The causes and consequences of cane burning in Fiji's sugar belt

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Introduction

For over a century sugar has been the dominant industry of Fiji. During this time it has shaped not only the country's economy but its history, politics, demography and labour relations, leaving virtually no substantive facet of life untouched. While the industry doubtlessly possesses the capacity for further growth, this potential, and quite possibly the very survival of sugar production, are subject to a multifaceted threat emanating from imminent reductions in revenue after the forthcoming demise of the Lomé Agreement, rising milling and farm costs, deteriorating productivity, inadequate investment, poor labour relations and attitudes, uncertain land tenure and declining cane quality. These problems are widely appreciated and a strategic plan aimed at addressing them has recently been developed ('Sugar Industry Strategic Plan' 1997).

One of the main problem areas identified in this strategic plan relates to the practice of burning cane prior to its harvesting. This practice has been increasing rapidly of late to the extent that the 1997 season will see the proportion of burnt cane delivered to the mills at an all time high of approximately 62%, a figure that industry officials describe as a disaster. In the context of sugar production in Fiji, burning is undoubtedly a major source of avoidable inefficiency, affecting both the costs of production and the potential incomes of all those stakeholders whose livelihood comes directly from sugar earnings or indirectly from economic activities sustained by the spending of sugar revenues.

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Unfortunately neither the full measure of these inefficiencies nor the complex reasons that motivate farmers and harvesters to burn in Fiji are widely appreciated. Accordingly, the purpose of this paper is to analyse the practice of burning, and to investigate the nature of the costs it imposes and the reasons why it is done. While it is hoped that the paper may prove of interest to those concerned with the sugar industry generally, it is particularly intended to contribute to current efforts to rescue the industry in Fiji.

As a starting point, the paper will summarise the organisation of sugar production in Fiji, as it is not possible to understand the motives for burning without being aware of the industry's unique institutional structure.

An overview of sugar production in Fiji

About 4 million tonnes of cane are normally harvested each year in Fiji, producing over 400,000 tonnes of sugar. The cane is grown by some 23,000 small-scale farmers on farms typically averaging 4 hectares. An increasing number of these farmers now combine farming with other economic activities. While some also harvest their cane, the great bulk of the cane is harvested by some 15,000 cane cutters. All the cane is cut manually.

The large numbers of growers and cutters imposes a formidable coordination exercise at harvesting time. For optimal efficiency each mill must operate continuously at its design capacity. Thus the Lautoka mill, Fiji's largest, has an hourly crushing capacity of 350 tonnes of cane, which translates into a daily demand of over 8,000 tonnes. To secure this requirement from the thousands of farmers who grow cane, a harvesting plan covering the entire season is drawn up, which each day assigns a quota—a specific tonnage to be harvested—to selected farmers. Rail trucks sufficient to deliver this quota are assigned to the designated farmers, though farmers who use lorry transport will have to arrange their own cartage. All farmers to whom a quota is assigned have to arrange for harvesting gangs to cut their cane and load it on to rail trucks or lorries. This coordination exercise is further complicated by the fact that normally a given farmer's daily quota will constitute only a portion of his total crop, notwithstanding the very small size of farms. This means that each farmer will be called upon to deliver several—usually two or three—daily quotas distributed throughout the June to January harvesting season. The reason is that growers do not like their crop to be completely harvested at either the beginning or the end of the season as at these times the yield of their cane—which for the growers means gross cane tonnage—is not maximised. More difficult harvesting at the season's end due to the onset of the rainy season reinforces this preference for peak season quotas. At the same time it is logistically impossible for all growers to have their cane cut, transported and crushed during that particular time—September and October—when the cane's yield is at its absolute peak and the weather is benign. The harvesting plan accordingly shares amongst growers both the desirable and the less desirable calendar dates for cutting, to ensure that no particular grower is unduly favoured or penalised by the timing of his scheduled cut. Such demonstrable equity is an understandable prerequisite for grower cooperation. At the same time in the interests of maximising the productivity of the entire complex system of activities that constitutes the sugar industry it is imperative that the need for an equitable distribution of quotas be balanced against the efficient use of milling, transportation, manpower and cane resources.[1]

Essential to this complex coordinating and balancing exercise is trust, goodwill, communication, order and discipline. Discipline is advanced through what is called 'The Master Award', a detailed legal document stipulating the rights, responsibilities and duties of all those associated with the growing, harvesting, transportation and crushing of sugar cane. But even with this regulatory artifice, coordination has proven to be an inexact science, with inevitable difficulties. Particularly problematic is that farmers often harvest more than their quota, especially in the most favoured months.[2] This excess lies around waiting for transportation and milling and serves to disrupt the harvesting plan. Compounding this are periodic mill breakdowns, labour problems and the inefficiency of the rail transport system, which is slow, prone to derailments, and often unreliable (Davies 1997). The combined effect of coordination problems, failure to abide strictly by the terms of the harvesting plan, transportation and milling disruptions and the fact that all cane is cut manually rather than mechanically is that the elapsed time from cutting to crushing is high. Indicative of this is the fact that only 43% of burnt cane, for which priority is given, was crushed within 48 hours of harvesting in the Lautoka mill in 1996.

The prevalence of cane burning

The burning of cane may be deliberate or it may be accidental. In Fiji it is estimated by the industry that over 95% of all burning is deliberate, the residual 5% being attributable to lightning, carelessness or neighbourly sabotage (which is, of course, also deliberate). Some of the deliberate burning is initiated by the growers, some by the harvesting gangs. Given the very low incidence of accidental burning, no grave sin would be committed by assuming, for analytic convenience, that all burning is deliberate. When one analyses the incidence of (deliberate) cane burning in Fiji, two separate issues stand out: the trend over time and the trend within any given season.

