APPENDICES

with the advice on the
environmental aspects of sugar
production and recommen-
dations for improvement at TPC,
Kilombero and Mtibwa, Tanzania

(appendices 1 to 11)

APPENDIX 1

Letter from Royal Netherlands Embassy dated 10 February 1998 in which the Commission has been asked to submit an advice.

Royal Netherlands Embassy

Ambassade
van het Koninkrijk
der Nederlanden

Commissie voor de milieu-effectrapportage
ingekomen: 19 februari 1998
nummer: 030-58
dossier: b/i/in: 48-98
kh/Po/Sh/Mo/bib/Sc

Netherlands Commission for EIA
Att. Mr. J.J. Scholten
P.O.Box 2345
Utrecht
The Netherlands

Subject: Environmental audit sugar estates Dar es Salaam, 10 February 1998

No.: 98-AS2B-035

Dear Mr.Scholten

With reference to earlier conversations and correspondence, and more specifically the fax of the Commission, dated 8 january 1997 and our comments on this fax (dated 21 January 1998 and 10 February 1998), I herewith ask the Commission for EIA to advise on an environmental audit for the following four sugar estates in Tanzania: Kilombero I and II, Mtibwa and TPC.

The Tanzanian authorities (Private Sector Reform Commission) welcomes collaboration with the Commission in preparing this advice.

For the preparation of the advice a working group should be formed which ideally consists of two or three Netherlands experts and two Tanzanian experts. The preparation of the advice should be carried out jointly.

Contact persons at the level of DGIS are Mrs. A. Wevers of the Environmental Programma and Mrs. K. Kramer of the Netherlands Embassy in Dar es Salaam, Tanzania.

The revised Terms of Reference and the programme as well as the members of the working group are awaited, with reference to the agreement of March 1993 between the Commission and DGIS.

Looking forward for your reaction.

For the Ambassador,

Karen Kramer
Second Secretary

cc.: Mrs.A.Wevers, Environmental Programma (DML/MI)

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APPENDIX 2

Project information

Proposed activity: The Government of Tanzania is planning to privatise four sugar companies in Tanzania. In the present planning this will be the case in the summer of 1998. On request of the Netherlands Embassy in Dar es Salaam an advice has been prepared in order to assist the Tanzanian Authorities, in particular the Parastatal Sector Reform Commission (PSRC), in their negotiations with the new company owners on possible and necessary adaptions of the company with respect to a better environmental management.

Categories: agriculture, sugar production, DAC/CRS code 11123

Project numbers: Royal Netherlands Embassy 98-AS2B-035: Commission for EIA: 030

Progress:
Letter requesting for advice: 10 February 1998
Site visit by working group: 13-28 March 1998
Advice submitted: 17 April 1998 (1st edition)
Advice submitted : 14 July 1998 (2nd edition)

Significant details:
The Commission is of the opinion that present sugar production at TPC, Kilombero I and II and Mtibwa will not result in unacceptable environmental problems within and/or outside the bounderies of the estate. For the near future it is not expected that unacceptable serious environmental problems will occur. There is one exception to this general conclusion. At TPC use is made of a pesticide which has been banned internationally. The use of this pesticide may result in pollution of ground- and surface water and can affect the health situation of people applying this pesticide. It is recommended to stop the use of this pesticide. The Commission recommends the development of an environmental management, health and safety plan for each company.

Composition of the working group of the Commission for EIA:
Mr J.G. van Alphen
Mr P.R. Kakiziba (local expert)
Ms J.A.N. Kibassa (local expert)
Mr J.W. Kroon (chairman)
Mr J.D. Meidertsma
Mr R.V. Siemons

Technical secretary: Mr A.J. Kolhoff

APPENDIX 3

Review framework

The following issues have been reviewed:

- **Agricultural production at the estate**

Water resources
Water availability
- surface water
- ground water
Quality of water
- surface water
- ground water
Soil resources
Soil properties
- origin
- depth & texture
- salinity
- suitability for cane
- weather able minerals
- soil pH
- aluminium toxicity
Fertilization practices
- potassium (K)
- phosphorus (P)
- K & P applied
- nitrogen application (N)
- adequacy N application
- nutrient mining
- micro nutrient deficiencies
Agro-chemicals
Weedkillers
- products used
- quantities applied
- mode of application
Insecticides
- pest & products applied
- quantities applied
Fungicides
- pest & products applied
- quantities applied
National Quail programme
Irrigation
- % area irrigated
- system
- problems
- scope to optimize water use efficiency
- mining of water resources
Drainage
- natural drainage/ salinity problems
- waterlogging & salinisation
- maintenance of system
- down stream effects

- **Agricultural production by outgrowers**
- present
- use fertilizers
- agro-chemicals

- **Processing**

Use of fuel
- furnace oil quantities used
- diesel oil quantities used
- fuelwood quantities used
- depletion fossil fuels
- deforestation
- soil pollution
- acidification
- global warming
Grid electricity utilization
Inefficient resource utilization
Factory waste
- filtercake/ mud
- smoke
- boiler / furnace ash
- factory waste water
- bagasse excess

- **Living conditions & occupational health**

Water & sanitation
- availability drinking water
- quality drinking water
- sewerage system
- waste disposal
Diseases
- water borne diseases
- respiratory problems
- use of protective equipment
Fuelwood

APPENDIX 4

Programma field visit 13-28 March 1998

Friday	13-3	23.15 hour: Arrival at Dar es Salaam
Saturday	14-3	09.00 hour: Briefing of the Embassy staff in the Karibu hotel
Sunday	15-3	Departure Dar es Salaam to Kilimanjaro
Monday	16-3	Visit TPC
Tuesday	17-3	Visit TPC Visit District authorities
Wednesday	18-3	Departure Kilimanjaro to Dar es Salaam Report writing
Thursday	19-3	08.00 - 09.00 hour: visit PSRC (split up of the working group) 08.00 - 09.00 hour: visit Ministry of Agriculture 09.00 - 10.00 hour: visit Sudeco 09.00 - 10.00 hour: visit Ministry of Environment, 11.00 - 12.00 hour: visit National Environmental Management Council 12.30 - 13.30 hour: visit Tanesco 14.15 - 15.00 hour: visit Institute of Resource Assessment
Friday	20-3	Departure Dar es Salaam to Kilombero
Saturday	21-3	Visit Kilombero I and II
Sunday	22-3	Visit Kilombero I and II
Monday	23-3	Visit Kilombero I and II Visit Universtiy of Morogoro Visit district authorities, Kilosa district Departure Kilombero to Mtibwa
Tuesday	24-3	Visit Mtibwa
Wednesday	25-3	Visit Mtibwa Departure Mtibwa to Dar es Salaam
Thursday	26-3	Report writing
Friday	27-3	13.00 - 14.30 hour: Debriefing at the Embassy with Private Sector Reform Commission and National Environmental Management Council
Saturday	28-3	00.35 hour: Departure to Amsterdam

APPENDIX 5

Set up for an Environmental Management, health and safety Plan (EMP)

The EMP provides a delivery mechanism to address negative impacts, to enhance benefits and to introduce standards of good practice. The plan is a stand-alone document covering the agricultural production of cane, the processing of cane in the factory and the health situation of the labourers.

An EMP consists of the following two main components:

A. Mitigation plan

In this plan the following information is presented:

- a comprehensive list of mitigation measures or actions (preventive as well as corrective measures) that will be implemented;
- the person(s) responsible for ensuring full implementation of that action;
- the parameters that will be monitored to ensure effective implementation of that action;
- the timing for implementation of the action to ensure that the objectives of mitigation are fully met.

B. Monitoring plan

In this plan the following information is presented: measures to establish and verify changes to the present situation and indicative measures to assess effects where specific concerns are raised. The results of monitoring should be published in an annual report.

External reviewing of the implementation of EMP's is good practice in most countries and the Commission suggests to involve the National Environmental Management Council in reviewing of the estates.

APPENDIX 6

Recommendations for district authorities

In this appendix two recommendations are presented for the district authorities of respectively Moshi district (TPC) and Kilosa district (Kilombero I). These recommendations are the result of an environmental audit in which environmental problems are determined; problems caused by respectively the sugar companies and other (f)actors. In the main text of the advice only those recommendations are presented which can be considered by the companies.

For TPC and Kilombero problems will be described briefly followed by a recommendation. For Mtibwa no recommendations relevant for the district authorities were made.

TPC

Problem: It is reported that increasing abstractions of scarce surface water for agricultural use in the upper catchment leads to a gradual declining of the water discharge in the Kikuletwa river. TPC makes use of this river water and ground water for irrigation of the cane. A further decline of the availability of river water most likely means that TPC will request for the abstraction of more ground water. Irrigation is a condition to grow cane at TPC and TPC is a major user of river water.

Recommendation: Monitoring of the discharge of the Kikuletwa river.

Kilombero

Problem: Due to uncontrolled development of unplanned squatter settlements at the gate of the estate at Kilombero II. This area is crowded with people, especially in the cutting season. The sanitation and sewerage facilities in these settlements are inadequate and the quality is poor. It is reported that this area is a source of epidemic diseases like; cholera and tuberculosis due to the poor sanitation and sewerage situation. As a result of this epidemics the health situation of people in settlements around this site are affected.

Recommendation: Town planning combined with an improvement of the present sanitation and sewerage situation (the number of facilities and improvement of the present quality) is necessary to overcome this problem.

APPENDIX 7

TPC- Environmental audit

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TPC - Environmental audit

1. General information

TPC is located east of Moshi town. The total area owned is 16,000 hectare of which on average 6,500 ha is cultivated with sugar cane, 500 ha is cultivated with foodcrops. The remaining 9,000 hectare have been cultivated in the past, now they are not used anymore and forest arises. In total, there live 16,000 people in twelve camps at TPC of which 5000 are paid labourers (4000 men and 1000 women). Men are mainly involved in planting, cutting and irrigation practices and women are mainly involved in weeding.
In appendix 11 the results of the environmental audit for TPC are summarised and compared with the findings for Kilombero I and II and Mtibwa. It is recommended to make use of appendix 11 whilst reading this appendix.

2. Agricultural production of sugar cane

2.1 Agricultural situation

Average cane production over the period 1987 - 1997 was 369,290 tons. With a harvested area of 5.065 ha the average yields arrives at 72.9 tons of cane per ha-year. However, considering that 6.500 ha used for cane production the average yield stands only at 57 tons of cane per ha-year. The large discrepancy between area harvested and area in use for cane production can only partly be explained by land preparation and planting or cane standing on the field for more than 12 months. Planted cane is on an average followed by seven ratoon crops. Some fields, however, have to be planted yearly. Probably some 500 ha of land have to be uprooted and replanted annually due to White grubs.
It is noted here that the statistics of TPC do not reflect the effective loss of production due to pests or inadequate farm and transport equipment, as the production is expressed in tonnes of cane per *harvested* hectare (TCH). For the past ten years the company crushed an average of about 370,000 tons of cane, which corresponds to an average yield of about 75 TCH. This gives on average a yearly harvested acreage of 4,954 hectares, with a maximum year of 5,768 and a minimum year of 3,389 hectares). With a total area under cultivation of 6,500 hectares, this means a coverage of 76 per cent and an average yield per *cultivated* area of about 57 TCH[1]].

1 In the other estates (Kilombero and Mtibwa) the gap between planted and harvested acreage is much smaller and to less annual uprooting and replanting, less break down of farm and transport equipment and/or lower downtime of the factory.

2.2 Availability, quality and use of water

Water availability and quality

Water for irrigation, the factory and drinking water supplies are abstracted from rivers and from groundwater. TPC has permission for a total withdrawal of about 300 cusecs (8400 l/s). Water is of good quality (EC < 0.8 dS/m, SAR < 15). Only water from the Kikuletwa river has a higher salinity (EC = 1.4 dS/m).
The availability of river water is declining gradually due to increasing abstractions for coffee and bananas in the upper catchment. Groundwater is (still) amply available.
A permission to expand the network of boreholes on the estate can easily be obtained from the regional water department. An assessment of requests for water in terms of long-term regional supply and demand projections is not done.

Irrigation and drainage

Irrigation water is applied by furrow irrigation in about half of the estate, overhead irrigation is being practised in the other half[2]. The net application of irrigation water is in the order of 1000 mm per year. There is an additional rainfall of 500 mm. Drains, having a depth of 1.5 - 2.0 m, have been installed at regular distance (300 - 400 m apart). The depth to the ground watertable is regularly monitored and fluctuates between 1.2 - 2.1 m. In some spots the ground water table occurs at a shallower depth. Drainage does not appear to be a major issue. Yet, considering the incipient salinity problem in some parts of the cultivated fields a small drainage survey would be necessary to properly assess the dynamics of waterlogging and salinity.

