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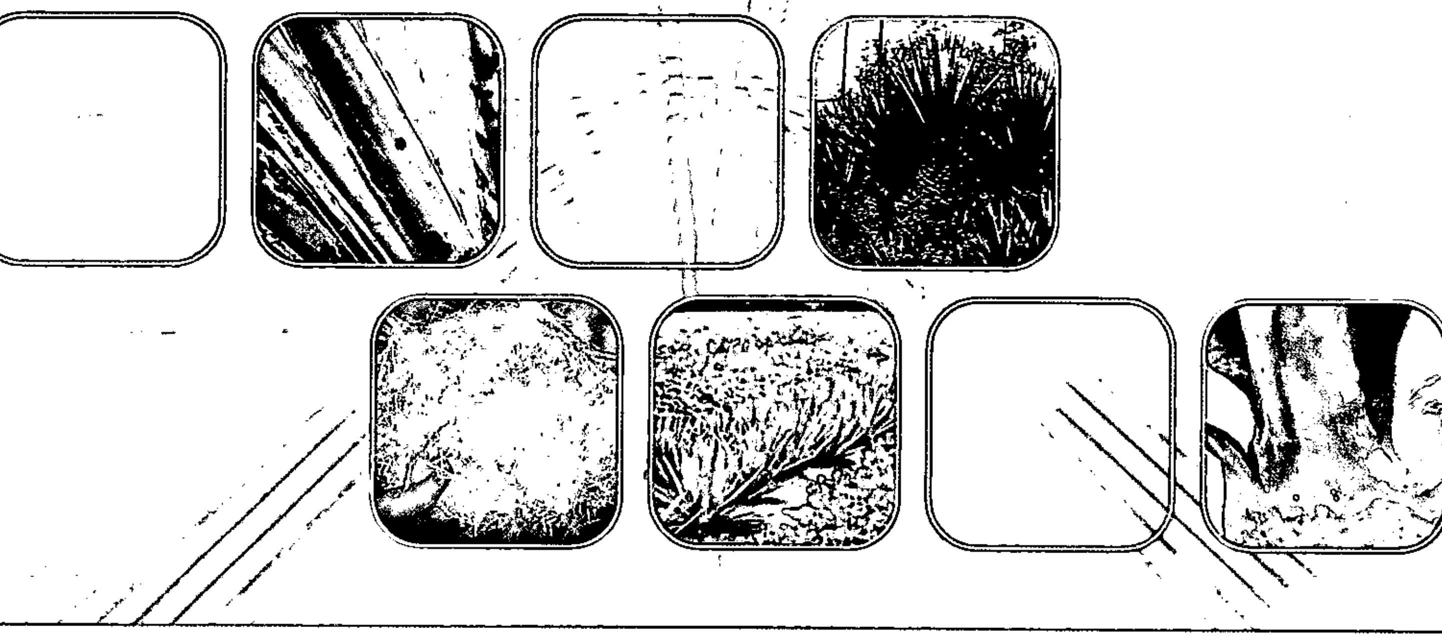
UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

Common Fund for Commodities
Project CFC/FIGHF/07

Product and market development of sisal and henequen



Improved Flume Tow Recovery System

Project completion report/Addendum B.1

Kenya and Tanzania, January 1997 – June 2004

COMMON FUND FOR COMMODITIES

Product and market development of sisal and henequen

Project completion report, Addendum B.1

Improved Flume Tow Recovery System

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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

Vienna, 2006

Project Completion Report preparation: National and international experts and consultants involved with the project, with contributions and support from the national teams.
General guidance and consolidation: Ms. Mayra. Sanchez Osuna, Project Manager.
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Common Fund for Commodities (CFC)
Stadhouderskade 55
1072 AB Amsterdam
P.O. Box 74656
1070 BR Amsterdam
The Netherlands

Telephone (++31 20) 575 4949
Fax (++31 20) 676 0231
e-mail: managing.director@common-fund.org
website: www.common-fund.org

United Nations Industrial Development Organization
Vienna International Centre
P.O. Box 300
A-1400 Vienna
Austria

Telephone (++43 1) 26026 3945
Fax (++43 1) 26026 6819
e-mail: M.Sanchez-Osuna@unido.org
website: www.unido.org

Food and Agriculture Organization of the United Nations
Commodities and Trade Division
Via delle Terme di Caracalla
00100 Rome
Italy

Telephone (++39 06) 5705 4201
Fax (++39 06) 5705 4495
e-mail: esc-registry@fao.org
website: www.fao.org

Project Completion Report

Sub-component B.1
"Improved Flume Tow Recovery System"

CONTENT

Abbreviations and acronyms

CFC	Common Fund for Commodities
KES	Kenyan Shilling
KSB	Kenya Sisal Board
PPM	Parts per million
TZS	Tanzanian Shilling
UNIDO	United Nations Industrial Development Organization

I. Project Sub-component Summary

1. Title: Improved flume tow recovery system
2. Location: Kenya: Vipingo Estate - Tanzania: Kwaraguru Estate
3. Starting Date: January 1997
4. Completion Date: June 2004
5. Sub component external financing – excluding counterpart contribution