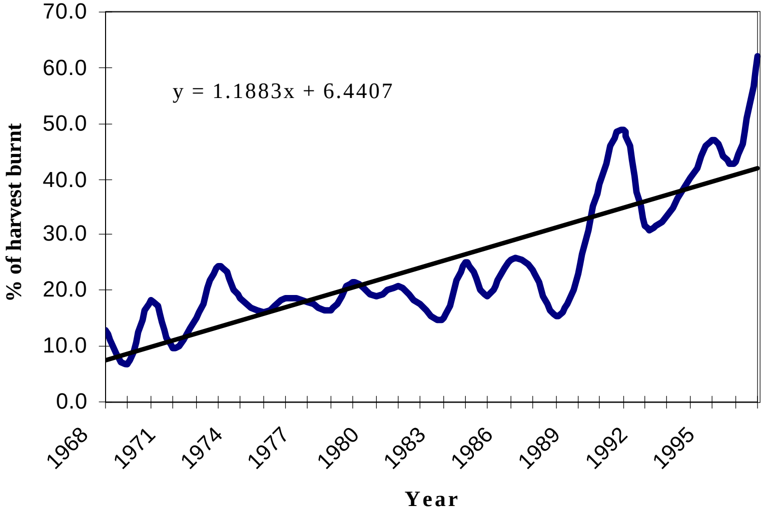
Concerning the trend over time, the proportion of the total cane crop that is burnt annually is depicted in table 1, which shows figures for the thirty-year period 1968 to 1997. The data are plotted graphically in figure 1.

Table 1 Burnt Cane as a % of Total Harvest (by volume) 1968–1997

Year	**% burnt cane**	Year	**% burnt cane**
1968	12.9	1983	14.9
1969	6.9	1984	25.0
1970	18.2	1985	19.2
1971	9.6	1986	25.6
1972	15.1	1987	23.6
1973	24.3	1988	15.5
1974	18.6	1989	22.8
1975	16.1	1990	39.8
1976	18.6	1991	49.0
1977	18.1	1992	31.5
1978	16.4	1993	33.4
1979	21.5	1994	40.2
1980	19.0	1995	47.0
1981	20.7	1996	43.4
1982	17.7	1997	62

Source Fiji Sugar Corporation, 1997

Figure 1 Burnt Cane as a Percentage of Total Harvest, 1968-1997



It is clear from both the table and the figure that the incidence of burning has been increasing markedly over the 30-year period. The equation of the linear trend line in figure 1 shows the rate of burning to be increasing at an annual average rate of 1.19%. At the same time it is abundantly clear by inspection that the rate of increase of burning took a quantum jump after 1989. Indeed from 1968 to 1989 the proportion of cane burnt increased at an annual average rate of less than 0.5%, while from 1989 to 1997 the annual average rate of increase was over 3%, a sixfold jump in the rate of increase.

Prior to the continuous series described in table and figure 1, the pattern of burning appeared to be similar to that from 1968 to 1989, being generally less than 20% but with substantial oscillations within that range. At the same time in one year, 1961, the rate of burning in the Lautoka mill was 65.6% (UNDAT Report, 1974, provided by the FSC), even higher than the current disastrous year, 1997.

With respect to the incidence of burning within any one season, a distinctive pattern has emerged in recent years, similar to that illustrated in table 2, shown later in the paper. At the beginning of the harvesting season, from June to August, burning is non-existent to minimal. During September and October burning rates of 25–30% become typical while from November to the season's end (late December or early January) the rate rises to between 75 and 100%.

The effects of cane burning

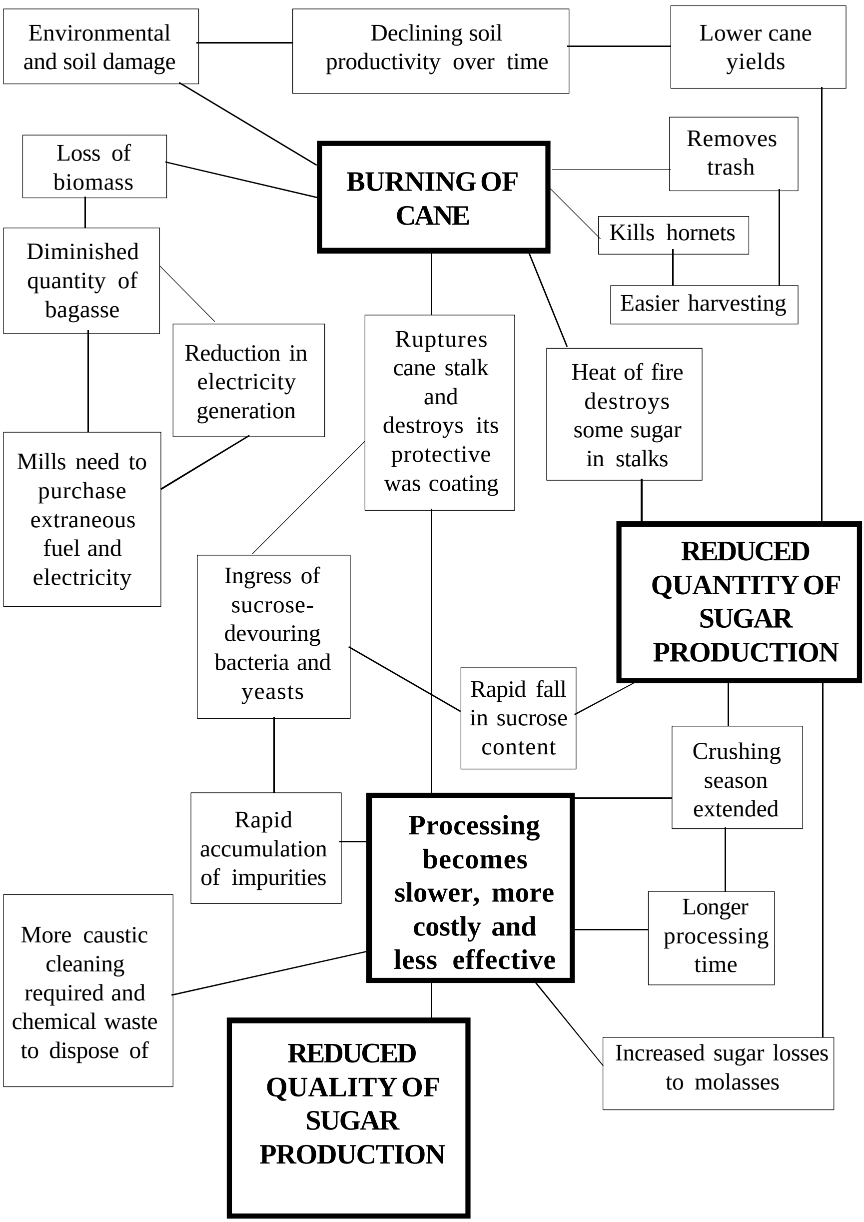
The effects of burning are widespread, affecting processing, harvesting, growing, and the environment. The complex cause and effect patterns of these effects are summarised in figure 2.