2.3 Quality and use of the soil

Soils in the estate are from volcanic origin. Contrary to most soils in Sub-Saharan Africa the estate soils contain weatherable minerals. An aluminium toxicity problem does not occur. Some 7000 ha of land are suitable for cane growing. Soils in the remaining 9000 ha show various constraints: soils are shallow, sandy, or saline. Salinity is widespread and is in principle a result of geo-genesis. Irrigation causes addition of, and above all a redistribution (often unwanted) of salts. In the past the area south of the factory was under irrigation, but had to be abandoned as a result of salinity. The likely cause of salinisation (and waterlogging) in this area is the occurrence of a hard and impervious layer at shallow depth in the soil.

According to the management of TPC the actual salinity level of the fields are not having an effect on yields, however no research data are available to verify this statement. On the other hand it was mentioned that there appears to be a correlation between the infestation of white grubs) and salinity: although the type of relationship between the two are not clear higher concentrations of white grubs are found on soils with a higher level of salinity.
The cultivated area is flat and cane is a perennial crop therefore soil erosion is not a problem.

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2 The irrigation pumps consume about one third of the total electricity of the estate, the factory and residential areas the other two thirds.

Nitrogen is applied at a rate of 150 kg/ha. This amount is not excessive considering a yield of some 70 tons of cane per ha. With this amount of cane 75 kg of N would be taken from the field to the factory. The remaining 75 kg of applied N per ha is lost by leaching and volatilization. These losses are quite acceptable. Fertilizer trials do not show a response to P and K applications. Hence, neither phosphate nor potassium fertilizers are being applied. Thus in principle cane production at TPC leads to soil mining of these elements. Boiler ash and filter cake, byproducts of the factory and rich in plant nutrients, are not being applied in cane fields. Boiler ash contains quite some sodium and filter cake enhances the infestation of white grubs (see below).

2.4 Use of agrochemicals (insecticides, herbicides, fungicides)

Large amounts of agrochemicals are used. The annual requirements in the early nineties were 360,000 litres (of which insecticides: Suscon Blue 25,000 kg and EDB 280,000 litres), (SKIL, 1991). As most chemicals have to be imported, it required foreign exchange (about 1.5 million US $ yearly). In recent years the use of agrochemicals is on the decline, which is not caused by diminishing of pest incidence but by declining profitability and cash flow of the sugar cane enterprise.

Table1: Purchase of agro-chemicals

	1995	1996	1997	type of agro-chemical
Suscon Blue	-	1,380 kg	2,610 kg	insecticide
Miral	-	1,405 kg	5,145 kg	insecticide
EDB	70,300 l.	51,000 l.	30,800 l.	insecticide
Round-up	11,00 l.	675 l.	38 l.	herbicide
Gespax Combi	11,105 l.	3,095 l.	14,200 l.	herbicide
Gespax H	1,860 l.	-	-	herbicide
Total costs in US$	~250,000	~225,000	~200,000	

These agrochemicals are used for the following purposes:

- White grubs (*Cochleothis Melolanthoides*) are a pest that has infested the estate since the early seventies. Infested fields are being uprooted. Thereafter EDB, Miral and Suscon blue are being applied in large amounts.
  White grub infestation is not at all under control. Reported losses amount to some 15% of the overall production of cane[3]. The infestation appears to be highest in fields showing salinity (and waterlogging). There are reasons to assume that the soil-injected methyl-bromide (EDB) for subsequent years aggravated the grubs problem due to the killing of predators and other biological life, possible resistance build-up in the pest. It is injected 45 cm deep in the soil,

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3 The yield per cultivated area gives a better indication of the economic yield. There is always a portion of the land used for seed cane, estimated at 500 hectares. On an average 1,046 hectares were not harvested each year (16 % of the area under cultivation) which can be attributed to infestation of White grubs and inefficient farm and transport equipment and other minor factors. The gross revenues foregone are in the order of 3.5 million US $, this represents about 16% of the total gross revenues (calculated with an ex-factory price of sugar of US $ 500/ton and extraction rate of 9% and 75 TCH/ha)

the fumes spread as far as 80 cm and it is said to maintain active for fourteen days. The situation seems to be out of control. Due to the excessive use of water to wash out the salts, it is expected that pesticides-residues end-up in surface- and ground water. Suscon blue is a residual insecticide applied after EDB to prevent/control re-infestation. According to the manufacturers of this chemical it is supposed to remain active in the soil for up to six years (in Australia it does). However, in TPC this chemical is only active in the year it has been applied.

- Weed killers are being applied in large quantities. Knapsack sprayers are being used but labourers wear no protective clothing or shoes.
- Round-up, is being used to enhance the ripening of cane.
- Within the framework of a national programme to control grain eating birds Quelas agro-chemicals are being aeroplane-sprayed over the estate as birds rest and nest in the cane plantations rather than in grain crops.

There is also a striking side-effect of the White grub pest: filter mud/cake (a nutritious byproduct of the sugar processing plant) is not applied to the soil as it was found that this it enhances the concentration of White grubs. Therefore filter cake is no longer applied to the fields but given free to the labourers who use it on their fields where they grow foodcrops.

3. PROCESSING OF SUGAR CANE

3.1 Present situation of the factory

The present state of the factory can be characterised as technically worn out. Down time of the factory is increasing and this leads to an increasing purchase of fuel resources, in particular furnace oil for the start-ups of the factory. The efficiency of energy use, in particular the use of fossil fuels and the related problems, is the most important environmental issue of sugar processing.
TPC factory has in principle the potential to be self-sustainable in terms of energy (avoiding the use of purchased fossil fuels and Tanesco electricity) but also to supply electricity for estate irrigation and perhaps to other parties (like estate villages and or Tanesco). These options are elaborated in appendix 10

3.2 Utilization of fuel

The use of furnace oil and diesel oil are fossil fuels which have potential hazardous effects to the environment, such as depletion of fossil resources:

- acidification due to emissions of SO_x into the air (in contrast to furnace oil and diesel oil, bagasse contains a negligible amount of sulphur);
- soil pollution due to accidents and careless fuel handling;
- global warming due to emissions of CO_2 into the air. In contrast: the CO_2 emission of burned bagasse is part of the closed carbocycle in the production and utilization of bagasse.

Resource depletion
The annual quantity of furnace oil used is presented in table 2. In financial terms, not taking into account other environmental issues, this depletion amounts to 150,000 USD/a.

Table 2: Consumption of furnace oil for factory running by TPC during 1995-1998

Source of fuel	Year	Litres	Yearly costs in US$
Furnace oil	1995/1996 1996/1997 1997/1998 (7 months)	530,000 800,000 1,900,000	150,000 300,000 450,000

Source: data provided by financial manager TPC

Acidification
With regard to low degree of industrialization and in view of the use of diesel and petrol fuelled road transport in the region, the contribution of TPC to acidification is negligible (not further quantified).

Soil pollution
Not considered.

Global warming
Not quantified, negligible.

3.3 Waste and emissions

The process produces a number of outputs which can be hazardous to the environment.

Filter mud
In general the quantity of filter mud varies with cane variety, soil type, milling efficiency, and other process parameters. In literature, quantities between 1 and 7 weight % of cane (wet basis) are reported. A specific assessment for TPC was not made. Filter mud contains about 1 % of phosphor (as P_2O_5) and 1 % of nitrogen (as N). Filter mud is used as fertilizer by the labourers. It is not used for cane fertilization as mentioned before. No negative environmental hazards directly related to filter mud were observed.

Effluent water
While the milling process shows a water intake of 45 t/h of water for every 100 t/h of cane (which is about TPC's current milling capacity), the factory shows a net water intake of only 5-10 t/h. This is due to the internal recycling of imbibition water and boiler feed water. Taking into account water losses occurring in cane processing (evaporation) the net effluent water is about 5 t/h. This water is rich in nutrients and fed into a pond from where it is made available to the plantation for irrigation.

The effluent water is characterized by a high BOD, but as it is not spilt into surface water resources there is no danger of down-stream pollution due to factory effluent water. Assuming that BOD is sufficiently reduced in above mentioned pond prior to irrigation.

Smoke
If only bagasse is used as a boiler fuel, smoke consists of water vapour, carbon dioxide and fly ash only.
Water vapour and carbon dioxide (being in balance with carbon uptake by the growing cane) do not pose an environmental hazard or risk. As for fly ash, there is no dust filter installed at TPC, neither is there at any cane sugar factory. There are no laws or regulations in Tanzania restricting industrial dust emissions. (In this respect Tanzania is no exception). It has been reported that smoke affects the health situation of factory labourers.

Furnace ash/ boiler ash
The quantity of furnace ash produced at TPC is about 1,200 t/a (based on 410,000 t cane/a). Currently the ash is dumped. Although no analysis reports are available from TPC a proximate ash composition can be reported here (based on literature):

- SiO_2: 60 - 80 %
- Al_2O_3 0.5 - 8 %
- Fe_2O3 1 - 8 %
- CaO 3 - 8 %
- MgO 0.3 - 5 %
- K_2O 4 - 13 %
- Na_2O 1 - 3 %
- P_2O_5 1.5 - 3.5 %
- MnO 0.1 - 0.3 %

If these elements leach into the soil on a small area there is no environmental damage.

Excess bagasse
TPC is not producing a surplus of excess bagasse.

4. LIVING CONDITIONS AND OCCUPATIONAL HEALTH

Drinking water
If electricity is supplied all camps are provided with sufficient drinking water from the boreholes. If electricity is cut off, drinking water has to be brought by tankers. Storage facilities of drinking water are lacking. Four out of the twelve camps are provided with electricity for illumination and milling.

Sanitation and sewerage
The sanitation situation is not adequate because facilities are scarce, not functioning during heavy rains and when there is no electricity.

Waste disposal
Solid waste is centrally gathered and dumped in the abandoned saline land in the southern part of the estate and does not cause problems. Liquid waste is collected by

tanks and use is made of what is called a French drain. Empty drums are cleaned at the factory by water and charcoal distributed to the labourers.

Water borne diseases
The people are facing the following water borne diseases:

- Malaria; From February 1997 to February 1998 7593 cases of malaria were registered. It is the most important health problem, likely related to improper irrigation practices. On average the number of cases at TPC are twice as high compared to the district figures. It seems that the area irrigated by surface irrigation has higher occurrence of malaria compared to the area where sprinkler irrigation is practised.
- Bilharzia; From February 1997 to February 1998 333 cases of bilharzia were registered. It is caused due to physical contact with surface water in the irrigation canals. Labourers involved in irrigation and cane cutting are mainly infected. To control Bilharzia the canals are dried temporarily and two types of snails are raised to control Bilharzia in a biologically way.
- Diarrhoea; from February 1997 to February 1998 1867 cases were registered. It is caused due to poor sanitary situation.

Other health problems

- Eye diseases; These are related to the occurrence of dust in the field.
- Respiratory diseases; These are related to dust, ash and bagasse.
- Problems related to noise of the factory are; headaches, joint pain and stress.

Use of fuelwood
Deforestation by the inhabitants of the estate is not a problem. About 5000 ha of the area owned by TPC is covered by secondary forest. This area became too saline to grow cane. Wood from this forest is distributed by the company to the residents and is used as additional fuel for the boiler. Cutting of all the wood is controlled by the management. It can be concluded that TPC is self sufficient in fuelwood. A recently started nursery provides the residents with fruit- and other trees.

5. GENERAL REMARKS

Water availability
It is mentioned that the availability of river water is declining due to increasing abstractions in the upper catchment for the cultivation of coffee and bananas. Figures, however, are lacking.

APPENDIX 8

Kilombero I and II - Evironmental audit

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Kilombero I and II - Environmental audit

1. General information

The Kilombero sugar company comprises two estates: Msolwa (K1) and Ruembe (K2). They are located south-east of the Mikumi National Park along the Mikumi-Ifakara road in the Morogoro Region. The area bordering the estates to the west is density populated. People live in a rather narrow strip of land in between the estate and the Migomberama Mountains. In front of K2 this strip of land hardly measures one km in width. In total, 10,000 people are employed at K1 and K2, approximately 6,000 of whom are seasonal labourers. Sugarcane is also produced by a large number of outgrowers living in the surroundings of the estates. In appendix 11 the results of the environmental audit for TPC are summarised and compared with the findings for Kilombero I and II and Mtibwa. It is recommended to make use of appendix 11 whilst reading this appendix.