Total Subcomponent Cost:	US$ 98,187
Of which:	
CFC Financing:	US$ 46,175 (Tanzania)
UNIDO:	US$ 23,900 (Kenya)
	US$ 28,112 (Tanzania)

II. Background and context in which the sub-component was conceived

II.1 Background and context

Sisal line fibre is found in fleshy leaf tissue associated with the vascular bundles. Separation of these fibres from the parenchyma involves mechanical crushing and scraping. There are basically two main types of line fibre extraction equipment: fixed and mobile decorticators. The majority of sisal estates in East Africa use the stationary decorticator normally known as "corona". The basic defibering units are two drums 100 and 150 cm diameter with blunt beater blades attached to them. Jets of water are directed into the fibre as it passes through each drum to wash the fibre and carry away the waste. This waste contains more than 94% of the materials in the green leaf as well as the water introduced in the drums. It also contains short fibre known as flume tow. The flume tow is not efficiently recovered, as demand is not particularly high in the cordage and other industries. Most of it is dumped in the land together with the other components of the decorticator waste.

To continue to improve the profitability of the sisal industry, the project proposed to recover and commercialize the short fibre after decortication. The development of an efficient system for the recovery of the flume tow was considered necessary and the sub-component B.1 was conceived to address this issue.

II.2 Objectives, outputs and targeted beneficiaries

The broad objective of this sub-component is to recover the optimum quantity of flume tow and to treat it appropriately to meet quality standard for pulping. Pulping the flume tow was actually not considered and the economic analysis related to the flume tow recovery was addressed mainly to the sale of the flume tow as such. The project appraisal report envisaged the design, installation and operation of two recovery systems: one in a sisal estate in Kenya and another in an estate in Tanzania.

During project implementation in Tanzania it was decided that the future biogas plant should be fed with the flume tow waste and therefore the sub-component's objective was broadened to include the separation of the mucilage from the rest of the biomass. The mucilage was to be used for fermentation in the biogas plant.

As sub-component outputs, two operational flume tow recovery plants are installed and the relevant final reports are available.

The sub-component targeted beneficiaries were the various stakeholders involved in sisal and in particular:

- Estates involved in sisal growing and processing leaves into fibre, including smallholders;
- Pulp and paper mills using sisal fibre.

III. Implementation and results achieved

III.1 Preliminary design considerations

During the process of sisal fibre extraction using conventional decorticators, about 15% of the fibre extractable is lost through the flume tow channel, passing out with the effluent.

It is possible to recover most of the solids from the decortication effluents. One possible method is by trapping the discharge from the drum ends and conveying them to a suitably designed squeezing device to remove excess water. The squeezed fibre is then passed through a rotating cylindrical shaker screen, so that leaf tissues are separated from the fibre leaving the fibre free to be collected at the lower end of the screen. The flume tow is then sun dried on the drying ground. The fibre is baled using the standard baling press used on the estate for baling line fibre.

It is desirable that the recovery system could be able to use all the discharge coming from the decorticator in a standard shift. Considerations are also made for the system to be able to handle the volumes of materials involved at the lowest possible cost. Other important factors are as follows:

- **Serviceability**: considering that waste flowing from the decorticator into the system is not steady, the system has to be flexible to adapt.
- **Maintenance**: the design has to be as simple as possible, using standard machine elements and locally available materials.
- **Ease of operation**: the system has to be operator-friendly and should require a minimum of training and education to be operated.

III.2 Implementation in Kenya

The sisal estate Rea-Vipingo Plantations Ltd. was contracted to design, install and operate a flume tow recovery system.

The design of the plant had to be adapted to the already available corona layout and building facilities. It includes the following basic equipment (see drawings in Annex 1A and 1B):

1. <u>Conveyors</u> to lift the sisal waste material from the corona small drum to the flume tow squeezer. The small drum has the function of decorticating the "butt" end of the sisal leaf. This drum decorticates approximately 41 cm of leaf where substantially a higher portion of the fibre on the leaf is situated.

2. <u>Double roller squeezer</u> spring tensioned. The spring tension is adjustable to allow the operator to either increase or reduce the pressure exerted on the sisal waste material to ensure complete removal of excess water from the sisal waste material.

3. <u>Rotary screen</u> to remove leaf tissues and short fibre from the tow. The inclination angle of the screen is adjustable to allow variation in the retention

time of the tow in the screen. Keeping the tow longer in the screen (horizontal position) can enhance cleaning but slows the output. Tilting the screen into acute angle reduces cleaning capability but increases the speed and output.

The flume tow obtained as final product from the screen is cleaned manually, air dried and processed in a carding machine and baled. Carding and baling operations are carried out using equipment available at the contractor's estate.

The implementation of the contract was monitored and supervised by the Kenya Sisal Board (KSB), project counterpart in Kenya.

III.3 Implementation in Tanzania

The recovery system was originally designed to recover the flume tow produced by the dry decortication system and from the big and small drums of the corona at Hale estate. To be able to produce clean fibre its design included a perforated belt inlet conveyor and water sprayers to wash the flume tow fibre before the first squeezing roller.