The effects illustrated in figure 2 resolve essentially into five principal categories of consequence: soil and environmental damage; diminished quantity and quality of sugar recovery; slower, more costly and less efficient processing; diminished energy potential of bagasse fibre; and easier harvesting. Each of these will now be addressed, though the *costs* of the burning to the industry will be estimated before the question of the ease of harvesting is examined in the context of the effects of burning on growers and harvesters.

Effects on soil and the environment

The burning of cane and the trash (undergrowth) that surrounds it leaves a residue of ash that quickly recycles the minerals of the burnt matter, which gives an immediate though very transient fillip to soil productivity. This, however, is an illusory gain for the medium and long term effects of burning are anything but salutary. The temperature within a moderate cane fire can quickly reach 400 degrees C (Foster 1979: 15), sufficient to cause the volatilisation and loss to the atmosphere of several key nutrients—nitrogen, sulphur and carbon in particular—and to destroy some of the organic matter, humus, bacteria, microorganisms and worms living in the surface layers of the soil. With repeated burning this diminishes the friability and porosity of the soils and their capacity to hold nutrients and water in the root zone (see e.g. Ellis & Mellor 1995: 228; Woomer & Swift 1994: 189; Kalpage 1975: 26; Owen 1975: 199; and Twyford & Wright 1965: 182). Compaction, drying and a much greater susceptibility to erosion by wind and rain follow directly. Thus both the quality and quantity of the most productive portion of the soil profile are directly diminished through burning. Over time this, of course, reduces the agricultural productivity of

Figure 2 The complex effects of cane burning



the soil, leading to secular decreases in the potential output of all crops, cane included. Additionally, and indirectly, burning can spread, touching off grass, bush and costly forest fires in the pine plantations found in the dry sugar-growing areas of Fiji.[3] Finally, the smoke produced by burning can be a nuisance and a source of health problems. It also releases greenhouse gases without providing in the process any offsetting benefits in terms of useable energy generation.

The quantity and quality of sugar recovery

If cane can be cut, transported and crushed within 16 hours of burning, milling costs and sugar recovery are not seriously compromised. Until recent years this was the normal pattern in Australia, though in recent years Australia, along with other cane growing regions, has been moving to eliminate burning, largely in recognition of both the environmental problems described above and the realisation that higher returns are possible from processing green cane.

The concerns in Fiji stem from the combination of burning with high elapsed times from burning to crushing, which, unfortunately, are normal given the institutional structure of the sugar industry in Fiji, as noted earlier. Indicative of such delay is the fact that in the 1996 harvesting season, 57% of burnt cane was delivered to the mill after 48 hours had elapsed and 22.6% after 96 hours.[4] In concert, burning plus delay allows the natural processes of biology and chemistry to erode both the quantity and quality of the sugar ultimately recoverable from the cane that is harvested. The process commences with the death of the cane stalk.

As with any animate creation, death in a cane stalk is followed by immediate deterioration. Deterioration occurs because death destroys the metabolic processes that regulate sucrose production and usage within the cane stalk and sucrose and other reducing sugars begin immediately to be converted into other substances, ethanol and dextran in particular. This process is effected through the ingress of sucrose-devouring bacteria and yeasts that invade the cane juice through any cuts or fissures in the stalk and multiply quickly once the stalk's natural defence mechanisms are destroyed.

It has been widely documented that the rate of deterioration of burnt cane is significantly higher than for green cane (Foster 1979; Payne 1989; Wood & Du Tott 1972; Blake & McNeil 1978; Wood 1973). The rate of deterioration, moreover, not only accelerates rapidly with time, especially after 24 hours, but it also accelerates much faster with burnt than with green cane. The causes of this differential rate of deterioration are as follows.

First, as with cut flowers, death for cut green cane does not come immediately: life seeps away gradually over several days, as its biological systems fail progressively. During this time it remains partially alive trying vainly to sustain itself, endeavouring to regulate its body chemistry and still able to resist infection from its wounds. The ongoing resistance of cut green cane to infection is witnessed in the very slow accumulation in its juices of alcohol and dextran (Blake & McNeil 1978). By contrast, burning immediately kills the cane stalk. There is no time lag (Payne 1989). The immediate and total destruction of the stalk's ability to resist infection allows the bacteria that produce dextran and the yeasts that produce alcohol to multiply without constraint at their geometric potential. This results in a similar exponential accumulation of dextran and alcohol. The maximum reproductive rate of such microbial invaders, moreover, is weather sensitive, being particularly rapid under high ambient temperature and humidity, as any home brewer will attest. These are precisely the sorts of conditions experienced in Fiji in November and December, when burning is most prevalent.