2. Agricultural production of sugar cane

2.1 Agricultural situation

K1 measures some 10,000 ha of which 3,600 ha are under cane; K2 measures 3,600 ha with 3,200 ha under cane. The area under irrigation measures 2,800 ha in K1 and 1,400 ha in K2. The remaining area is under rainfed cane. The average cane production for K1 and K2 during the period 1986 - 1996 is 394,890 tons. With a harvested area of 5,670 ha the average yield of cane arrives at 69.6 T/ha-year. Considering that 6,800 ha is in use for cane production the average yield however stands at only 58.1 tons of cane per ha-year [1]. Presently, about 1,800 hectares cane is cultivated by outgrowers and they could make use of 700 hectares which is currently not grown with cane if the factory could be rehabilitated to its original capacity. The average yield is 40 T/ha-year.

2.2 Availability, quality and use of water

Water availability and quality
Water for irrigation, the factories and drinking water supplies are taken from the Great Ruaha River. The river has a baseflow of some 25 cumecs. Peak flows probably are over 1000 cumecs. The estates have a permit to withdraw 6 cumecs. Downstream uses are negligible. At high discharge the sediment load is large. Water quality is good: pH=7.9(?), EC=0.1 dS/m. No water scarcity, in terms of overall availability, has to be expected in the coming decades.

Upstream the water intake of the Kilombero estate, Tanesco is running a reservoir and a hydro power plant.
At times there seems to be a conflict of interests regarding river flow management. In February 1998, due to an exceptional rainfall event, Tanesco discharged a large amount of reservoir water (to avoid a damburst?).

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1 Despite soil salinity problems and a severe white grub infestation at TPC above mentioned figures make clear that cane yield at Kilombero and at TPC are about the same.

The subsequent peak flow caused severe erosion downstream, eating away some 5 ha of cane fields. A spot on the lefthand, just downstream of the bridges and weir and close to K2 built-up area, would require the construction of erosion control measures.

Irrigation and drainage
Irrigation water is applied by overhead irrigation. The conveyance and distribution system consists of an underground network of high pressure asbest-cement pipes. Along the sublaterals risers have been installed at regular distances. Where and when water is required portable pipes and sprinklers are fitted onto the risers. The design capacity is 10 mm/hour. The irrigation system is operated with 6 electrical pumps adjoint a water reservoir. Together the pumps consume 40% of all electricity provided by Tanesco.

Data on depth of water applied were not readily available. Due to non-replacement of worn-out equipment the area under command cannot be covered adequately. The permit to withdraw 6 cumec is adequate to cover the area presently under command. Expansion of the command area would require additional water.

Field drains of 0.3 - 0.4 m depth are constructed at planting and ratoon. These drains, to collect surface water, discharge into 1.0 - 1.5 m deep collector drains, which in turn discharge in a network of main drains. Maintenance of field and collector drains is done manually. Lack of funds has caused deferred maintenance. The main drains used to be cleaned with a dragline. This machine is out of order. A dragline is not at all a proper machine for cleaning drains.

Outgrowers do not irrigate cane.

2.3 Quality and use of the soil

Soils on the estates are of alluvial origin. Soils are deep loams and clays. Sandy soils occur is a small portion of both estates. Clay soils, mainly occurring in K1 show a poor natural drainage. Soils contain an appreciable amount of wheatherable minerals. The dominant clay mineral is kaolinite. Soil pH varies between 5 and 8. An aluminium problem does not occur.

Nitrogen is applied (as urea) at the rate varying from 60-140 kg N per ha. The rate depends on soil texture, age and variety of cane and on whether cane is irrigated or not. Neither phosphate nor potassium are being applied. Considering the mineral reserve (micas) soil mining of only phosphate may take place.

Soil conditions in cane fields of outgrowers are similar to the estate. Outgrowers, in general do not apply (nitrogen) fertilizers. A lack of cash seems to be a major constraint to purchase fertilizers.
Boiler ash and filter cake, byproducts of the factory and rich in plant nutrients, are not applied in cane fields. Boiler ash is used in road construction. In K1 the filtercake (or rather the mud) is flushed into the river, in K2 it is applied to (kitchen) gardens.

2.4 Use of agrochemicals (insecticides, herbicides, fungicides)

Agrochemicals are used for the following purposes:

- Smut is the principal (fungal) disease. An integrated approach to control smut is being pursued: selection of healthy seed material, dipping seeds into fungicides, and roguing of smutted clumps.
- Fungicides used are Bayleton or Benlate. The application rate (0.6 g/l) is within acceptable limits.
- Weed killers like Gesapax Combi, Gesapax H and 2-4D are being applied at a rate of 2, 8 and 5 l/ha respectively. Applications are twice in plant cane and once in ratoon cane. The applied amounts are not excessive. In addition fields are weeded manually. Weedkillers are applied with knapsack sprayers. Labourers wear no protective clothing or shoes.

  Outgrowers do not apply weedkillers.

3. PROCESSING OF SUGAR CANE AT RUEMBE AND MSOLWA FACTORY

3.1 Present situation of the factories

The two factories are actually in a downward spiral and most efficiency indicators are worsening year after year. The down-time of the factories is around 30%, while the international standards are 10% (22 out of 24 hours). The down time is mainly caused by the critical state of the factories (75% break down and necessary repairs) and irregular supply of cane, caused by insufficient transport means and climatic conditions, contributes to 25% of the down-time in the past two years.

Like TPC, Msolwa (K1) and Ruembe (K2) could have been net suppliers of electricity based on bagasse fuel only. Both factories do supply electricity to other users (irrigation and residential areas) however quantities of supplementary fuels and purchased electricity necessary to produce those supplies are substantial. At the same time the factory operations at K1 and K2 are not at all independent of external fuel inputs either. The factory manager takes the position that furnace oil is a necessary complementary fuel in addition to the bagasse. Yet, a substantial amount of excess bagasse is developed during the usual crushing season at K1 and K2.

3.2 Utilization of fuel

The use of furnace oil and diesel oil are fossil fuels which have potential hazardous effects to the environment, such as:

- depletion of fossil resources;
- acidification due to emissions of SO_x into the air (in contrast to furnace oil and diesel oil, bagasse contains a negligible amount of sulphur);
- soil pollution due to accidents and careless fuel handling;
- global warming due to emissions of CO_2 into the air. In contrast: the CO_2 emission of burned bagasse is part of the closed carbon cycle in the production and utilization of bagasse.

Resource depletion (use of fuelwood)
The management of the factories report that fuelwood is only utilized for plant start-up at the beginning of the crushing season. The factories use 2,000 to 2,500 tons of fuelwood per year, originating from the Ruembe district in Kilosa district. It is reported that these quantities do not result in deforestation or soil erosion. Yet, if a sufficient quantity of bagasse was stored at the end of the crushing season there would be no need of using fuel wood at all. Rather than recommending careful management of the fuel wood resource, it is advised to improve the energy balance of the factory so as to make the use of fuel wood redundant. (Forest management leads to costs, the avoidance of additional fuels results in cost savings: a win-win proposition).

Resource depletion (use of oil)
In 1996/97 - a year during which only 240,000 t of cane was processed at K1 and K2 - the consumption of furnace oil was in the order of 1.7 M litre/a (data on consumption diesel oil was not available). In financial terms, not taking into account other environmental issues, this depletion amounts to 770,000 USD/a (based on price of furnace oil (delivered) = 300 TSh/l, exchange rate: 1 USD = 660 TSh). Furnace oil accounts for 35% of the total fuel cost of the estates. If no adaptations are made to the energy plant, furnace oil consumption and hence wastage of resources will rise proportionally with cane processed.

Acidification
Acidification for K1 and K2 is negligible (not further quantified).

Soil pollution
The pumping stations where furnace and diesel oil is taken from tankers and pumped into the storage tanks was inspected in view of potential leakages and less careful handling. The tank outlets were also inspected with regard to leakages. The pumping stations are built on a concrete structure. At K2 no oil spillage was observed. At K1 only little oil spillage was observed, concentrated on a few square metres. Although the soil is not surfaced the spillage cannot be considered as an environmental damage. No substantial spillage was found at the tank outlets either.

Global warming
The contribution of consumed furnace and diesel oil to global warming is negligible for K1 and K2. Yet fossil fuels would, in principle, not be needed as the factory energy requirements could easily be covered by making use of bagasse. The quantities of electricity purchased from TANESCO for use by Ruembe (K2) and Msolwa (K1) are aggregated as they are monitored together at one single metre. Kilombero does not desegregate the overall consumption into the various usages, the various domestic areas, Ruembe (K2) factory, Msolwa (K1) factory, irrigated areas of Ruembe (K2) and Msolwa (K1)) other than by an educated estimation.

3.3 Waste and emissions

The process produces a number of outputs which can be hazardous to the environment.

Filter mud
For Ruembe (K2) the quantities of filter mud were not assessed. All filter mud is applied as fertilizer in the gardens of factory personnel. No negative environmental hazards related to filter mud were observed.

Msolwa factory at Kilombero I is not fitted with a collection unit to collect the filter mud (all other factories do collect the mud). Presently, the filter mud is flushed into to the Great Ruaha river. Filter is rich in nutrients and may be used as a manure. The total amount of mud which is flushed away is estimated at 5,000 - 10,000 tonnes per annum during the six months crushing season. The spilling of filter cake in the river results in biological pollution of the river water, the self cleaning capacity will take care of this pollution, given sufficient residence time and hence distance from the injection point. An assessment of the extent of this biological pollution and its balance with regards to the self cleaning capacity of the river could not be made by the Commission as it is not clear how many people make use of this water.

Effluent water
Effluent water of K2 and K1 is used for irrigation. No negative environmental impact do occur.

Smoke (water, carbon dioxide, fly ash)
Smoke produced by K2 and K1 does not cause negative environmental impacts but it has been reported that it affects the health situation of factory labourers.

Furnace / boiler ash
Furnace and boiler ash of K2 and K1 is temporary stored at separate dump sites and then used for road surfacing. No negative environmental impacts do occur.

Excess bagasse
Over the past few years Ruembe (K2) has built up a considerable stock of excess bagasse which it was not able to burn in the boilers. This stock is now about 120,000 t and occupies a land area of about 40,000 m^2. The annual excess is approximately 20,000 t. The dump causes smell hindrance and spontaneous fires in the dump, which have occurred several times, causes a risk for the people living adjacent to this site. The available dump site adjacent to the factory is not sufficiently large and the furnace ash, temporarily dumped at the same site, has now started to be mixed with the excess bagasse. This is particularly hindering any future use of the excess bagasse. The reason for this build-up of excess bagasse is not precisely clear. Two possible explanations were given by the factory management:

1 The plant is not able to produce sufficient make-up water from juice condensate and is thus forced to utilize fresh make-up water from the river. While this water is of insufficient quality it needs to be treated with the usual water treatment chemicals. Apparently water treatment is insufficient.[2]] This has resulted in an extreme level of boiler scaling and hence strongly reduced boiler capacities (and efficiencies). This was then compensated by the use of furnace oil rather than bagasse, as with furnace oil higher flame temperatures can be obtained. In this manner the boilers would have been able to produce the desired quantities of steam. (It should be noted that this is a highly undesirable situation since boiler scaling may result in serious accidents, high maintenance cost and high operating cost if purchased fuels have to be used).

2 The cane delivered at the factory is severely contaminated with soil. While the raw cane washing facility is generally of a too low capacity to handle the reported amounts of contamination, it has not been operational during the last year. Part of the soil is coming with the bagasse (another part with the juice) and will result in increased ash contents.

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2 Whether this is due to a lack of finance to purchase the right chemicals in sufficient amounts, or whether the water is of a too low quality to be used at all in such large quantities is not clear to the consultant.

If the increased ash content is substantial it will result in a distorted fuel bed and hence a reduced furnace capacity. A change towards furnace oil is then a, albeit costly, solution. Note that hypothesis 1 presupposes a reduced heat transfer and reduced boiler efficiency which can be checked by an observation of the exhaust gas temperature. As for hypothesis 2 - the ash content of the bagasse when contaminated cane was employed has not been determined by the factory management. Soil contamination of the juice was measured and a quantity of 35 t of sand per day was found. If a similar amount would have gone into the bagasse, it would have resulted in an increase of furnace ash from about 7 to 42 t/day. The furnaces are definitely not designed for such ash load, and reduced capacities are very well conceivable under such circumstances. Ash measurements (quantities) are therefore recommended.

Msolwa (K1) creates a considerable amount of excess bagasse probably due to reasons similar to K2. The management of K1 applies an acceptable solution to this surplus. It is incinerated as it is produced at a site close to the boiler house.

4. LIVING CONDITIONS AND OCCUPATIONAL HEALTH

This chapter deals with the living conditions and occupational health situation of the outgrowers and people living at K1 and K2. For most issues no distinction has been between people living in the different sites because the hospital does not record systematically where people come from.

