin analysis in R/ha

+ Subtotal	1 166-45	1 166-45	1 166-45	1 166-45
Total costs	2 629-18	2 496-20	2 274-58	1 788-55
Gross revenue @ R830/t suc	8 217-00	7 470-00	6 191-80	3 502-60
Margin	5 587-82	4 973-80	3 917-22	1 714-05

APPENDIX 2

Costs of conventional and minimum tillage on farm 'A' at Darnall

Conventional tillage using SASEX machinery costings (Anon., 1994)

Replant	140 ha
Tractor	63 KW
Hours/annum	1 000 hrs
Cost per hour	R53,23

Ploughing operation: 3-furrow mouldboard plough, one pass, 1,2 m cut, speed of 4 km/h and taking 3 h/ha.
Harrowing operation: Disc harrow, two passes 0,2 m cut, speed of 4,5 km/h and 1,35 h/ha

Ploughing cost/ha including tractor: R148
Harrowing cost/ha including tractor: R100/pass

Total cost of operations: R348/ha for 140 ha = **R48 720**

Cost of minimum tillage for 140 ha

One-quarter (35 ha) manual chipping in winter
Two-thirds (105 ha) chemical minimum tillage in summer

Manual: 40 labourers/ha = R552-80/ha

Total cost for 35 ha:	**R19 384**
Chemical 8 l/ha	R144,00
Labour	R 38,00
Total	R182,00/ha
Total cost for 105 ha:	**R19 110**

Therefore, total cost of combined minimum tillage programme: **R38 494**

Using chemical minimum tillage **alone** on 140 ha: **R25 480**

APPENDIX 3

Calculation of the area of roads and waterways on farms 'B' and 'C' at Tinley Manor

Farm 'B'; infield and haulage roads: 11 220 metres × 3 metres = 33 660 m^2 (3,37 ha)

Farm 'C'; infield and haulage roads: 31 110 metres × 3,5 metres = 108 885 m^2 (10,89 ha)

Farm 'B'; waterways: 1 260 metres × 2 metres = 2 520 m^2 (0,25 ha)

Farm 'C'; waterways: 6 180 metres × 3,5 metres wide = 2120630 m^2 (2,16 ha)

APPENDIX 4

Cost of road surfacing on Farm 'A'

Quarry material transported seven kilometres: R15/m^3
Quarry material per metre of 3,5 m wide road: 0,5 m^3
Grader cost: R110 per hour and completes 500 m of road per day
Grader cost per 1 000 m = R1 760
Quarry material cost = 0,5 × 1 000 × R15 = R7 500
Total cost = R9 260 per 1 000 metres (R1 760 + R7 500)

APPENDIX 5

Productive land lost in damaged and undamaged waterways, farm 'A'

Undamaged waterway:

width	4,3 m
length	95 m
gross margin/Ha	R3 917,22
area of waterway	4,3 m × 95 m = 408,5 m^2 (0,04 ha)
revenue lost	0,04 × R3 917,22 = R156,69

Damaged waterway:

width	11 m
length	95 m
gross margin/Ha	R3 917,22
area of waterway	11 m × 95 m = 1 045 m^2 (0,11 ha)
revenue lost	0,11 × R3 917,22 = R430,89

Cost of repairs to damaged waterway, farm 'A'

Grass planting

Labourers	2 @ R23,07/day	R 46,14
Tractor	3 hrs @ R35/ha	R105,00
Trailer		R 50,00
	Subtotal	R201,14

Tree planting (50 trees)

Labourers	2 @ R23,07/day	R 46,14
Trees	50 @ R4,00	R200,00
Tractor	3 hrs @ R35/ha	R105,00
Trailer		R 50,00
	Subtotal	R401,14

Grand total R602-28