A subcontract was awarded to Katani Ltd. in August 1999 to design and build a flume tow recovery system and it was expected to be completed in two years time. Mr. Gilead Kissaka, mechanical engineer, and Mr. E. Swai, the engineer then in charge of Ngombezi Central Workshop owned by Katani Ltd. visited Rea-Vipingo Estate and Kilifi plantation in Mombasa. They evaluated the two flume tow recovery systems and, upon their return in Tanga, they prepared the designs for a flume tow recovery system suitable for sisal dry decortication.

Due to strategic reasons, in 2002 it was decided to change the location of the system. The new location was decided to be Kwaraguru estate, owned by Amboni Ltd., where the construction of the biogas plant was planned. The "new objectives" of flume tow recovery system were to use not only to recover the flume tow, but also to "treat" the sisal fibre decortication waste by removing the short fibres before the "waste material' is used as raw material for the biogas plant.

Kwaraguru estate produces fibre using wet decortication processes. The waste generated has a solid content between 1 - 1,5% that is much lower than the solid content (4 - 4.5%) of the waste generated in the Hale dry decortication. The changes in the installation site and from dry to wet decortication technology required some changes in the original design of the flume tow recovery plant.

The collection of the diluted wet decortication waste from the big and small drum using belt conveyors was no longer required and an inclined elevator was incorporated as an effective way of picking sisal waste from the flume channel. The above changes called for the installation of the flume tow plant alongside the flume tow channel. To do this, diversion of the flume channel to an open collection chamber, where the flume tow with mucilage and part of the liquid waste would be picked by the elevator and taken to the squeezer for forward processing, had to be constructed. The quality of the flume tow recovered in the modified system was expected to be the same as in the original system to meet the original objective of recovering clean fibre to meet quality standards for pulping.

In October 2003 the exact location of the flume tow recovery plant was decided following the mission of the international expert on biogas generation from sisal waste. In November 2003 the cage and squeezer were moved to Kwaraguru Estate after a Memorandum of Understanding was signed between Amboni Ltd. and Katani Ltd. The contract for the construction of the flume tow system was modified accordingly and the system was built. Unfortunately at the time when testing of the equipment and the techno-economic study was due, Kwaraguru Estate was experiencing a critical water shortage that resulted in the suspension of decortication. This caused an additional delay in project implementation.

III.3.1 System description

The flume tow recovery system is designed to operate continuously under the condition that feeding at the corona is approximately steady and that there are sufficient quantities of water flow, to transport the flume tow from the decorticator to the collection chamber, from where it can be picked by the elevator fingers to the squeezer. Under those conditions, the discharge being carried to the elevator approximates a uniform or steady flow.

On the other hand, if there is insufficient water to transport the discharge, then there is an accumulation of the waste in the channel until enough water has accumulated to be able to push the waste to the chamber and consequently to the elevator. If that happens, the large load picked by elevator fingers causes undue strain to the elevator. This reduces the efficiency of the elevator.

The main elements of the system (see Annexes 2A, 2B and 2C) are as follows:

1. Elevator to collect sisal waste from the collection chamber to the squeezer. It is locally fabricated at the Katani central workshop using mild steel sheets, channel sections, angle irons, bearings, round bars and welding electrodes.

2. Single stage roller squeezer consists of two rollers that are spring loaded, to accommodate for uneven amounts or clumps of waste to be squeezed. Load/tension on the springs is adjustable to allow for increased pressure or reduced pressure on the material being squeezed for the desired effect.

3. Cage (rotary screen shaker): it is a revolving cylindrical cage that separates leaf tissue and short fibre. The tissues drop out and the fibre is collected at the output end. Retaining the tow in the cage longer, can enhance cleaning but slows the output per unit time. Increasing the cage retention time or reducing it, is done by a screw adjustment mechanism that increases or decreases the inclination angle of the cage.

The flume tow recovery process flow diagram is attached as Annex 3.

III.4 Data collection

III.4.1 The experiments conducted in Kenya

One of the activities conducted in Kenya consisted in the evaluation of the number of fibres in the different sections of the leaf: butt end (0-50 cm), mid section (50-80 cm) and tip end (80-100 cm) of sisal leaf. Sisal leaves 100 cm long from 5-year-old plant previously cut four times were used in the experiment and the data collected was as follows:

Section	No. of fibre (range)
a. Butt end	720-953
b. Mid section	352-539
c. Tip end	147-261

It should be noted that the flume tow was recovered from the small drum of the corona; this drum has the function of decorticating the "butt" of the sisal leaf, approximately 41 cm of the leaf itself where substantially a higher portion of the fibre is located.

Other data collected refer to the production potential, as highlighted in the paragraphs below.

Production per hour: results show that the production of flume tow ranged from 28 Kg/hour to 47 Kg/hour. Attaining a constant production output is effected by too many factors outside of the function of the flume tow recovery plant. But the most prominent factor is the low waste output from the corona.

While most estates have waste outputs of around 15 to 20%, Rea-Vipingo only has a waste output of 10 to 12%. This is due to the fact that Rea-Vipingo sisal leaf is generally shorter in length then up-country sisal estates. This is due to soil and fertilization factors.