Drinking water

The source of water for domestic use is the Great Ruaha river. It is reported that this his water is not safe and is the source of water borne diseases especially in the wet season. It is doubtful that these diseases are caused by poor water quality of the river. The discharge of the river is large (even in the wet season) and BOD is probably high. The water quality has not been sampled by the estates or the hospital.

Usually the drinking water is treated by chlorine, sometimes e.g. January-March 1998 is not treated for unclear reasons. People are advised to boil their drinking water always, but some do not do it. There is a shallow well where the cane cutters draw their drinking water.

A definite drinking water supply system is under construction. This water is of good quality and is tapped from small streams in the hills opposite K1. A number households living adjacent to K1 receive already water from this system.

Sanitation and sewerage

Sanitary situation at K1 and K2 is fairly good with exception of area C at K2 where the sewerage system is not perfect. The main problem is the low gradient of the system. During the rainy season damming up and backflow of raw sewage water may occur. However, there are plans to repair the system. They have already started to dig temporary pit latrines, the speed of rehabilitation will depend on the financial situation of the factory.

In the unplanned settlements around the estate poor sanitation is aggravated by the ever-increasing population. About 21,000 people live in the neighbouring area and out of these, about 10,000 live in unplanned areas. There are no sewerage systems in these settlements as a result run-offs during the rain seasons carries all the effluent and solid waste towards the Ruaha river which is also the source of water for domestic use. Most of the epidemics such as cholera spreads to the estate from these areas.

Waste disposal
Domestic waste is collected by two tractors, one for K1 and another one for K2. Drums used to be supplied to every house for collecting waste but it is no longer done. The waste is dumped near Ruaha river and Manzese area.
Empty drums are given to labourers and villagers who use them for irrigation and other domestic purposes. Unlike TPC, the empty drums are not cleaned at the factory. Cleaning is done by the people by either burning charcoal into them or by filling the drums with fermenting maize bran.

Water borne diseases
The people are facing the following water borne diseases. They are ranked according to the number of people affected:

1. Malaria is disease number one and all age groups and in particular children are affected. It is reported that on average all inhabitants visit the clinic once a year for malaria treatment. To fight malaria the following preventive measures are taken: Before the arrival of the temporary workers at the cutting season, houses are fumigated against mosquitos. Prophylaxis (chloroquine tablets) are provided weekly to the cane cutters coming from non-malaria areas, Iringa and Mbeya regions. It is reported that standing water, due to poor drainage, is the most important cause of malaria.
2. Typhoid; All age groups are affected.
3. Worm infestation; In particular school children and cane cutters are affected.
4. Diarrhoea; In particular children are affected. It is reported that diarrhoea is caused due to poor functioning sanitation/sewerage system and supply of biologically polluted drinking water from the river. It has been argued above that this last mentioned cause is unlikely.
5. Bilharzia (schistocomysis); The occurrence of this disease is not linked to the production of cane at the estate or by the outgrowers. Only children and adults working in paddy fields which are located in the areas around the estate are affected.
6. Cholera and tuberculosis; Epidemics occur commonly during the rainy season. Squatter settlements at the gate of the estate at K2 are a source of epidemic diseases like cholera and tuberculosis due to insufficient and poor sanitation and sewerage facilities.

Other health problems
The people are facing the following other health problems:

- Pneumonia (in particular children are affected) and bronchitis; Regularly cases of (chemical) bronchitis are recorded and these are related to inhalation of chemicals during spraying of chemicals. Chronic bronchitis is commonly recorded and could be caused by dust, gas emissions from the boiler, ash from the fields resulting from burning. These diseases probably occur due to lack of proper protection such as the use of nose masks, eye protectors, etc.
- Respiratory problems; It is reported by the hospital that most of the respiratory problems/coughing under factory workers are those dealing with the sugar clearing process in Msolwa factory (K1) where they work with sulphur fumes. In K2 these problems do not occur because the factory workers have no contact with sulphur fumes.
- Infertility problems. Infertility rate is striking high among resident men and women (it is reported that about 25% of the resident women is infertile). This is caused by sexually transmitted diseases.

Use of fuelwood
Apart from the protected area within the Udzungwa forest reserve, deforestation in the surrounding hills with subsequent erosion problems have been observed. Fuelwood is fetched from Ruembe forest in Kilosa district. Permission to harvest is provided by the forestry department. However, it was reported by the Institute of Resource Assessment at Dar es Salaam (IRA) that enforcement and monitoring is lacking as a result, the rate of deforestation in Kilosa district especially around Mikumi National Park is increasing (a study carried out to access the state of the environment - vegetation cover by IRA for the Kilosa District Council). It was reported by the IRA that Kilombero could be the source of deforestation through its factory operations and fuelwood for domestic use for the population it supports/attracts. With respect to fuelwood used by the factories this can not be true, according to the Commission. Both factories do not use more than a few hundred cubic metres of wood per year. With respect to deforestation caused by fetching feulwood and or land use changes the Commission can not judge (quantitative) the impact of this activities because this was not studied.

5. General remarks

Land use changes
The land use in the hills (located in the upstream catchment) adjacent to the estate is changing due to lack of land in the valley and an assumed increase of the population pressure. The forests in the hills are changed into land for growing food crops. This results in an increase of soil erosion. As a result of this changes in land use it is mentioned that the base and peak flow of the Ruaha river and other small rivers changes. The occurrence of flooding of low laying areas at K1, presently cultivated with paddy, might be related to the described developments.

Land use conflicts
This issue was mentioned at PARS, Institute of Resource Assessment and confirmed at Kilombero (Field Assistant Manager, Mr. Mwanzalima). The area under dispute is at Msolwa, section C of farm 6, covering about 163/170 hectares. Although this land is now being utilized by the company (under cane), basically it belongs to the village, hence to outgrowers. The land was given to the village for future expansion. Now that the company is to be privatized land use claims have been reported.

APPENDIX 9.1

Mtibwa- Environmental audit

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Mtibwa- Environmental audit

1. General information

Mtibwa is located east of the Nguru Mountains in the Morogoro region, about 120 km from Morogoro town. In total about 10,000 people are employed at Mtibwa, approximately 6,000 of whom are seasonal labourers. Sugar cane is also produced by outgrowers who live in a number of villages around the estate.

2. Agricultural production of sugar cane

2.1 Agricultural situation

Average cane production over the period 1987-1997 at the estate measured 179 060 Tons. With a harvested area of 2,997 ha the annual yield of cane per harvested ha arrives at 59.7 Tons. The area cultivated, however, measures 3,806 ha and the yield arrives at 47.0 T/ha/year. These figures obscure the effect of the decision to take poorly producing cane fields out of production. The area harvested reduced from some 3,300 ha (1987-1992) to about 2,400 ha (1993-1997). The yield of outgrowers ranges from 20-40 T/ha.

2.2 Availability, quality and use of water

Water availability and quality
Water for irrigation and the factory are abstracted from the river Diwali. Mtibwa has a permit for a withdrawal of 1.5 cumec. Water is of good quality (EC < 0.2 d S/m, pH $= 6.8$). The availability of water fluctuates over the year with the occurrence of the rainy seasons. Low flows are critical and in times when water (for irrigation) is most needed it occurs that only 0.7 cumec can be abstracted.
Geological soundings revealed that groundwater is available. Yet exploration wells have to be sunk to assess potentials.

Irrigation and drainage
The irrigation system consists of an intake structure, badly in need of repair; a lined conveyance channel; two reservoirs and pumping stations; and an underground pressure pipe system covering 1800 ha of the 3800 ha area cultivated. Irrigation water is applied overhead. The area under command cannot be adequately covered due to an overall water shortage (particular in the period when water is required most), power shortages, and lack of portable field equipment. Application rates and depths of water applied could not be obtained. Considering the above under irrigation seems to be common practice. Irrigated cane yields are reported to be only 15% above rained cane yields. Field drains are installed at the planting of cane. Field drains are connected to road-side drains having a depth of 0.5 - 1.0 m. The system is for surface drainage, not to control the ground water table.
Out growers do not irrigate, their cane production is rained only.

2.3 Quality and use the soil

Soils in the estate are of alluvial origin. Soils do contain weatherable minerals; soil pH varies from 5.5 - 7.5 and Aluminium toxicity does not occur. A detailed soil survey revealed that soil conditions varied over a short distance: sandy loamy and clay soils do occur within one cane field. This poses a problem to the design of the irrigation system.Some 300 ha of land went out of production as a result of the twin problem of waterlogging and salinisation. Also high exchangeable sodium contents have been reported.

Nitrogen is applied at rates varying between 150 and 400 kg/ha of $(NH4_4)_2SO_4$.
Hence net N application varies from 30-80 kg/ha. Actual application depends on whether cane is irrigated or rained and on whether it is a planted or ratoon cane. Applied amounts come close to the quantity of N carried away in the cane to the factory. Fertilizer trials do not show a response to P and K applications. Hence neither phosphate or potassium fertilizers are being applied. Boiler ash is used in road construction. The filter cake is used in gardens and farmers fields.
The application of gypsum to reduce exchangeable sodium is being considered. Gypsum application at this moment would be waste of funds. First the problems of waterlogging and salinisation and of irrigation water shortage would have to be solved.

Outgrowers do not apply potassium or phosphorous fertilizers. Nitrogen is reported to be applied (as urea) up to 125 kg/ha/year.

2.4 Use of agrochemicals

White grubs have appeared in 1984. The pest is well under control. No insecticides are being used. Also smut infestation occurs. Smut control is by planting healthy material and by roguing of smutted clumps. No chemicals are being used.White scales appear in some 35% of the estate. The infestation is controlled by early cutting, planting self-trashing varieties and using natural predators. As natural predators are killed in pre-harvest cane burning, the possibility of mass propagation of the natural predators is looked into.
A collaborative research program is carried out by the International Institute on Biological Control (Nairobi) and the Kibahe Sugar Research Station on certain fungi, which show a potential in the combat of white grubs.

Outgrowers are facing the following important pests: smut and white scales. Smut is controlled by roguing and burying smutted clumps. No measures are taken to combat white scales. Weeding is done manually only at planting small doses (2-3 l/ha) of 2-4 D or Gesapax are applied.

3. PROCESSING OF SUGAR CANE AT RUEMBE AND MSOLWA FACTORY

3.1 Present situation of the factory

The Mtibwa factory was recently rehabilitated with Dutch assistance. Yet, the factory is not self-sufficient in energy supply. In combination with a set of relatively inefficient turbines, the boiler plant does not have a sufficient large capacity.

Table 1: Steam balance

Mill drives (kg steam/kWh)	17
4 x 0.4 MW	
operated at 0.25 MW each: total power (MW)	1
steam consumption (kg/h)	17
Power turbines (kg steam/kWh)	
2.5 MW	12.50
1.5 MW	17.3
operated at full load: total power (MW)	4
steam consumption (kg/h)	57.2
Total steam consumption (kg/h)	74.2
Boiler capacity (t steam/h)	60
Lack of steam capacity (t steam/h)	14.2

As it is likely that the boiler capacity is sufficiently large in terms of process steam - available specific steam capacity would to an even high 0.6 t steam/t cane at a boiler capacity of 60 t steam/h and a crushing rate of 100 t cane/h - it is expected that rehabilitation of the power turbines is attractive. This is not further elaborated here.

Due to the imbalance of the factory, a large quantity of excess bagasse is produced annually (about 15,000 t/a). At the same time Mtibwa is forced to utilize fuel oil (60,000 l. worth 33,000 US$ in 1996/97). The occurrence of the excess bagasse is not an environmental problem ads such, but it poses an environmental option as it may be either (1) used to avoid the consumption of fuel oil; (2) used for an increased production of electricity or, alternatively, (3) may be utilized as raw material for charcoal production (substituting for charcoal made of wood).

3.2 Utilization of fuel

The use of furnace oil and diesel oil are fossil fuels which have potential hazardous effects to the environment, such as:
- depletion of fossil resources;
- acidification due to emissions of SO_x into the air (in contrast to furnace oil and diesel oil, bagasse contains a negligible amount of sulphur);
- soil pollution due to accidents and careless fuel handling;
- global warming due to emissions of CO_2 into the air. In contrast: the CO_2 emission of burned bagasse is part of the closed carbon cycle in the production and utilization of bagasse.

Resource depletion
Furnace oil and diesel oil is used but the quantities haver not been recorded. Fuelwood and charcoal (a few hundred cubic metres) are used for plant start-up.

Acidification
Acidification is negligible.

Soil pollution
Pollution of the soil around the storage tanks and tank outlets are not observed.

Global warming
The contribution of fossil fuels to the process of global warming is negligible.

3.3 Waste and emissions

The process produces a number of outputs which can be hazardous to the environment.