Second, burning heats the interior of the cane stalk and its juices to 80–98 degrees C. This directly destroys some sugar and also promotes chemical changes that facilitate degradation of sucrose levels and purity (Foster 1979).

Third, burning produces longitudinal ruptures in the stalk and destroys its protective wax coating. Bacteria and yeasts are consequently afforded much greater access to cane juices than is the case with green cane.[5]

In addition to accelerating deterioration, burning results in the cane stalk absorbing considerable quantities of water if it is not cut immediately. This dilutes the sucrose content and, if left standing for 48 hours, may increase the weight of the cane stalk by up to 8% over and above the level it would have been if cut green or immediately upon burning, notwithstanding either normal transpiration losses or losses in the weight of fibre occasioned by burning (Wood & Du Tott 1972: 153).

The best concrete evidence of the direct effects of burning on sugar recovery in Fiji relates to the accumulation of dextran, a stubborn impurity that interferes with both milling, and, later, refining operations. While burning has a direct effect on sugar content (POCS, the percentage of obtainable sugar in the cane juice),[6] the POCS is also strongly influenced by weather, the variety of cane planted and cultivation practices. Dextran accumulation is not. Table 2 shows the average amount of dextran in parts per million (ppm) for each week of the 1996 crushing season in the Lautoka mill, along with the proportion of the total weekly harvest that is burnt and the proportion of burnt cane that is delayed by over 72 hours. It is clear by inspection that as the crushing season progresses and the proportion of burnt cane increases, there is also a dramatic rise in the dextran content. This is confirmed by regressing dextran levels against both delay and percentage burnt. This yields a strong statistical relation with a multiple R Square of 0.77.[7] This is further supported by experiments on dextran accumulation over time conducted by FSC. These experiments show that the dextran content of cut green cane remains roughly constant at minimal levels (<30 ppm) for a week, while for burnt cane dextran levels reach 700 ppm after 2 days and 2,400 ppm after 7 days (FSC data 1989).

More complex and costly processing

The accumulation of impurities, dextran in particular, that results from burning, directly affects the processing and recovery of sugar, with these difficulties increasing as the proportion of burnt cane increases. When dextran reaches levels typical of those of the latter half of the crushing season the liquor extracted from the cane becomes highly viscous, causing the processing rate to slow, as evaporator heating surfaces quickly become scaled and less efficient. The need to descale these surfaces repeatedly using labour and caustic chemicals gives rise to substantially increased cleaning costs while further interrupting and slowing processing operations. Additionally, burnt cane causes feeding problems in the cane conveyors, the juice oozing from ruptures in the stalks causing slippages and jams,[8] which translate into a slower grinding rate of burnt cane. Together these factors cause the processing rate per hour of burnt cane to fall by approximately 20% from the green cane level. A correspondingly longer time is therefore required to process the harvest, with each extra hour of milling time, in the case of the Lautoka mill, costing $4000. Such delays also force the crushing season to be extended into late December and January, times when the cane crop will have passed its peak maturity (which occurs at mid-October) and will be experiencing a natural decline in its sugar content.

Table 2 Dextran levels, burnt cane percentage and percentage delayed, by week, for the 1996 crushing season, Lautoka Mill

week ending	% of burnt cane delayed by >72hours	burnt cane as % of crush	dextran, parts per million, in liquor
June 10	93.7	1.2	23
June 17	98.7	0.3	18
June 24	51.6	0.1	10
July 1	59.6	0.2	17
July 8	82.5	1.4	10
July15	85.3	2.2	10
July 22	75.5	2.9	30
July 29	61.3	2.1	20
August 5	83.7	4.0	28
August 12	46.4	4.6	10
August 19	72.3	10.8	10
August 26	56.1	12.3	10
September 2	54.6	23.1	10
September 9	43.9	30.7	20
September 16	37.9	33.6	30
September 23	27.3	44.8	60
September 30	44.4	54.6	556
October 7	43.4	65.6	270
October 14	36.8	77.2	173
October 21	35.2	83.8	80
October 28	39.8	86.4	529
November 4	29.5	90.9	1070
November 11	42.1	86.4	2330
November 18	33.7	94.6	1929
November 25	29.5	96.7	315
December 2	26.4	97.5	807
December 9	35.9	97.8	1712
December 16	37.9	98.0	1918
December 23	33.2	95.1	2800
December 30	53.1	97.6	1597
January 6	22.5	97.8	2942
January 13	32.2	99.0	1743
January 20	29.6	99.1	2930
January 27	61.4	97.2	3513

Source Fiji Sugar Corporation, 1997

The viscous liquor squeezed from burnt cane also results in less efficient sugar recovery rates. Sugar becomes harder to crystallise and more remains in solution to escape as molasses, the end product remaining after all sugar has been recovered. However, given that the current world price for molasses is $F140 per tonne while the world price for sugar is $F3–400 per tonne and the preferential price of sugar in the UK and European markets is over $F900 per tonne, this is clearly a less than desirable trade-off.