200 bundles output tests: scope of the test was to determine the influence of leaf length and of cutting cycle in the line fibre and in the flume tow recovered. The results achieved are summarized in the table below. It should be noted that shorter, younger leaf produces higher losses, hence more flume tow.

Table 1. 200 bundles output tests

			INPUT				OUTPUT			
Test No	Field No.	Block No	Bundles	Average length of leaves (cms)	Cycle Cut No.	Leaves weight (Kg.)	Line fibre weight (Kg.)	Flume tow weight (Kg.)	Line fibre %	Flume tow %
1	M9	912	200	100	8th	1762	108.36	13	6.15	0.74
2	N15	931	200	80	5th	1642	99.34	16	6.05	1
3	O7	973	200	70	3rd	1548	53	18	3.42	1.16
4	Q17	981	200	80	1st	1180	27	18	2.29	2

1275 bundles tests (one 13.6 tonne trailer load): scope of the test was to determine the line fibre and flume tow recovered from 100 cm average length leaves from the seventh cut cycle. Two tests were conducted using 1275 bundles each; the results achieved are summarized in the table below. All 100 cm leaves showed an output of between 0.4% to 0.45% flume tow. This is equivalent to 459 kg to 520 kg of flume tow production per shift. This is very dependent upon leaf source, age, length and condition of the corona decortication process.

Table 2. 1275 bundles output tests

			INPUT				OUTPUT			
Test No	Field No.	Block No	Bundles	Average length of leaves (cms)	Cycle cut No.	Leaves weight (Kg.)	Line fibre weight (Kg.)	Flume tow weight (Kg.)	Line fibre %	Flume tow %
5	P22	902	1275	100	7th	11475	695.2	45.9	6.05	0.40
6	O22	901	1275	100	7th	115387	669.2	52	5.8	0.45

- Full shift production runs: scope of the test was to determine the production capacity of carded flume tow. 38 full shift production runs were conducted from 28 August to 12 October 2000, the duration of the shifts varied from 10h50 min to 14h40 min. One shift is an average of 13,330 bundles sisal leaves. The average production capacity of carded flume tow: 39.51± 4.73 kg/hour (complete data is included in Annex 4).

As part of the trials the main chemical and nutritional characteristics of sisal waste (decorticator waste) were analyzed. The results are included in Annex 5.

III.4.1.1 The influence of carding on flume tow quality

Flume tow usually has a good colour when it leaves the recovery plant. However, after a period of a day's drying, it changes into a dirty brown colour. This is due to fermentation of the acid remaining on the flume tow. The flume tow also remains stiff and congealed after drying.

The carding machine is basically a sisal-brushing machine, but instead of the metal beater bars it is fitted with pin sharp spikes fixed to the periphery of a horizontal cylinder. The cylinder is 0.5m in diameter and 1.5m in length. There are six rows of spikes, each 1-inch high and the drum evolves at 100 rpm (or 5 m/s). The flume tow is combed gently freeing knots and softening the texture of the fibre.

Carding not only improves the texture, the appearance is also greatly enhanced turning the colour into a softer brown. During carding any dried tissue adhering to the fibres is removed.

It was concluded that carding is essential in attaining any reasonable grade from 1 to 3. Carding losses were measured and determined to be 5% of each consignment.

III.4.2 The experiments conducted in Tanzania

Production per hour: data were collected by measuring the weight of sun-dried quantities of flume tow collected at the cage in each one hour. The experiment was set so that only weights that could be easily handled or lifted were dealt with.

Timed batch samples were collected at time intervals, each batch being a 1-hour weight sample and 42 timed samples were collected in a 7-day test giving about six batches per day. Samples were collected at the cage exit, labelled and spread in the sun to dry. On average, in 1 hour, 45.44 Kg of dry flume tow were produced, this value is close to the maximum obtained at Rea-Vipingo.

Results are shown in Annex 6.

Experiments were conducted also to evaluate the efficiency of the decorticator, that proved to be very low because of worn-out saddle pieces, knives and drums, which had to be reconditioned. As mentioned when discussing the results obtained in Kenya (section III.4.1) most estates have waste outputs of around 15 to 20%, while for Kwaraguru wastage was as high as 45%. These results are included in Annex 6 as well.

Production per 100 Kg input: instead of working on the bases of bundles, as done at Rea-Vipingo, at Kwaraguru tests were performed using 100 Kg of leaves as input to the decorticator to determine the yield of line fibre and flume tow respectively. The results are included in the table below.

Table 3. 100 Kg output tests

	INPUT				OUTPUT			
Test No.	**Field**	**Leaf weight (kg)**	**Average leaf length (cm)**	**Cycle (Cut No.)**	**Dry line fibre weight (kg)**	**Dry flume tow weight (kg)**	**Line fibre %**	**Flume tow %**
1	1998/99	100	125	2nd	3.5	0.7	3.5	0.7
2	1998/99	100	115	3rd	2.3	1.5	2.3	1.5
3	1995/96	100	98	8th	5.10	1.0	5.10	1.0
4	1995/96	100	100	8th	4.8	0.9	4.8	0.9

Tests number 1 and 2 were carried out before perfecting the decorticator. After these two tests some of the decorticator beater knives were replaced and some were reconditioned following breakdown of the beater knives. Tests number 3 and 4 were carried out at higher decorticator efficiency hence low fibre waste.