Filter mud
The amount of filter mud is not assessed. It is not applied in the cane fields but is applied at the gardens of the labourers.

Effluent water
Untreated waste water from the factory is discharged into an open drain and channelled beyond the estate border in south-eastern direction. It is reported to disappear somewhere in the bush (evaporation or point recharge of ground water) or said to flow into a riverine marshy area. The sewage water has a high BOD content. Every month several tons of $Na_2CO_3/NaOH$ are being discharged as well, this salt being the waste product of cleaning tanks with caustic soda.

Smoke (water, carbon dioxide, fly ash)
Smoke produced at Mtibwa does not cause negative environmental aspects. Like Kilombero it is reported for Mtibwa that some affects the health situation of factory labourers.

Furnace/boiler ash
Furnace/boiler ash is temporary stored and used for road surfacing. No negative environmental impacts occur.

Excess bagasse
Mtibwa produces annually 15.000 ton of surplus excess bagasse. This excess is incinerated. The occurrence of this excess is not an environmental problem as such, but it poses an environmental option as it may be either (i) avoided by an improved utilization for surplus electricity production or, alternatively; (ii) may be utilized as a raw material for charcoal production (substituting for charcoal made of wood). These options are elaborated respectively in appendix 10 and 9.2.

4. LIVING CONDITIONS AND OCCUPATIONAL HEALTH

Drinking water
Drinking water is tapped from the river Mbulumi and is sufficient all year round. There is a canal from the river that leads the water into a collecting dam from where it is pumped into tanks. The water is treated with chlorine and it is advised to boil the water.

Sanitation and sewerage
Toilets, washrooms are old and inadequate. The sewerage system is poorly functioning and flooding of the residential areas occur in the rainy season. It is reported that due to this situation water borne diseases occur.

Waste disposal
Solid waste is collected and stored at a dump. No negative environmental effects occur.

Water borne diseases
The people are facing the following water borne diseases;

- Malaria is the most important disease at Mtibwa which affects all age groups (3,828 cases reported at the hospital - Mtibwa Annual Report, 1996). It is reported that the most important cause of malaria is the occurrence of stagnant water in the field and poor drainage systems in the residential areas. Improvement of run-off in the drains is among the strategies used by the sanitation/public health section to control malaria. It was reported that, malaria is increasing since the applied amount of residual insecticides is reduced. For instance in 1994: 1000 packets (each 100 mg.) of the insecticide were used and the number of malaria cases reported was 6,900; whereas in 1996, only 289 packets were used, and the cases of malaria reported were 9,034.
- Typhoid fever, diarrhoea, skin infections and cholera. This are common diseases during the rain season which are normally exacerbated by: inadequate/poor functioning sanitary system (toilets and washing rooms).

Other health problems
Skin infections or allergies, pneumonia and respiratory problems, cut wounds and noise due to the use of agro-chemicals without proper protection.

Use of fuelwood
Fuelwood and charcoal are the major sources of domestic fuel. There are only little trees within and around the estate area. Almost all the trees have been cut down for cane and paddy farms. Charcoal is obtained about 30 km from the estate.
Women workers through their association (MWEMA) are working in collaboration with ILO and the Workers union (Tanzania Plantation and Agricultural Workers Union) to find affordable alternative sources of energy. Improved stoves and the use of Bagasse charcoal are among the proposed alternatives.

APPENDIX 9.2

Mtibwa- Financial assessment of technical options for improved use of bagasse

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Mtibwa- Financial assessment of technical options
for improved use of bagasse

1. INTRODUCTION

Bagasse is a by-product of cane sugar production, the potential ways of utilisation go beyond energy options alone. They include:

- energy options:
    - Boiler fuel for factory process heat.
    - Boiler fuel for factory process heat and process electricity (and office lighting).
    - Boiler fuel for factory process heat, process electricity (and office lighting) and estate uses, i.e. domestic lighting of factory staff, labour villages, irrigation power (Note that this option can be distinguished into various alternatives which differ in costs and revenues).
    - Boiler fuel for factory process heat, process electricity (and office lighting) and estate uses, i.e. domestic lighting of factory staff, labour villages, irrigation power (Note that this option can be distinguished into various alternatives which differ in costs and revenues) and delivery of surplus electricity to the grid.
    - Charcoal briquettes for use as cooking fuel.
    - Compressed bagasse briquettes as industrial boiler fuel.
    - Methanol.
- pulp and paper;
- paper board, box board, corrugating board, fibre board, particle board;
- furfural (used in the fine chemicals industry);
- alpha cellulose (used in the fine chemicals industry);
- xylitol (sweetener);
- plastics;
- poultry litter, mulch and soil conditioner;
- bagasse concrete.

The environmentally focussed ToR of the Commission for EIA leads to an orientation towards energy applications of bagasse.

In this Appendix the use of excess bagasse for the production of charcoal is assessed. The assessment is based on - where available - data from existing proposals and studies. If relevant studies and proposals are not available the Commission prepared its own system designs.

2. CHARCOAL PRODUCTION FROM BAGASSE AT MTIBWA

Mtibwa is the only factory which avails of a permanent excess of bagasse. To date this excess is being incinerated at a cost without making any use of it. In contrast, the production of charcoal briquettes for household utilization would be a productive use. Before discussing the technology and the economics, a brief overview of the conditions of charcoal production and consumption in Tanzania is presented.

2.1 Charcoal supply and demand

In Tanzania charcoal is almost exclusively produced in the traditional way. The charcoal maker cuts branches of (selected) trees and places these over a row of dry wood and covers it with earth, with a opening in the front and the back. After the dry wood has been burned the openings are covered and the anaerobic burning of the wood continues. After a couple of days (depending the size of the heap) the charcoal is ready. Charcoal making is a profitable business for poor people - the return to labour is higher than of an agricultural land labourer[1]]and generates an additional income in particular in the agricultural off-season. The tree species most preferred for charcoal making are *Acacia* and *Combretum* species from natural woodlands, and those planted in woodlots and public lands (e.g. *Acacia mearnsii*, the wattle tree).

In Tanzania the consumption of charcoal takes place in the cities, that are the regional capitals (piles with bags of charcoal are often found on street corners) and a small part in district towns. In the villages and in the rural areas charcoal is rarely used, as there is a good supply of fuelwood, which do not involve cash transactions for most consumers (own collection), and if bought the fuelwood is cheaper than charcoal.

Charcoal is a major export product from the rural areas. For instance, a survey in Monduli district showed that only 2.7 per cent of the charcoal production was consumed by a small number of households in the district capital and further by institutions (hospitals, schools, hotels and restaurants[2]] and 97.3 was exported outside the district (mainly to Arusha and even to Kenya). Although local disparities may occur, in general the district energy balances show surpluses[3]]. Overall, there is no shortage of fuelwood and charcoal, which is evidenced by the fact that the prices of charcoal in the different towns of Tanzania do not differ much. On an average charcoal is being produced within a range of 30 - 50 km from the cities. The direct competitors for charcoal (in the cities) are kerosene, electricity and gas (but are still minor energy sources).

2.2 Prices

There is a price fluctuation between the seasons. During the rainy season (October - June) the prices of charcoal are high due to problems of transportation: the roads to the production sites become impassable for large lorries and the supply decreases leading to higher prices.

Prices of a bag of charcoal during the rainy season are TSh 3,000 - TSh 3,500 in towns, and during the dry season from TSh 1,800 to TSh 2,000. The prices at the production sites are TSh 1,000 (dry season) to TSh 1,200 (rainy season); these are also the prices of the bags which can be seen along the main roads, e.g. the Dar es Salaam - Morogoro - Dodoma - Singida - Mwanza road, and other main roads.

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[1] Source: Planning for a better environment in Monduli district, J.Douwe Meindertsma and J.Joost Kessler (eds), NEI, January, 1997.

[2] Source, see previous footnote.

[3] See for instance: Towards better use of environmental resources; a planning document for Mbulu and Karatu districts, Tanzania, J. Douwe Meindertsma and J. Joost Kessler (eds), NEI, January 1997.

The difference between the prices of the production sites and the prices in the towns can be explained by the transport costs and relative scarcity of the product (seasonal):

- The cost of production at the production site of TSh 1,200 plus TSh 600 for transport costs (10-tons trucks) plus a margin of TSh 200 per bag gives a sales price of TSh 2,000 per bag[4]. During the rainy season the charcoal is collected by 4-wheel driven small cars, which increases the transportation costs by more than 50 per cent.

2.3 Alternatives for charcoal making

For the Mtibwa estate, basically two alternatives have been considered, i.e.:

- Conversion of the entire bagasse surplus into charcoal briquettes for supply to markets outside the estate;
- Conversion of only a part of the available charcoal surplus into briquettes for consumption in the estate and its vicinity.

Alternative 1: Utilization of the entire bagasse surplus for charcoal production

The total amount of charcoal briquettes which can be made from the available excess bagasse (15,000 t/a) is about 3,000 t briquettes/a. This figure takes a conversion ratio of 25% into account (air dried bagasse to charcoal) as well as an amount of binder and other additives. This is much more than can be consumed in and around the estate, the charcoal consumption of which is in the order of 100 t/a (80 t/a by the sugar factory in its metal workshop, 25 t/a by the say 50 richer families). If, therefore, the total bagasse surplus is to be converted into charcoal briquettes, then the major part of the product needs to be transported to one or more cities.

The closest point where the charcoal could be traded in a concentrated manner would be Morogoro which is at a distance of 120 km from the estate. We assume an average sales price of TSh 2,500/50 kg bag of wood charcoal in Morogoro. While the effective content of good quality charcoal in a bag is about 43 kg (at least 15% may be supposed to consist of fines and brands), the effective sales price of wood charcoal in Morogoro is 58,000 TSh/t. For handling and transportation to Morogoro we assume TSh 1,000/bag of wood charcoal. This is equivalent to 23,000 TSh/t of wood charcoal. Disregarding distribution margins and price reductions potentially needed to sell the charcoal briquettes, this brings the maximum allowable ex-factory price to 25,000 TSh/t (38 US$/t).

The technology selected is a manually operated technique which was successfully developed in Indonesia in the 1940s[5] and further tested and adapted in Sudan (1993).[6] In brief, the mill run bagasse is first baled and stacked to allow atmospherical drying up to a moisture level has been reached of 20% on wet basis.

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[4] Payment for labour to go with the truck to collect the charcoal are about TSh 30,000 per 100 bags (which is 300 TSh per bag). For the rainy season (10-tons trucks), the costs are about TSh 300 per km (fuel: diesel costs TSh 400, is 100 TSh /km, 200 TSh/ Payment for labour to go with the truck to collect the charcoal are about TSh 30,000 per km for fixed costs. With an average distance of 2 x 50 km the costs are TSh 30,000 per 100 bags or TSh 300 per bag.

[5] De Haer, P. M. D., *et al.*, Koolbereiding uit ampas en melasse (*The manufacture of bagasse-molasses coal*, in Dutch), Arch. Suikerinustrie Nederland en Nederlands Indië, 1 (1941), pp. 631-637.
Val, R, De fabrikatie van ampas-melassekool (*The fabrication of bagasse-molasses coal*, in Dutch), Arch. Suikerindustrie Nederland en Nederlands Indië, 1 (1941), pp. 638-644.

[6] Siemons, R.V., Forestry development in Sudan, Carbonisation of fresh bagasse, GCP/SUD/047/NET, Consultant's report, Forests National Corporation, Food and Agricultural Organization of the United Nations, Rome, 1993.

Although not tested for the Tanzanian climate, we assume a storage duration of a couple of months as reported in literature.[7] The air dried bales are subsequently carbonised in metal kilns constructed from used 200 litre drums covered with a sheet metal lid. The kiln volume is 2 m^3. Two labourers can operate 4 kilns simultaneously and proceed through two carbonisation cycles per each kiln-day. Year round charcoal production is assumed. A rough estimate of production cost is presented below.

Table 1, Cost calculation of bagasse charcoal.

General data				
Exchange rate (TSh/US $)	660			
Labour cost (TSh/d)	600			
Depreciation period (a)	5			
Maintenance (% of inv./a)	10%			
Interest (% of inv./a)	15%			
Cost of baled bagasse (TSh/t50)	6 600			
= (TSh/t25)	9 900			
Production unit				
No. of kilns	4			
No. of operators	2			
Cycles per kiln-day	2			
Kiln volume (m2)	2			
Kiln load (kg bagasse/cycle)	230			
Yield (kg charcoal/kg bagasse)	0.25			
	month/a	d/month	d/a	
Annual operating period	11	23	257	
	kg/cycle	kg/kiln/d	kg/kiln/a	kg/a
Bagasse consumption	230	460	118 391	473 564
Charcoal production	58	115	29 598	118 391
Investments				
Unit	#	TSh/pc	Total (TSh)	
Kilns	4	59 400	237 600	
Spades	2	6 600	13 200	
Buckets	2	6 600	13 200	
Total			264 000	
Production cost	TSh/a	TSh/kg	US $/t	
Financing cost	78 755	0.67	1.01	
Labour	308 846	2.61	3.95	
Raw material	4 688 285	39.60	60.00	
Maintenance	26 400	0.22	0.34	
Total	5 102 286	43.1	65.3	

Since the cost of charcoal after conversion of bagasse is estimated at 43,000 TSh/t (65 US$/t), which is the major raw material for charcoal briquettes, it must be concluded that this alternative is not financially feasible.