The sugar produced from burnt cane is also of inferior quality, with elongated crystals, a poor colour, and a high residual content of dextran. Tate and Lyle, Fiji's biggest customer, has repeatedly complained about the declining quality of Fiji sugar, while the USA imposes penalties on sugar with dextran levels exceeding 250 ppm. Indeed, to try to salvage its sugar quality Fiji has had to resort to adding various chemicals and enzymes to control dextran levels though this both is expensive and comes at a time when consumers are resisting artificial additives in food. It also seeks the same sort of solution as found by 'the old woman who swallowed a fly' in the children's nursery rhyme: far better not to swallow the fly (not to have burning and dextran in the first place) than to swallow the horse to catch the cow etc.

Diminished energy production from bagasse fibre

Burning consumes much of the fibre in the leaves and tops of the cane stalks. In machine harvesting of unburnt cane, much of this fibre, which can constitute about 40% of the total fibre content of cut cane stalks, is available alongside the residual bagasse, the fibrous pulp left after all cane juice is extracted from the crushed stalks. This provides a valuable fuel, which is used to generate both heat and electricity to power the energy intensive milling operations, with the substantial excess electricity often being sold to national grids. Burning cane in the fields thus diminishes the fossil fuel replacement potential of bagasse fibre (see Payne 1989 and related citations therein), something that can obligate mills to purchase extraneous boiler fuel and electricity.

With manual harvesting, much but not all of the fibrous leaves and tops are trimmed and left in the field, as opposed to being processed. While this reduces the energy potential of the processed fibre there are nevertheless major compensating gains in that the green trash blanket provides a valuable cover that conserves moisture in the soil, protects the soil from erosion, protects young ratoon crops from heat stress, and provides a mulch that minimises weed growth. Also, when eventually ploughed in, it constitutes an important source of green manure. Thus irrigation, weeding and fertiliser costs are reduced while yields can be subject to considerable improvement (*Australian Canegrower* 1988). Alternatively, green cane tops can also be used as a source of animal feed. All these benefits are lost through burning.

The estimated costs of burning to the Fiji sugar industry

Many, but not all, of the costs created by burning have been quantified by the FSC. In the seven year period 1990–1996 the industry has lost an average of the equivalent of 20,000 tonnes of sugar per season due to burning, including 11,500 tonnes due to the effect of burning on the POCS and 8,500 tonnes due to processing difficulties in the mills. This represents an annual loss in revenue of $F11 million per season. The 1997 season with its record burning rates is expected to increase this loss to 24,000 tonnes of sugar or over $F13 million in revenue given the $550 average revenue per tonne of sugar received by Fiji from its combination of preferential and world market prices.[9]

Added to these losses are the additional costs of processing burnt cane. The actual costs for the 1997 season are summarised in table 3.

Table 3 The extra milling costs incurred in processing burnt cane, 1997

Cost increases due to	Additional costs per tonne of cane ($F)	Total additional production cost ($F millions)
Extended season length	1.6	3.71
Extra enzymes and other chemicals	0.8	1.39
Caustic cleaning	0.37	0.86
Administration*	0.05	0.12
Total additional cost	**2.82**	**6.54**

* Administrative costs increase because much more supervision of the milling process is required for burnt cane. Greater administrative costs are also imposed on field officers who have to check on times of burning: these latter costs are not included in the table.

Source Fiji Sugar Corporation, 1998

In total the direct costs of burning, including lost revenues and additional costs, are nearly $20 million. For the canegrowers, the loss in earnings amounts to $9.1 million, given a 70/30 division of sugar revenues between growers and miller.[10] For the FSC, the loss is $10.44 million, $3.9 million in reduced earnings and $6.54 million in extra costs.

The effects of burning on growers and harvesters

Given the deleterious effects of cane burning on soils and soil productivity, and the income that is lost to the farming community from sugar losses, one may legitimately ask, why do they do it? There are several reasons.

First, burning removes the weeds and undergrowth, as well as many of the leaves on the cane stalks, and makes harvesting considerably easier and quicker. This is particularly true if the cane is poorly cultivated and weed infested. Cultivation practices, moreover, have been deteriorating over time, as weekend and hobby farmers increase in number, and as uncertainty over lease renewals detracts from the willingness to expend maximal efforts on agronomic practices.[11] Burning also destroys hornets, which nest in cane fields towards the end of the crushing season. Consequently, despite the fact that cutters are paid more to harvest green cane, especially if it is weed infested, some cane cutters evidently insist on burning a cane field before they will harvest it and have reportedly even threatened farmers who wanted to harvest green cane (Sugar Industry Tribunal 1989: 109).[12]

Second, with respect to soils, the great majority of cane farmers are tenant farmers rather than landowners. Combined with the current conjunction of expiring leases and uncertainty over future lease renewals, this is hardly likely to motivate farmers to engage in the agronomic practices necessary to maintain long term soil fertility.

Third, burning has traditionally been used by growers as a political vehicle for displaying disapproval with miller or government. The very high burning rates in 1961 coincided with the Eve Commission’s Report on the sugar industry, which contained numerous provisions—including land classification, burnt cane rules and a complex formula on sharing the proceeds of sugar revenues between grower and miller (then the CSR)—that were unfavourably received by the growers (Moynagh 1981: ch. 8). More recently the military coups of 1987 and the current uncertainty over land tenure have been blamed for implanting or exacerbating a ‘couldn’t care less' attitude amongst the Indian cane growers and a general unwillingness to cooperate in any voluntary venture involving the (Fijian controlled) government-owned Fiji Sugar Corporation.

Fourth, because growers get paid according to the tonnage of cane they deliver, and because burnt cane, if left uncut for 48 hours, shows measurable and not insignificant increases in weight, an economic incentive exists for burning.