The same tests conducted at Rea-Vipingo gave lower yields of flume tow indicating better mechanical condition for the decorticator at Vipingo than the one at Kwaraguru. This resulted in minimum waste going out with the effluent and hence much less flume tow recovered.

Results for 100 kg can be extrapolated for any weight of sisal of leaves as the input to the decorticator.

IV. Lessons learned

IV.1 Recovering flume tow: an economic evaluation

IV.1.1 Kenya

According to the economic evaluation that was done in Kenya, drying and handling labour costs and electricity costs represent approximately 80% of the costs of production. Three different approaches were considered while trying to reduce costs (Annex 7). The lowest production cost (cost to run the recovery plant, dry the flume tow and prepare it for sale) achieved was KES 12.85 per kilogram. This was not acceptable as the market price at the time of the project (2001) was about US$ 200 per tonne, or approximately KES 14 per kilogram.

The manufacturing and assembling costs, including taxes and labour, totaled US$ 25,978.

IV.1.2 Tanzania

The flume tow recovery plant was test run and all the components constituting the plant were closely inspected for performance. Designed speeds were met. Test data were collected on flume tow recovery. An average of 45.44kg per hour of sun dried flume tow could be recovered giving about 454 kg per shift. This cost about TZS 37,527 per tonne, collected and ready to sell (no carding was performed at Kwaraguru).

A current market price of about TZS 50,000 per tonne gives a margin of profit of TZS 12,473 per tonne.

The manufacturing and assembling costs, including taxes and labour, totaled US$ 23,020.

Table 4. Flume tow production costs in Kenya and in Tanzania

	KWARAGURU 2004		REA VIPINGO 2001	
	TZS/kg	US$/ tonne	US$/ tonne	KES /kg
Drying and handling labour	11.86	11.29	67.33	5.05
Recovery plant labour	12.56	11.96	13.33	1.00
Carding machine labour	none	none	13.33	1.00
Baling press labour	3.56	3.39	3.33	0.25
Electricity costs	5.16	4.91	68.00	5.10
Baling materials cost	4.40	4.19	6.00	0.45
TOTAL COST	**35.42**	**35.74**	**171.32**	**12.85**
Price US$/tonne ex-factory		**47.62**	**200**	
Net profit US$/tonne ex-factory		**11.88**	**28.68**	

Note: All dollar conversions used are as at the end of 2004:
1 USD = 1050 TZS = 75 KES

IV.2 Development lessons

The required system as per specifications was designed, fabricated, installed, and tested at the two estates in Kenya and in Tanzania. The implementation of sub-component B.1 activities followed the Appraisal Report, with the exception that the flume tow was not evaluated for pulping. The dirty brown colour of the flume tow and the parenchyma content makes the fibre not suitable for pulping, especially in Tanzania where carding was not done and the hammer mill proved to deliver much better fibre more efficiently. Other comments in this respect are included below in section V.2.

The plant seems to remove enough suspended solids to make the effluent suitable for feeding the biogas plant, even though a screw separator is foreseen before the biogas plant inlet tank.

IV.3 Operational lessons

The implementation arrangements proved to be satisfactory. The implementation in Tanzania experienced many delays, partially due to the contractor internal organization and partially to the changes in project location.

Since the location of the biogas plant will be changed, the flume tow recovery plant will have to be moved from Kwaraguru to a new estate.

V. Conclusions and recommendations

V.1 Kenya

The length of the leaf that is related with the age of the plant influences the percentage of flume tow recovered from the small drum: the shorter younger leaf produces higher losses in the decorticator, hence more flume tow.

The average production capacity of the flume tow recovery plant is 39.51 ± 4.73 kg/hour.

It is important to thin out (for ventilation) the output from the rotary screen before sun drying and to turn it from time to time during drying to avoid fermentation and development of a dirty brown color.

Carding losses are about 5% of the dried flume tow recovered. This operation improves the texture, appearance and color, hence the grade of the product. Sisal growers are encouraged to improve upon the quality of their flume tow to reach one of the higher grades and command better prices.

Drying and handling labor and electricity costs account for approximately 80% of the production costs associated with labor for the various operations, electricity and baling materials only. The lowest cost achieved is KES 12.85/kg of baled flume tow. This cost is very high and does not allow for production, as the market price for this product is approximately US$ 200/tonne or KES 14/kg.

Even though the flume tow recovery system is mechanically successful and produces the expected output, it is not, however, viable economically in its current format.

The recovery of the flume tow perhaps could be more viable economically and environmentally friendly if instead of just collecting the flume tow it could be combined with the utilization of the green matter or flesh in the waste for production of other by-products such as hecogenin, inulin, biogas/electricity, sodium pectate, waxes, etc.

V.2 Tanzania

For the duration of the tests, the flume tow recovery plant has demonstrated that it is capable of being used in the recovery of clean flume tow.