[7] Paturau J. M., By-products of the cane sugar industry, 2nd. ed. Elsevier Scientific Publishing Company, Amsterdam, 1982.

The major reason for the high cost of charcoal from bagasse is the high cost of baling which is needed for this particular production method. As can be seen from the above table, baling cost amounts already to 9,900 TSh/t of air dried bagasse, which is equivalent to 39,600 TSh/t charcoal (60 US $/t) after conversion at a rate of 25%. At this cost level it is not needed to much refine the costing of the other items such as labour and investments in kilns. Any further elaboration of the charcoal option should be focussed on avoiding the baling step or on strongly reducing the cost of baling.

Alternative 2: Charcoal briquette production for consumption in the estate and its vicinity

By producing charcoal for consumption in and around the estate, the relatively large transportation cost to urban centres can be avoided. As such this option could be a lot more attractive than the large scale one discussed above. As discussed previously, the local charcoal consumption level is about 100 t/a. Assuming 100% market penetration, an equivalent quantity of briquettes would be required, to be produced from roughly 300 t bagasse/a. This is negligible in view of the available bagasse surplus of 15,000 t/a. To produce charcoal at this scale would certainly not contribute to a more efficient use of bagasse at Mtibwa.

3. CONCLUSION

The two options for charcoal production at the Mtibwa estate appear not to be financially feasible (large scale) or relevant (small scale). The main reasons are the following:

- It is very difficult to compete with the traditional charcoal producers for whom the wood raw material is very cheap (wood is amply available in places relatively close to the consumer centres), although it is noted that charcoal prices are higher in areas close to national parks and conservation areas where charcoal making is forbidden (e.g. in the Arusha/Moshi region).
- The location of the factory (relatively far from urban centres) together with the cost of baling the bagasse - which is necessary before further processing - make that the product cannot compete in urban centres.
- The small volume required for local consumption makes the small scale option irrelevant in view of improved bagasse utilization at Mtibwa.

APPENDIX 10

Final assessment of alternatives for electricity generation from bagasse for TPC, Kilombero I and II and Mtibwa

Table of contents

Appendices

1. General Introduction

Bagasse is a by product of cane sugar production, ten potential ways of utilisation go beyond energy options alone. they include:

- energy options:
  - Boiler fuel for factory process heat.
  - Boiler fuel for factory process heat and process electricity (and office lighting).
  - Boiler fuel for factory process heat, process electricity (and office lighting) and estate uses i.e. domestic lighting of factory staff, labour villages, irrigation power (Note that this option can be distinguished into various alternatives which differ in costs and revenues) and delivery of surplus electricity tot the grid.
  - Boiler fuel for factory process heat, process electricity (and office lighting) and estate uses i.e. domestic lighting of factory staff, labour villages, irrigation power (Note that this option can be distinguished into various alternatives which differ in costs and revenues) and delivery of surplus to grid.
  - Charcoal briquettes for use as cooking fuel.
  - Compressed bagasse briquettes as industrial boiler fuel.
  - Methanol.
- pulp an paper;
- paper board, box board, corrugating board, fibre board, particle board;
- furfural (used in the fine chemical industry);
- alpha cellulose (used in the fie chemicals industry);
- xylitol;
- plastics;
- poultry litter, mulch and soil conditioner;
- bagasse concrete.

The environmentally focussed ToR of the Commission for EIA leads to an orientation towards energy applications of bagasse.

In this appendix the generation of additional electricity by the installation of more energy efficient boiler- turbine systems on basis of improved use of bagasse is assessed. The assessment is based on - where available the -data from existing proposals and studies. If relevant studies and proposals are not available the Commission prepared its own system designs.

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2. ELECTRICITY GENERATION FROM BAGASSE

2.1 Introduction

In this section an assessment is made of the financial profitability of an investment in the energy section of sugar mills to increase the energy efficiency of bagasse utilisation, particularly for the generation of electricity.

The Tanzanian sugar factories are designed such that bagasse is a boiler fuel for factory process heat, process electricity (and office lighting) as well as a selection of estate uses (domestic lighting of factory staff, labour villages, irrigation power).[1]]
Usually the systems are designed in such a manner that staff houses are supplied with electricity, and some irrigation power is supplied on the basis of bagasse. However, under the circumstances prevailing at the estates and factories, the energy plant are not capable of even supplying these basic needs. From the exercises reported below it becomes clear that rehabilitation of the estates/factories towards energy self-sustainability of the factories is financially justified and is a first priority. The Base Case, therefore, in view of which the alternatives of increased energy efficiencies are to be evaluated, are energy systems which enable sugar factories to provide for factory process heat, process electricity (and office lighting) as well as domestic lighting of factory staff.

The reasons why achievement of the Base Case (self-sufficiency of the factories with some adjacent services) is indeed a first priority are the following:

- As boilers for process heat are needed anyway, the incremental investment in electricity and shaft power generation equipment (i.e. turbo-genets and mill turbines) is marginal and results in much lower cost that the cost of grid supplied electricity;
- A sugar factory needs to be absolutely independent of a third party for power supplies.

Although also the TAC factor was originally designed according to this schedule, the current status of the factory and the estate (including the energy plant, the sugar processing plant and the cane transportation system) makes the factory far from self-sufficient: Due to frequent stoppages large quantities of furnace oil, fuel wood and diesel oil need to be purchased. The Commission concludes from its evaluation that if the Base Case is compared with the present situation, the Base Case is an extremely profitable investment, due to:

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1 Strictly speaking in technical terms the combined production of heat and electricity is called "co-generation". In recent literature the supply of excess electricity,- produced by a private power producer- to the grid is also sometimes referred to as co-generation. Whereas this confusion is a cause for misunderstandings we prefer to call the latter"independent power-production" or IAP.

- The reduction in the purchase of furnace oil, diesel and phalloid for the repeated start-up of the factory and electricity generation during down-time and as complementary fuel. During the past years the consumption of furnace oil has increased drastically: from 530,000 litres in 1995/96 to 800,000 in 1996/97 and already 1,900,000 litres in the first 7 months of 1997/98.

This gives an almost perfect exponential rise in the cost: from US $ 150,000 to US $ 300,000 and likely US $ 600,000 for the mentioned years[2]] (In our calculation of the ICR an amount of US $ 500,000/a of diesel is included).

- The reduction of down-time. At present the factory is non-operational during two days weekly (Sundays and Mondays for repair), and frequent run-downs daily, giving a downtime of 35-40%, leading to three major impacts:
  - Higher operational costs per unit of sugar produced (US $ 250,000);
  - Lower than potential quantity of cane crushed (cane deferred);
  - Less sugar produced: 10% or 3,500 tons a US $ 400 is US $ 1.4 million;
  - Loss of cane quality, as well as qualities of intermediate and end products (US $ 200,000).

The investments needed for the Base Case are reviewed in table 1 of this appendix. Based on these consumptions the ICR of the Base Case is 24% (at a project duration of 25 a), making this investment highly attractive. Whereas this outcome is not a surprise, it is surprising that the investment has not been made yet.

Options for increased efficiencies in the energy utilization of bagasse go beyond, and should be compared with this Base Case. These options can be principally distinguished as follows:

1. Increased energy efficiency for extended electricity production during crushing season only, with the objective:
   1.1 To replace base load electricity for irrigation, purchased under the Base Case during the crushing season;
   1.2 One step further: To replace base and peak load electricity for irrigation (again only that which is, under the Base Case , purchased during the crushing season) and to sell surplus power to the grid;

2. Increased energy efficiency for complete independence of the grid of the entire estate. The technology would be to increase energy efficiency in such a manner that a bagasse surplus can be created and stored for utilization outside the sugar campaign in such a manner that the bagasse surplus is sufficient to provide for year round electricity consumption by the estate (including electricity for irrigation).

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2 The consumption of diesel during these years fluctuates form 18-35,00 litres. the year 1994/95 is an exception. During this year there was a complete run-out of the steam-driven turbo there was a complete run-out of the steam-driven turbo generator, which is reflected in diesel consumption: 256, 019 litres (more than 10 times normal consumption).

In technical terms Option 1.1 goes with the investment in relatively low pressure equipment of about 20-30 bar(a), depending on the power demand of irrigation activities and of factory operations.
Option 1.2 requires higher pressure boilers of about 45 bar(a) - again the precise pressure depends on power demand. While simple steam systems comprising back-pressure turbo-genets may be suitable, the technology can be made more efficient (and more complex, and perhaps more profitable) by installing a condensing system. In the latter case a condensing turbine, a condenser, a de-aerator and a water treatment plant would be required. Due to lack of detailed information not Option 1.1, but Option 1.2 has been assessed.

Option 2 would be the most complicated one, only attractive if large price difference exist between purchased and sold electricity. As such difference does not exist, and further, the additional costs involved in the storage of the excess bagasse increases the costs of generating electricity by the factory, this option is not feasible.

Whereas it is an ongoing debate whether or not the increased efficiency of bagasse utilisation can be justified for environmental or economic reasons, it is understandable and acceptable that sugar factories look into these options from a financial point of view in the first place. In accordance with that approach the generation of electricity (additional to the Base Case) can be seen as an secondary output of the factory, aimed at:

- making the irrigation system more independent from the grid, and
- making the irrigation system more effective (by a larger and more reliable supply).
- reducing costs of electricity purchases;
- collection of additional revenues from electricity sales.

2.2 Previous studies

In the past several studies on increased electricity generation from bagasse at TAC were made. These are:

- a study carried out by Sugar Knowledge International Ltd. (SKILL);[3]
- a study by the Stockholm Environmental Institute (SEI);[4]
- a study by Luleå University of Technology;[5]
- two nearly identical studies by the NEI with regard to two ORET applications (by HOLEC and by GEMCO).[6]

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3 Sugar Knowledge International Limited, Rehabilitation programme sugar industry Tanzania. Tanganyika Planting Company Ltd, Report of Electrical engineer, May 1991.

4 Jenefors, Ann-Christin, Malin Kihlblom and Rwabangi Lutheganya. A bagasse fuelled steam power plant; some possibilities to increase electricity generation. Working paper Energy, Environment and Development Series, No 22. Published by the Stockholm Environment Institute in collaboration with SIDA, 1993

5 Kjellström, Björn. Technical and financial feasibility of increased power generation at TAC Sugar Mill in Moshi, Tanzania, Lulea University of Technology, 1993 (Publication medium unknown).

6 NEI, Rehabilitation of the power plant of the sugar mill, Tanganyika Planting Corporation Ltd. Tanzania, ORET 95/52, for DGIS, 1997

These studies were partly used for the present evaluation. However, the Commission had to prepare certain specific data sets due to a less adequate framework of some of those studies.
The ORET-applications only consider alternatives which are characterized by too high costs, and too much advanced steam conditions and which show a considerable over-capacity in relation to cane supply. Moreover the ORET evaluation studies do not make a comparison with the Base case as defined above. Some of these studies also take insufficient account of the limited production capacity of the TAC estate. This particularly holds for the study by Kjellström (production levels of up to 605,000 t cane/a are being considered. This is way too large, see below).

3. THE TPC FACTORY

The Commission is of the opinion that a starting point for the evaluation is provided by the maximum potential annual cane production at a given site (taking into account eventual extensions of the cultivated area). For TAC, the Commission estimates this quantity to be approximately 450,000 t cane/a. This limitation is mainly due to soil conditions. It should be noted that a considerable agricultural effort is needed to achieve the indicated annual cane production as current average production levels are approximately 395,000 t cane/a. The factory capacity corresponding to the annual throughput of 450,000 t cane/a is 100-130 t cane/h. The crushing season would then show a duration of 218-168 days respectively. This is based on a factory availability of 86%, which is an internationally accepted figure.[7]
From a comparison with international sugar operations (180 d/a is a usual figure) it is concluded that 164 d/a is a bit short and that hence the capacity of 130 t cane/h is too high for TAC. For further evaluations the Commission assumes a capacity of 100 t cane/h. The Base Case and the alternative are defined as follows:

- The Base Case represents a thorough overhaul of the technically depreciated power section, implying the replacement of the boilers (60 t steam/hour, 12.5 bar(g) and 250 oC) and installation of a new power turbine (2.5 MW) and new mill turbines (aggregate capacity 1.6 MW). The estimated investment is US $ 7.3 million. The Base Case is self-sufficient in power for the factory and the office/domestic complex.
- The Alternative consists of the installation of a new boiler (45 bar(g), 370 oC, 60 t steam/hour), new back-pressure power turbines (6 MW) and new mill turbines (aggregate capacity 1.6 MW). The estimated investment is US $ 13.7 million. Additional electricity, available for the substitution of irrigation power purchased under the Base Case and for grid delivery, amounts to 13,400 MWh/a.