Fifth, and undoubtedly most important, burning permits growers to jump the harvesting queue. To try to minimise sugar losses consequent on the rapid deterioration of burnt cane, the FSC awards farmers having a burnt cane field an immediate quota to harvest and an allocation of rail trucks (if they are in a rail gang) for its delivery (Davies 1997). This priority accorded to cutting and transporting burnt cane is thus an attempt to make the best of a bad situation. Growers, naturally, are aware of this priority treatment. And when it is felt that delivery is uncertain, or that accumulated delays may back up the cut of their own crop into the wet weather months when harvesting costs rise and cane yields begin to diminish, or if growers are just not content with their position in the harvesting plan, they often burn in an attempt to jump the queue, to expedite delivery of their own crop. Thus, as is evident in table 2, burning rates tend to be low in the beginning of the season, when the cane has yet to reach peak maturity, and increase rapidly as the season wears on, when fears of late harvesting increase. Such fears were particularly strong in 1997 when a three week strike by mill employees delayed the harvest and resulted in considerable 'panic burning' (*Fiji Times*, 2 February 1998). Of course whenever someone jumps to the front of the queue, someone else—the farmer who does not burn—is pushed to the back.[13] And once burning rates reach a certain critical level, farmers who normally harvest green come to resent both the favoured treatment accorded the burners and their own consequential relegation in the harvesting plan. Accordingly, as has demonstrably happened in 1997, they feel compelled defensively to follow suit, to prevent further delays to the cutting of their own cane. Bad practice drives out the good. (The thought processes that govern these decisions to burn can be instructively summarised in a simple game theoretic setting, as shown in the appendix.)

Burnt cane penalties

The inferior quality of burnt cane and the higher costs associated with its processing clearly suggest the importance of some form of price differential as compared to green cane. This is indeed the case, the price differential varying according to the delay from burning to acceptance by the FSC according to the formula set out in table 4.

Table 4 Burnt cane penalties, 1997

Number of hours from burning to delivery	Penalty
<24*	Price of green cane (ie. no penalty)
24–48	Green cane price less 9%
48–72	Green cane price less 12%
72–96	Green cane price less 13%
96–120	Green cane price less 15%
120–144	Green cane price less 16%
144–168	Green cane price less 17%
>168	Cane rejected

* In calculating the number of hours from burning to delivery, the actual day of burning is ignored.

Source ‘Master Award’, Sugar Industry Tribunal, 1997.

The revenue that is retained from paying a lesser price for burnt cane goes into what is called a ‘Burnt Cane Fund’. This fund is then divided between miller and those growers who delivered green cane, according to the following formula: for burnt cane that is, for example, between 24 and 48 hours old, a 9% deduction from the green price is imposed, as table 4 shows. Of these 9 percentage parts, 5 go to growers, distributed according to the green tonnage delivered, to reward them for the superior product they deliver and to compensate them for any relegation in the harvesting schedule resulting from the burnt cane queue jumpers. The remaining 4 parts of the penalty go to the FSC to compensate it for the extra costs incurred in processing burnt cane. As the delay from burning to delivery increases and the burnt cane penalty likewise increases, growers continue to receive a flat 5 parts of the penalty while the FSC absorbs the rest. Thus with cane between 144 and 168 hours old the penalty is 17%, of which 5 parts go to the growers and 12 parts to the FSC. This formula is structured in recognition of the escalating milling costs associated with the exponential increase in dextran levels as burnt cane ages.

In the years 1990–1996, the Burnt Cane Fund has been averaging around $1.7 million per year, though in 1997 the Fund, paradoxically, fell to $1.45 million.[14] Of this figure FSC collected $0.8 million, the growers $0.65 million.

In addressing the appropriateness of these penalties, several points must be noted. First, the rapid escalation of burning since 1989 demonstrates conclusively that they are no deterrent. Many burners are able to avoid paying any penalty at all:[15] since there is no penalty in the first 24 hours and since the actual day of burning is not counted in the ascertainment of delay, it is possible to deliver without penalty burnt cane that is up to 48 hours old, an age at which rapid deterioration will have already set in. Moreover in computing the penalties the FSC depends on the honesty of growers and its own field officers to report an accurate time of burning!

Second, the slow rate by which the penalty increases with time does not correspond to the exponential rate of deterioration of burnt cane.

Third, the actual funds entering the Burnt Cane Fund, some $1.45 million in 1997, are trivial compared to the $20 million revenue losses and actual extra milling costs caused by burning, as discussed earlier. This means the suppliers of burnt cane receive a price considerably in excess of its real worth and are thus in receipt of an implicit subsidy from the green cane farmers and miller. This, in turn, points to a further motivation to burn, the pursuit of easier income through free riding on the backs of the green cane farmers and the FSC.

At this stage it is important to note that the penalties for burning were more severe up until 1989. In particular they included a provision delaying the payments for burnt cane for 3 months beyond the date of payments made to green cane suppliers, something extremely unpopular with the burners, coupled with penalties similar in structure to, but less than, those in table 4. A report in 1989 (the Kermode Report), which was to form the basis of the first Master Award,[16] recommended removing the unpopular provision for delayed payments in return for increasing burnt cane deductions to levels close to double the current penalties. The growers resented this change and embarked on a course of industrial action, eventually resulting in intercession by the President of Fiji. The results of this intercession were that the penalties for burning were reduced to their current levels. Although the FSC attempted as a *quid pro quo* to reintroduce the delayed payment provision, the growers were successful in their resistance to this. As wholly expected within the industry, these concessions were followed by the rapid escalation in burning seen from 1990 to the present.

In summary, current penalties for burning range from non-existent to minimal and are certainly less than the perceived advantages to growers of the easier, earlier and more certain harvest that burning can bring. The proclivity of growers to burn, moreover, is clearly sensitive to the level of penalty, being low when penalties are high and increasing rapidly when penalties are reduced.