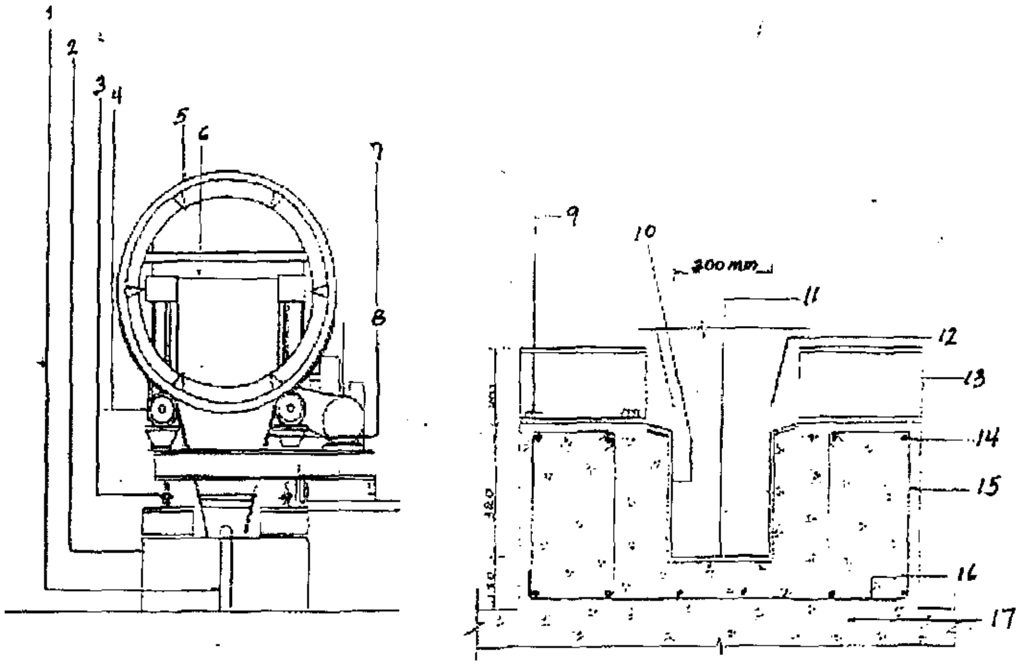
Due to low efficiency of the decorticator and inadequate water supply to the decorticator, the waste discharged to the flume tow recovery plant was above expected quantities and was not uniform.

The flume tow recovery system has also demonstrated that it can be used as a primary stage in the separation of mucilage and green flesh, from the rest of the biomass, in quantities, which can be used in the biogas plant. However, because the mucilage still contains, some short fibre, means should be incorporated in the biogas plant to recover traces of short fibre still remaining in the mucilage. Energy from biogas production can be used to generate heat and electricity in order to power the decorticator and flume tow recovery plant

Based on the trials, it is noted that the use of a flume tow recovery system for short fibre extraction is feasible and more efficient than manual extraction and that it gives cleaner flume tow. This clean flume tow may find different uses including that of pulping. However, the parenchyma level depends on the decorticator efficiency. Under low decorticator efficiency some parenchyma still adheres to the flume tow and cannot be separated in the flume tow shaker screen, making it unsuitable for pulp production.

The flume tow recovery plant operates at little profit, and because of the low selling price of the flume tow, is not viable economically as it is now.

Annex 1A – Flume tow recovery plant design (Rea-Vipingo Plantations)