Also other technologies are conceivable for the Alternative, such as the replacement of the mill turbines by electric engines (an alternative which should go

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7 Based on 2 days factory overhaul per 30 days moth and 2 hours overhaul for each operational day.

with a larger turbo-genset), or the installation of a condensing steam system for an even more increased electricity efficiency. Since this study is on a pre-feasibility level, the Commission decided to limit the evaluation to one alternative only.
The Base Case and the Alternative have been balanced such that further use of furnace oil, wood, diesel oil and electricity for sugar processing is no longer needed. Any financial advantages in this respect should be attributed to the Base Case. It is assumed that the bagasse is converted into electricity at any time of its availability, which implies that the electricity can be consumed by the estate or delivered to the grid at that very moment. In this respect it should be noted that the available surplus power capacity (2.9 MW) is close to the installed capacity for irrigation (4 MW). As it is very unlikely that the available power can be instantly and totally consumed by the irrigation system, a delivery contract with TANESCO is a prerequisite. The investments should therefore also reflect adequate protection equipment.

In the evaluation, of the Alternative (compared to the Base Case), only the incremental costs and benefits related to generation of additional electricity are taken into account. The assumptions for the calculation of the incremental ICR and its values are presented below:

- Project life time is set at 25 a. As the technical lifetime of this time is also 25 a, no reinvestment are needed.
- A 12 % interest rate on half of the initial investment is assumed, together with a cost of 2.5 % annually on the initial investment for maintenance and spares;
- No additional costs for skilled labour, training, overhead, consumables are assumed;
- All electricity additionally generated is priced at US $ 0.10 per kWh.

The value of additionally produced electricity is considered to be realistic for the following reasons:

- The total electricity bill of TAC during the 1996/97 season was TSh 1,093,203,480, with an exchange rate of TSh 600 for 1 US $ gives a total expenditure of US $ 1.8 million . The total consumption of kWh was during the same period 15,791,000 and 38.505 kVA.

The average cost of electricity therefore is US $ 0.11 (including kVA charge) and for the price for the kWh US $ 0.085.[8]]

- TANESCO claims that it is in principle interested to purchase electricity from anyone, including the sugar estates. According to information collected at TANESCO Headquarters, TANESCO pays US $ 0.10 to a tea estate in Mbeya.

It was noted that TANESCO takes the position not to pay for kVA to TAC. For a utility which is seriously interested in independent power production this may be is an unrealistic proposition, as is proven in other countries where electricity

8 The power charge of TANESCO was TSh 7,300 per kVA. Deducting the consumed kVA from the total bill gives the payment for kWh. The average price over the first 4 year of the 90's has ben US $ 0.10 (based on NEI's ORET evaluation 95/36, Dfl. 0.19/ kWh with exchange rate for the US $ of Dfl. 1.80).

is produced by third parties.[9]] Yet, for the purpose of this pre-feasibility study the simple approach of a single value for purchased and sold power is adequate.

A listing of the required investments for the Base Case and its Alternative is presented below. For the investment an overall estimate was based on a specific investment of 1,800 US $/kW installed power.

Table 1, Investment review of electricity generation options

Investments	**Base case**	**Alternative**
New boiler, characteristics:	Yes	Yes
Capacity (t steam/h)	60	60
P (barg)	12.5	45.0
T (oC)	250	370
New power turbine	Yes	Yes
Capacity (MW) (10% overcapacity)	2.5	6.0
New mill turbines (steam)	Yes	Yes
Capacity (MW)	1.6	1.6
New mill drives (electrical)	No	No
Capacity (MW)	-	-
Switch gear and protection	as required	as required
Cost (USD) (installed)	7 308 000	13 680 000

With the above assumptions an ICR of 12 % results for the Alternative. This is close to being attractive. On the other hand, this result is very sensitive to a number of assumptions which could not be verified by the Commission. A major sensitivity arises from the investment level of the Alternative. The specific situation at TAC may give rise to a higher cost level. The ICR decreases to 9.4% if the incremental investment cost increases to 120% of the estimated value. ?? by 10% and to a mere 7.5% if the investment cost increases by 20% Since the Alternative appears to be financially feasible at first sight, a closer elaboration is recommended.

It should further be noted that both the Alternative and the Base Case assume an efficiently operated sugar estate and factory. A much larger investment than indicated in Table 1 is therefore required.
Investments should also cover replacements of field equipment (land preparation, harvest), irrigation (machinery for maintenance of drainage canals, implements) and cane transport equipment.

9 Note that not only a quantity (kW) is required by a power purchaser.

If the Alternative of increased electricity production is to be pursued further, it is therefore necessary to evaluate the complete investment package in view of the sustainable financing.

Closer evaluation may very well reveal that the recommendation made by SKILL (1991), i.e. to replace the boilers by a new one operating under a moderately increased pressure of 20 bar (instead of the actual 12.5 bar), appears to be the best solution.

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4. THE MTIBWA AND KILOMBERO FACTORIES

Proposals for the other factories are not further explored in detail. But in general terms the feasibility for installation in the existing plants seems lower than for TAC:

- Preliminary estimates showed that for Mtibwa higher incremental investments for less additional electricity are required. Moreover, the replacement of the existing boiler by a high pressure one would imply a considerable capital destruction since the boiler has been retubed recently (1994).
- The Kilombero factories have a much lower capacity than TAC, which makes attractive IRRs less probable for the two individual sites. Shutting down the actual two factories and erecting a new modern one with a larger capacity with a co-generating powersystem could be an option in the near future.[10] For a new larger scale factory the alternative of installing a more efficient energy plant for surplus electricity production is recommended for consideration.

10 The option of one instead of two factories is less attractive from the point of supply of cane: both estates are separated by the Ruaha river and it would create large traffic problems if the trucks/ tractors with cane have to pass the actual narrow bridge (and this is costly).

5. CONCLUSIONS

The replacement of the actual out-dated energy section of the sugar factories (in particular the old TAC factory, build in the thirties) by more modern ones (medium pressure systems) are unavoidable. The rehabilitation of the old systems is just buying some time and may be costly as the necessary investments are delayed and potentially higher profit margins are foregone for another number of years.

Under the conditions prevailing at TAC the installation of medium-pressure power systems (of 20-45 bar) may be an attractive investment. This may particularly hold true since the entire energy plant at this factory needs complete replacement. However, this investment in improved efficiency power plant should go along with a much larger package addressing the total of operations. The sustainable financing of the complete investment needs a thorough evaluation.

Any future research on the issue of increased electricity generation should be guided by two principles:

- A proper Base Case of a smoothly operated estate and factory should be defined and assumed in the evaluation of alternatives (This implies integral overhaul of the factory and of the cane production and provision system);
- A realistic assessment of the agronomic potential (volume of cane to be crushed) should be assumed.

UNITS

Length	m	metre
Area	m^2	square metre
Volume	m^3	cubic metre
Weight	g	gramme
	kg	kilogramme
	kg_x	kilogramme of matter at a reference moisture content (MC_w) of x $\%_m$
	t	tonne (1000 kg)
	t_x	tonne of matter at a reference moisture content (MC_w) of x $\%_m$
Time	a	year (365 days)
	d	day (24 hours)
	h	hour
	s	second
Energy	J	Joule
	Wh	Weather (= 3600 J)
Power	W	Watt (= J/s)
Pressure	bar(a)	bar absolute
	bar(g)	bar gauge
Temperature	°C	degree Celsius
	K	degree Kelvin (°C + 273.15)

Subscripts

d	dry basis
DAF	dry, ash free basis
w	wet basis
m	with %: mass percent
v	with %: volume percent

Prefixes

m	mill (10^{-3})
c	cent (10^{-2})
k	kilo (10^3)
M	mega (10^6)
G	gaga (10^9)
T	term (10^{12})
P	pea (10^{15})

Appendix 1.1 TAC - Bagasse electricity potential

Technical specifications			
General			
Fibre content	16.5%	%d of cane	
Moisture content of bagasse	50.0%	%w	
Calorific values of bagasse			
NCVw	8 033	kJ/kg	at MCw = 50%
GCVw	9 910	kJ/kg	at MCw = 50%

Factory characterization, assuming rehabilitated factory and cane transport system:

Crushing rate	100	t cane/milling h
Bagasse production rate	33	t50 bagasse/milling h
Cane production capacity	450 000	t cane/a
Annual bagasse production	148 500	t50 bagasse/a
On milling days		
Planned daily factory overhaul	2	calendar h/24 calendar h
Hence: load factor on milling day	92%	
On average day of crushing season		
Planned seasonal factory overhaul		
Monthly	48	calendar h/milling month
Hence availability per month	28	milling d/milling month
Daily	2	calendar h/24 calendar h
Hence availability per month	625	milling h/milling month
Hence load factor on crushing season	86%	

Operations characterization, assuming rehabilitated factory and cane transport system:

Potential sustainable cane input	450 000	t cane/a
Duration of crushing season	219	calendar day/a
=	7.20	calendar month/a
=	5 255	calendar h/a
Compare data given by TAC for non-rehabilitated situation		
Duration of crushing season	274	calendar day/a
=	9.00	calendar month/a
Bagasse production		
On actual milling hours	33	t50 bagasse/milling h
Average during milling days	30	t50 bagasse/milling h
=	726	t50 bagasse/milling day
Average during crushing season	28	t50 bagasse/calendar h of crushing season
=	678	t50 bagasse/calendar day of crushing season
=	148 500	t50 bagasse/crushing season
=	148 500	t50 bagasse/a

Energy consumption, assuming rehabilitated factory

Process steam	0.550	t steam/t cane
Power		
Electricity	12.5	kWh/t cane
Mill drives	210	kg steam/ t cane
=	10	kWh/t cane
Offices + Domestic	X	
Hence total power demand (kW)		
Factory	2 208	
Offices + Domestic	50	
Total	2 300	
Steam capacity (based on process heat requirement)	55	t steam/h

Option	**Base case**	**Alternative**
	12.5 barg	45 barg
Power utilization		
Factory, offices and domestic	2.30	2.30 MW
Available for irrigation	-0.08	2.89 MW
Quantity of electricity for irrigation and/ or grid	-368	12 985 MWh/a
Based on:		
Load factor on crushing season	86%	86%
Duration of crushing season	5 255	5 255 calendar h/a
Alternative calculation		
Electricity produced (kWh/a)	9 982	23 335
Existing use (factory + domestic)	9 982	9 982
Surplus	0	13 354

Investments

Investments	**Base case**	**Alternative**
New boiler, characteristics:	Yes	Yes
Capacity (t steam/h)	60	60
P (barg)	12.5	45.0
T (oC)	250	370
New power turbine	Yes	Yes
Capacity (MW)	2.5	6.0
New mill turbines (steam)	Yes	Yes
Capacity (MW)	1.6	1.6
New mill drives (electrical)	No	No
Capacity (MW)	-	-
Switch gear	as required	as required
Cost (USD) (installed)	7 308 000	13 680 000
Incremental cost (USD)	-	6 372 000

Appendix 1.2 TPC- steam calculations

	TPC 12.5 barg system	TPC 45 barg system
Feed water		
In		
P (bara)	1	1
T (oC)	80	80
h (kJ/kg)	334.958	334.958
Out		
P (bara)	13.50	46.00
T (oC)	80	80
h (kJ/kg)	335.9505	338.5318
delta h	0.9925	3.5738
Boiler		
Boiler efficiency (on NCV)	81%	81%
Inlet		
h (kJ/kg)	335.9505	338.5318
Outlet		
h (kJ/kg)	2929.544	3131.912
delta h	2593.5935	2793.3802
Turbine		
Inlet		
P (bara)	13.50	46.00
T (oC)	250	370
h (kJ/kg)	2929.544	3131.912
s (kJ/(kg.oC))	6.767485	6.585597
Outlet isentropic		
P (bara)	2	2
T (oC)	120.2309	120.2309
X		
h (kJ/kg)	2564.936	2493.386
Delta hs	364.608	638.526
Turbine efficiency (isentropic)	65%	65%
Outlet		
P (bara)	2	2
T (oC)	120.2309	125.2329
X	99.38%	100.00%
h (kJ/kg)	2692.5488	2716.8701
Turbine steam consumption (kg/kWh)	15.19	8.67