Conclusions

The escalation of cane burning in Fiji is a problem serious enough to undermine the health and possibly the viability of the industry. Most obviously it has been eroding the quality and long term marketability of Fiji's sugar while also preventing the realisation of the maximum income obtainable from the tonnage of cane actually grown in the fields. It also coincides with rapid moves in the major sugar growing countries to eliminate burning. At a time of unprecedented global competition, when buyers are becoming increasingly quality sensitive, and when even the medium-term prospect of further preferential prices is rapidly receding, such avoidable inefficiencies cannot be countenanced. It must also be emphasised that the direct financial losses of burning in the form of reduced revenues and higher production costs come entirely in the form of lost industry profit[17] and the ability to sustain profit is the primary criterion that separates those activities that can survive in the marketplace from those that cannot. Less obviously, but important nonetheless, burning causes income transfers that set farmer against farmer,[18] damage the property of the landowners, and support an 'up yours' mentality that destroys the cooperation and trust that is absolutely essential to system-wide efficiency, given the complex institutional structure of the Fiji industry. It must be stopped. But how?

Certainly attention must be paid to the reliability of transport and milling operations as the reality, and, perhaps more importantly, the perception that harvesting delays contribute to queue jumping behaviour.[19] But without the reintroduction of significant deterrent penalties this, by itself, would doubtless have little effect. The only way that the deeply ingrained attitudes of the current generation of farmers can be changed quickly is by making burning financially costly. Proposals to change the basis of payment from cane tonnage to sugar content will partially address this but symbolically, the explicit penalising of burning, for example by subjecting it to the sort of delayed payment abolished in 1989, or, even better, completely prohibiting it by law, must be included in recognition of the external costs the burners inflict on green farmers relegated to less favourable dates in the harvesting queue, the FSC whose milling costs increase, the landowners whose soil is damaged, the pine plantations razed, the other environmental costs, and the effect on the economy generally, which is robbed of scarce foreign exchange and the multiplied effects of its expenditure.[20]

Doubtless the reintroduction of effective deterrent penalties, or the imposition of a total prohibition, would prove difficult given the intense political polarisation of the grower fraternity. But this cannot be used as an excuse for inaction, given the perilous state of the industry. The time for decisive measures is long overdue. Equivocating further is simply fiddling while the industry burns.

Notes

This paper benefited greatly from the cooperation of the Fiji Sugar Corporation (FSC), which permitted me virtually unrestricted access to its records. For this I am most grateful. I am also indebted to numerous individuals connected to the sugar industry who provided much invaluable advice. Early drafts of this paper were circulated to the FSC, the Sugar Commission of Fiji (SCOF), the Sugar Cane Growers' Council, the Sugar Industry Tribunal, the Bureau of Sugar Experiment Stations, Queensland (BSES), and Booker Tate Ltd. The comments I received cleared up some early misconceptions and greatly improved the finished document: to all respondents I am much obliged. Of course, any errors of fact or interpretation are solely mine.

1 The need to treat the 23,000 farmers equitably by allocating 2 or 3 daily quotas to each results in a massively complex harvesting schedule embodying some 50,000 separate elements. These elements have to be organised so as fairly to share the favourable and the not so favourable harvesting dates while at the same time making the best use of milling, transportation and harvesting resources, a truly formidable exercise.

2 In the favoured middle part of the season in the Lautoka mill area it is not unusual on some days to see farmers harvesting 15,000 tonnes cane more than their combined quotas provide for.

3 Between 1991 and 1995, cane burning triggered 146 separate forest fires, covering over 1,770 hectares of pine plantation (Fiji Pine Ltd 1998).

4 These figures understate actual delays since for reporting purposes the actual day of burning is not counted, as elaborated later in the paper.

5 The rupturing of the cane stalk coupled with the ability of cut green cane to resist bacteria and yeasts results in a far greater concentrations of alcohol in cut burnt cane than cut green cane (Blake & McNeil 1978).

6 Regressing the POCS level against the percentage of the cane crop that has been burnt for each year for the period 1968–1997 produces a negative relationship, significant at the 1% level, which shows that 19.7% of the change in the POCS level since 1968 'can be explained' by changes in the level of burning. The principal results of the regression were R Square = 0.197; P value = 0.008; t-statistic = -2.574 and its equation was $y = 13.46 - 0.035x$, where y is the annual POCS level and x is the corresponding burnt cane percentage. Although this is a very significant result, it still, of course, leaves over 80% of the change unexplained. This is not surprising given the changes in cane variety, weather and agronomic practices that have occurred over the 30-year period.

7 The equation of the regression is dextran level = -1375.7 + 16.71 delay time + 25.76 burnt cane %. The P values for delay is 0.07 and for burnt cane %, 0.000003.

8 For similar reasons burnt cane causes problems in delivery. In particular cane stalks lose their rigidity and sag 24 hours after burning. This, coupled with the presence of cane juice oozing from ruptures, contributes to load slippages and train derailments.

9 These figures are direct estimates based on observed differences in POCS level in burnt and green cane as received in the mills and historical processing rates. They are also quite conservative. To illustrate, the statistical relation between POCS and the annual percentage of burnt cane delivered, as discussed earlier, yields a regression equation of $y = 13.46-0.035x$, where y is the annual POCS level and x is the corresponding burnt cane percentage. If burnt cane fell to zero, so that $x = 0$, then the POCS level would equal 13.46, a figure which, for example, is 12.6% higher than the actual 1996 POCS level of 11.9. Given that 454,000 tonnes of sugar were produced in 1996, a 12.6% increase would amount to some 57,204 tonnes of sugar worth over $F31million! Such extrapolation, of course, is dangerous especially given the low R Square (19.7%) of the equation. It is just used to illustrate that the historical data available on POCS and burnt cane suggest that the FSC's estimates of lost sugar do not appear exaggerated.