Corona Section: End and detail

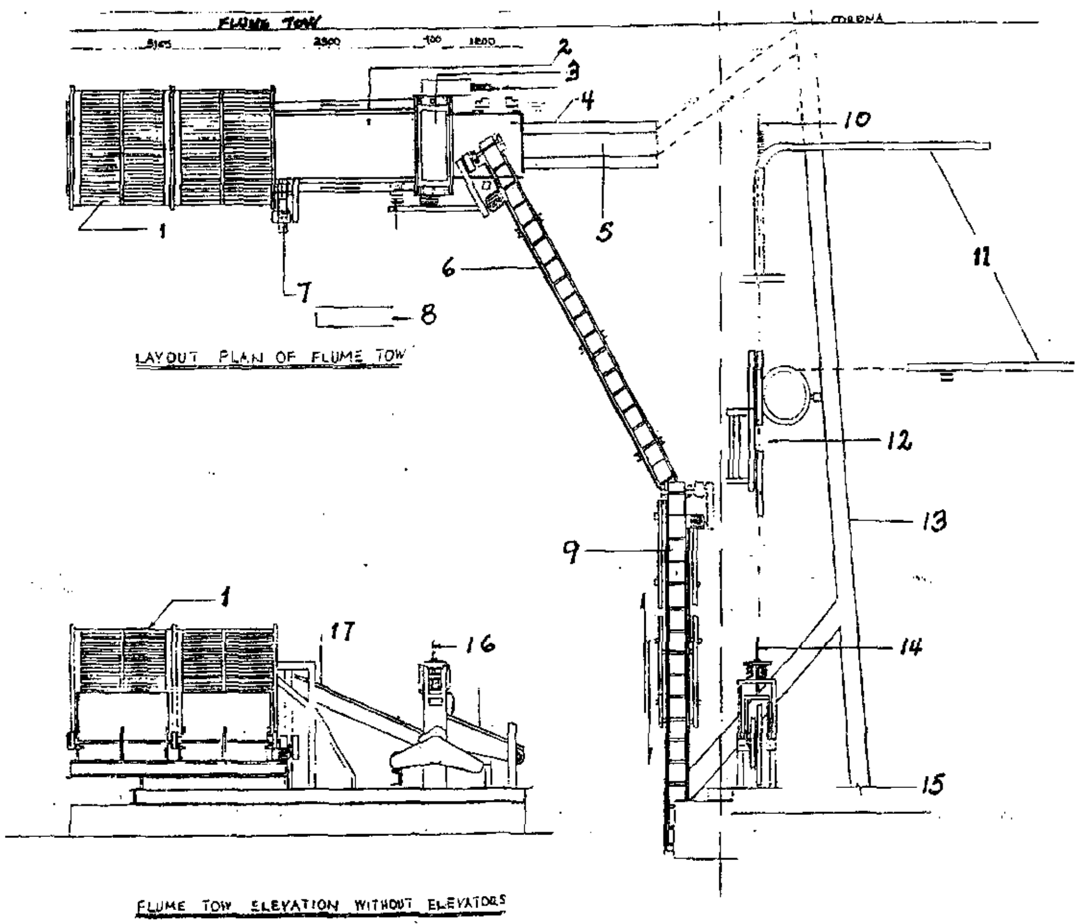
<u>Discharge end elevation</u>

1	Inlet pipe to H.P. water
2	Mounting base
3	Bolted hinge
4	Ø230 rollers
5	Rotary screw
6	Feeder belt
7	Pulp defectors
8	Motor

<u>Detail to section A-1</u>

9	Holding down bolte
10	12mm thick waterproof plaster
11	Pulp disposal channel
12	Pulp chute discharging to the channel
13	Universal beam 8"
14	Main bars
15	Stirrups
16	Transverse bars
17	Reinforced concrete

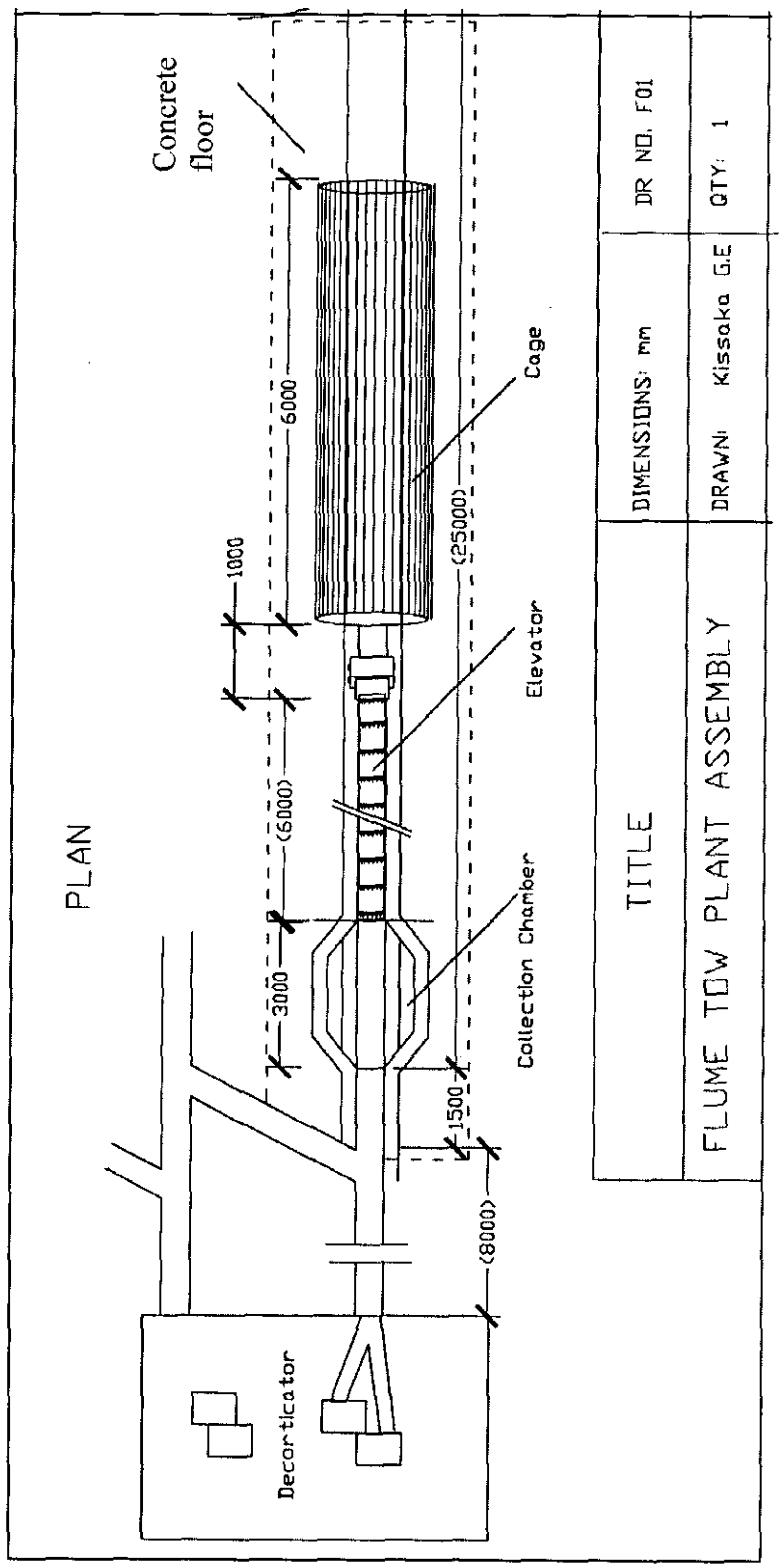
Annex 1B – Flume tow recovery plant design (Rea-Vipingo plantations)