Overall efficiency (NCV) = Cycle efficiency * Boiler efficiency (NCV)* Mechanical turbine efficiency * Generator efficiency * Parasitic efficiency

Cycle efficiency = dh turbine/(dh boiler + dh f-w pump - dh piping)

Cycle efficiency	9.1%	14.8%
dh turbine	236.9952	415.0419
dh f-w pump	0.9925	3.5738
dh boiler	2 593.5935	2 793.3802
dh piping	-1	-1
	6.6%	10.6%
Overall efficiency		
Cycle efficiency	9%	15%
Boiler efficiency (on NCV)	81%	81%
Mechanical turbine efficiency	100%	100%
Generator efficiency	98%	98%
Parasitic efficiency	90%	90%
Calculation of available power		
Mill turbines		
No.	4	4
Aggregate installed power (kW)	1600	1600
Used power (kW)	1200	1200
Steam consumption (kg/kWh)	22	13
Turbine efficiency	45%	45%
Steam consumption (t/h)	26	15
	60	60
Utilized boiler capacity (t/h)		
Used by mill turbines (t/h)	26	15
Remaining for electricity (t/h)	34	45
This to be converted at efficiency	6.6%	10.6%
= steam consumption (kg/kWh)	15.2	8.7
Momentary power availability (MW)	2.22	5.19
This power for Factory, offices and domestic	2.30	2.30
Available for irrigation	-0.08	2.89

Appendix 2 Cash-FLOW schedules

Financial feasibility cogeneration sugar factory TAC

Additional electricity Alt. 1 (MWh/a)	13 354

it is assumed that this electricity is utilized either by transferring to TANESCO, either by own irrigation system

Depreciation rate	15%
Interest on half of the incremental investment	12%
depreciation: not incorporated in cash flow	
maintenance and spares: 2.5% yearly on incr. inv.	
Savings/revenues on additional electricity (US$/kWh)	0.1

Accepting the base case and calculating only incremental benefits and costs, the following results are obtained:

Project duration (= technical lifetime) (a)

Capital
Capital cost (annuity) (USD/a)
Incremental interest cost (USD/a)
Incremental operating cost (USD/a)
Labour
Maintenance (2,5% of investment)
Total incremental annualized cost (USD/a)
Annual savings Tanesco bill/sales to grid (USD/a)
Specific cost of additional electricity (USD/kWh)

	15	25	30
	Base Case	Alternative	Incremental
	7 308 000	1	6 372 000
	1 089 721	13 680 000	970 457
	382 320	985 745	
	159 300		
Cash flow of costs/benefits in 1000 USD	0		
	159 300		
	1 631 341		
	1 335 350	1 527 365	1 512 077
	0. 023	0.015	0.014

Alternative 1

	0	1	2	3	4	5
cost	6 372	542	542	542	542	542
gross ben		1 335	1 335	1 335	1 335	1 335
net benefit	-6 372	794	794	794	794	794
ICR	9%	15 years				
ICR	12%	25 years				
ICR	12%	30 Years				

Comparison present situation and base case:

incremental		1	2	3	4	5
cost	7 308	621	621	621	621	621
fuel saving		500	500	500	500	500
lower costs		250	250	250	250	250
more sugar		1 400	1 400	1 400	1 400	1 400
higher quality		200	200	200	200	200
gross ben		2 350	2 350	2 350	2 350	2 350

net benefit	-7 308	1 729	1 729	1 729	1 729	1 729
ICR	23%	15 years				
ICR	24%	25 years				
ICR	24%	30 years				

Note: cost includes maintenance and interest

For further evaluation of Alternative 1:

Project duration (=technical lifetime) (a)	25					
	0	1	2	3	4	5
cost	6 372	542	542	542	542	542
gross ben	0	1 335	1 335	1 335	1 335	1 335
net benefit	-6 372	794	794	794	794	794
ICR	11.7%					

Sensitivity to investment

Variation	Incremental investment	ICR	Variation	Electricity price	ICR
100%	6 372 000	11.7%	100%	0.1	11.7%
70%	4 460 400	21.3%	70%	0.07	3.7%
80%	5 097 600	17.4%	80%	0.08	6.6%
90%	5 734 800	14.3%	90%	0.09	9.2%
100%	6 372 000	11.7%	100%	0.1	11.7%
110%	7 009 200	9.4%	110%	0.11	14.0%
120%	7 646 400	7.5%	120%	0.12	16.3%

APPENDIX 11

Comparision of findings from environment audit for TPC, Kilombero I and II and Mtibwa

Statistics Average 1987-1997	**TPC**	**Kilombera I and II**	**Mtibwa**
total cane production from estate	369 290 tons	394 890 tons	179 060 tons
area cultivated	6 500 ha	6 800 ha	3 810 ha
area harvested	5 065 ha	5 670 ha	2 997 ha
yield area cultivated	57.0 t/ha	58.1 t/ha	47.0 t/ha
yield area harvested	72.9 t/ha	69.9 t/ha	59.7 t/ha
% area not harvested	22%	17%	21%

Issues	**TPC**	**Kilombera I**	**Kilombera II**	**Mtibwa**
Agricultural production estate				
Water resources				
Availability				
• surface water	Declining due to upstream activities	Adequate	Adequate	Short supplies
• ground water	Ample	Not required	Not required	Exploration needed
Quality				
• surface water	Good, except at one off take	Good	Good	Good
• ground water	Good	-	-	Not known
Soil resources				
Soil properties origin	Volcanic/alluvial	Alluvial	Alluvial	Alluvial
• depth and texture	Deep and shallow loams and sands	Deep loams and clays	Deep loams and clays, some sandy soils	Soil texture highly variable over short distance
• salinity	Present	Absent	Absent	Present
• suitability for cane	Moderately to poor	Loams very, clays moderately to poor	Loams very, clays moderately to poor	Moderately to poor
• weatherable	Present	Present	Present	Present
• mineralssoil pH	5.5-8.5	5-8	5-8	5.5-7.5
• aluminium toxicity	No	No	No	No

Issues	TPC	Kilombera I	Kilombera II	Mtibwa
Fertilization practices				
• potassium (K)	Not required	Not required	Not required	Not required
• phosporus (P)	No response to applications	No response to applications	No response to applications	No response to applications
• K and P applied	No	No	No	No
• nitrogen (N) applications	130 kg/ha	60-140 kg/ha	60/140 kg/ha	40-80 kg/ha
• adequacy N applications	Variable rates according to crop stage would increase efficiency	Adequate	Adequate	Adequate
• nutrient mining	No problem at present	No problem at present	No problem at present	No problem at present
• micro nutrient deficiencies	Occasionally B, Mo and Zn	No	No	Zn (?)
Agro-chemicals				
Weed killers				
• products used	Gesapax combi,Gesapax H, Roundup (occasionally), 2-4D, and Dimapax	2-4D, Gesapax combi, Gesapax H	2-4D, Gesapax combi, Gesapax H	2-4D, Gesapax combi
• applied quantities	3-4 l/ha, acceptable	4-8 l/ha, acceptable	4-8 l/ha acceptable	4-8 l/ha acceptable
• mode of application	Knapsack sprayer, no protective clothing or masks used	Knapsack sprayer, no protective clothing or masks used	Knapsack sprayer, no protective clothing or masks used	Knapsack sprayer, no protective clothing or masks used
Insecticides				
• pest and applied products	White grub: EDB, Miral and Suscon Blue	-	-	White grub: biological control pursued
	-	-	-	White scales: biological control pursued
• applied quantities	EDB 30-70l/ ha, miral 1-5 kg/ha, Susscon blue 1-3 kg/ha			
• observations	large quantities applied, EDB banned worldwide. EDB kills everything. White grub not under control at all	-	-	-

Issues	**TPC**	**Kilombera I**	**Kilombera II**	**Mtibwa**
Fungicides				
• pest and applied products	-	Smut: Bayleton and Benlate	Smut: Bayleton and Benlate	Smut: no chemicals used
• applied quantities		Small for dipping plant material	Small for dipping plant material	
National Quail Control Program	Spraying by aeroplanes. Dead birds collected by children			
Irrigation and Drainage practices				
• % area irrigated	100% gravity/ overhead deferred	78% overhead minor	44% overhead minor	45% overhead
• system	Gravity/overhead	Overhead	Overhead	Overhead
• problems	Deferred maintenance power shortages	Minor	Minor	Deferred maintenance power shortages
• scope to optimise water use efficiency	Much	Likely	Likely	Much
• mining of water resources	Not at present	Not at present	Not at present	Not at present
Drainage				
• natural drainage or salinity problems	Soils contains salt	Large portion poorly drained clay soils. Not under cane.	-	-
• waterlogging and salinization	Few hundreds of ha under cane. Other areas abandoned long time ago	Hardly, except the above mentioned area	Hardly	Few hundreds of ha abandoned
Outgrowers				
• present	No	Yes	Yes	Yes
• use fertilizers	-	N occasionally, no P or K	N occasionally, no P or K	25-50 kg N/ha, no P or K
• agro-chemicals	-	Not applied	Not applied	Small quantities of weed killer 2-4D and Gesapax Compi

Issues	TPC	Kilombera I	Kilombera II	Mtibwa
Indirect effects of plantation				
• Use of fuelwood	Estate is self-suff icient, 5000 ha covered by forest	Deforestation occurs due to high land pressure	See K1	Deforestation occurs due to high l and pressure
• High pollution density	-	Nearby hills well protected occurence of epidemics (cholera, TPC) in unplanned settlements	See K1	Nearby hills encroached
• River management	-	Responsibilities unclear river bank erosion	See K1	-
Processing				
Utilization of fuel				
• diesel oil quantities used	Unknown	Unknown	Unknown	Unknown
• furnace oil quantities used	530,000 l (95/96) 800,000 l (96/97) 1,900,000 l (97/98*) * 7 months	unknown 1,700,000 l (96/97*) unknown * for K1 & K2	See K1	Unknown 60,000 l (96/97) Unknown
• fuel wood quantities used	Few hundred cubic meters	2,000 to 2,500 tons/year K1+K2	See K1	Few hundred cubic meters fuelwood & charcoal
• acidification	Negligible	Negligible	Negligible	Negligible
• soil pollution	Not considered	Lillte oil spillage, concentrated	No spillage	No spillage
• global warming	Negligible	Negligible	Negligible	Negligible
Water & sanitation				
• filtercake/mud	Applied in foodcrops and gardens	6,250-7,500 ton/a is flushed into the river, causing biolo-gical pollution	Applied in gardens	Applied at cane fields and gardens
• effluent water	Collected in natural pond and re-used for irrigation	Re-used for irriga-tion	Re-used for irriga-tion	Saline high BOD water disappears downstream in the bush (about 1 cusec)
• smoke	Affects possibly health situation factory workers	Affects possibly health situation factory workers	Affects possibly health situation factory workers	Affects possibly health situation factory workers
• furnace/boiler ash	Used for roas construction	Used for road construction	Used for road construction	Used for ronad construction
• excess bagasse	None	15,000 to 20,000 ton/a, incinerated safely	20,000 ton/a stored at dump: 100,000 ton causing fire hazards, smell	15,000 ton/a, used for the start up in new season

Issues	TPC	Kilombera I	Kilombera II	Mtibwa
Living conditions and occupational health				
Water & sanitation				
• drinking water	Ground water, good quality, availability not always guaranteed	Surface water, qual. biologically polluted treated with Cl, part drinking water scheme	Surface water, qual. biologically polluted treated with Cl	Surface water, qual. biologically polluted treated with Cl
• sanitation & sewerage	Insufficient, poor quality, heavy rains causes flooding	Fairly good	Fairly good, in section C of K2 poor	Insufficient, poor quality, heavy rrains causes flooding
• waste disposal	Waste is stored, no problem	Waste is stored near Ruaha river, no problem	Waste is stored near Ruaha river, no problem	Waste is stored, no problem
Water borne diseases				
• malaria	Most common	Most common	See K1	Most common
• bilharzia	Common	Common, not due to cane prod. but due to rice production	See K1	Not common
• worm infection	Common	Common	See K1	Not reported
• diarrhoea	Common	Common	See K1	Common
• cholera	Non-existent	Common	See K1	Common
Other health problems				
• respiratory problems	Common under factory workers	Common due to inhalation of agro-chemicals & contact with sulphur	Common due to inhalation of agro-chemicals	Common due to inhalation of agro-chemicals