10 The division of sugar revenues between growers and miller varies according to a formula based on harvest size. The minimum the growers receive is 70% and that increases slightly as the harvest increases. Recent harvests have produced typical shares of 73/27 between growers and miller.

11 Uncertainty over lease renewals particularly contributes to a reluctance on the part of growers to incur the expense of replacing old ratoons with new seed stock. Old ratoons tend to be particularly susceptible to weed infestation given the gaps that appear between cane stalks that grow therefrom.

12 It should be noted that current harvesting rates range from $10–13 per tonne for green cane. Payment for burnt cane is $1 less per tonne. However, the current shortage of good cutters has allowed most to demand the green rate even when they burn.

13 Fijian farmers and cutters in particular appear seldom to burn (SCOF interviews). They tend, therefore, disproportionately to be relegated to the back of the harvesting queue.

14 The reason that the record burning rates of 1997 produced a smaller than usual Burnt Cane Fund is that a higher percentage of burnt cane than usual attracted no penalty, ostensibly falling within the <24 hours from burning to delivery category. This highly unlikely result most probably is attributable to the intense pressure put on field officers to mis-report the actual time of burning, when burning rates spiral out of hand.

15 About 40% of all burners in fact pay no penalty, recorded optimistically as falling within the <24 hours from burning to delivery category.

16 Prior to the Master Awards, the rights and responsibilities of grower and miller were specified in concise 10 year legal contracts. The text of the Kermode Report is reproduced in full in the 1989 Master Award.

17 For the FSC burning simultaneously increases costs and reduces revenue: for the growers it produces only revenue reductions, given that harvesters are now generally paid the green rate for harvesting burnt cane and that they are paid by the tonne cut not the time taken. Thus for both groups the financial effects of burning come entirely in the form of lost profit.

18 If there were no burning in 1997 growers would have received an estimated $9.1 million in extra income, as noted earlier. Given the 1997 harvest of 3.28 million tonnes cane, this amounts to an additional payment of $2.77 per tonne. At the same time if there were no burning, green cane farmers would have lost their 1997 Green Cane Bonus of $645,000, or $0.51 per tonne of green cane delivered. Thus the burners robbed the green cane farmers of over $2.20 net income per tonne of cane.

19 The current 73/27 (approximately) revenue sharing formula that came into effect in 1975, unfortunately, permits little room for strategic investments in rail or mill. Interestingly the CSR pulled out of Fiji after the growers' share was increased to 65% in 1970, judging the residual 35% going to the miller as being insufficient to sustain profitability (see Moynagh 1981: ch.9).

20 Given that burning is really a national issue, not simply a farming or a sugar issue, a legal prohibition that makes burning an offence and requires FSC not to accept burnt cane is doubtlessly the preferred solution. Reinforcing this is the fact that whenever burning has been addressed through consultation between miller and grower, it quickly turns into a divisive 'us and them' issue that is whipped up into a hopeless, unsolveable problem by the amateur and professional politicians that seem to thrive on, and sometimes owe their livelihood to, discord in Fiji's sugar belt.

Appendix

Burning in a Game Theoretic Setting

		Farmer B	
	Strategies	Burn	Not Burn
Farmer A	Burn	A, B: harvest date unchanged; income of both reduced due to sugar losses.	A: early harvest, income maximised. B: harvest relegated, income mainimised (if cane not harvested).
	Not Burn	A: harvest relegated, income minimised (if cane not harvested). B: early harvest, income maximised.	A, B: harvest date unchanged, aggregate sugar revenues maximised.

In the above playoff matrix we have two players, Farmer A and Farmer B. Each has two strategies, to burn or not burn.

If A burns and B does not, then A's harvest is advanced and B's relegated. While A's burning will cause some sugar losses, they will be distributed across all growers (the penalties for burning not reflecting real costs), so A can free ride on the revenue generated by the green harvester B. A's harvesting will be easier with burning so this, coupled with free riding on B's green harvest and the benefits that accrue from a more favourable harvest date, generate the maximum possible income for A. By not burning when A does, B will find his harvest delayed when the onset of rains makes harvesting and in-field transport more difficult and costly. Some of the sugar income realised from his green harvest will be transferred to the burners, the actual price of burnt cane exceeding its real worth. Finally, and most seriously, a possibility exists that crushing might cease before B's crop can be harvested, thus exposing him to the greatest possible loss. If B burns and A does not, the story is reversed.

If both A and B burn, there will be no change in the harvesting plan, each burning cancelling the other out. Harvesting costs will be reduced but incomes will be reduced by much more, burnt cane not producing as much sugar as green.

If both A and B choose not to burn then again there will be no change in the harvesting plan, and harvesting costs will increase somewhat. However, aggregate sugar revenues will be maximised, which would more than compensate for the extra harvesting costs of green cane.

While the optimum result for the industry is for neither grower to burn, this strategy carries with it the highest risk for the individual. If A burns and B does not, the possibility exists of B's crop not being harvested until the season's end, thus inflicting maximal possible income losses. This risk, coupled with the maximum perceived income that can be earned when one burns and the other does not, induces both to burn. But this produces a suboptimal result—the same harvesting schedule as if neither burned, and easier harvesting not compensating for reduced sugar earnings.

Thus we have a classic prisoners' dilemma situation, a non–zero sum game where minimax thinking yields a suboptimal choice of strategy. The optimal strategy, not to burn, is not chosen because of the lack of trust and the bloody-minded desire to pursue individual interest regardless of the effect it has on others, or on the common good. Perhaps an apt description of much of what goes on in the sugar industry in Fiji today.

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