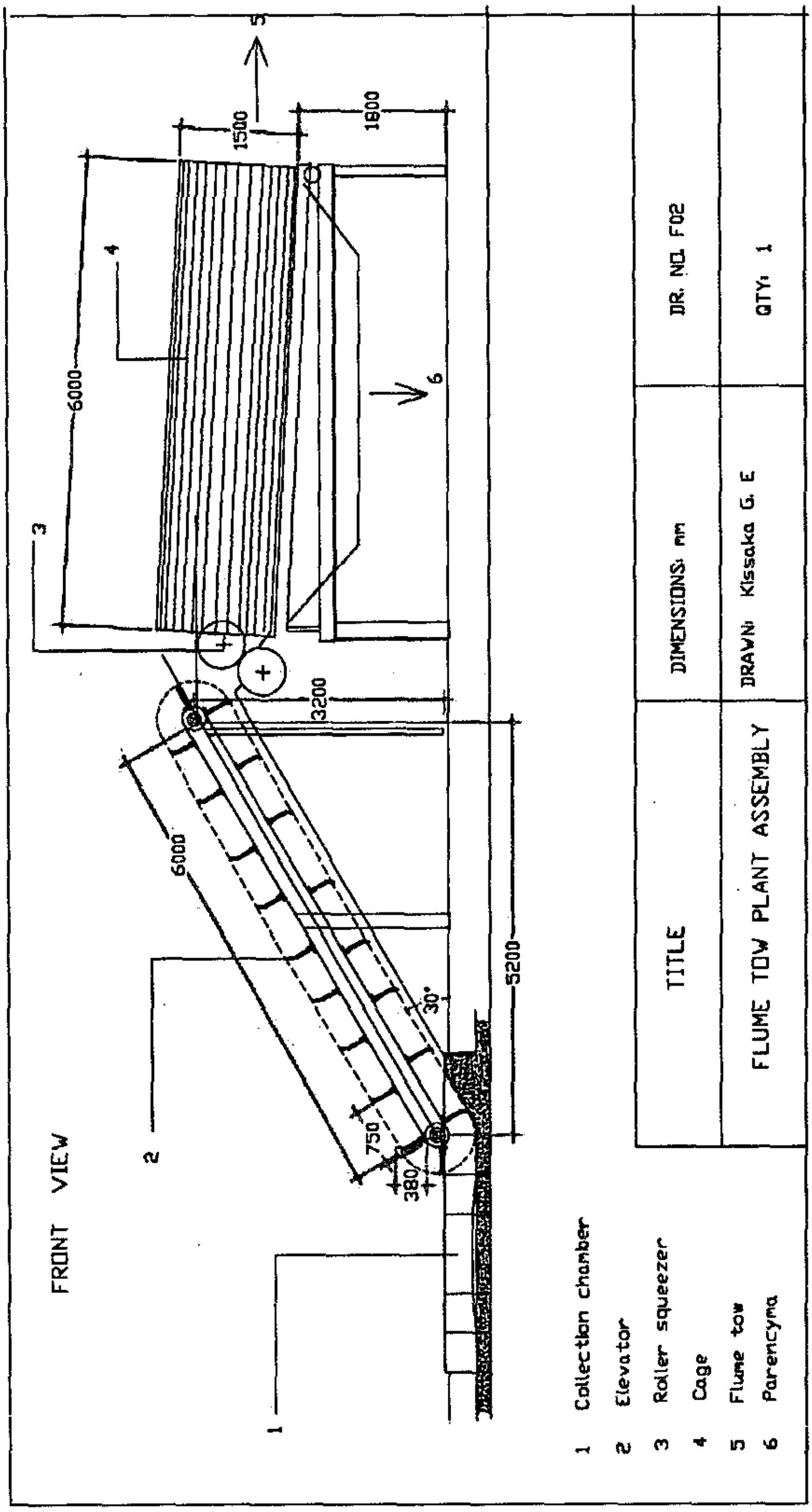
Corona Section – Plan & Elevation

1	Rotary screen on rollers
2	Feeder belt
3	Squeezer roller
4	Feeder belt
5	Pulp disposal channel
6	Elevator No. 2 (stationary)
7	Screw drive motor
8	Switch board
9	Elevator No. 1 (movable)
10	Tensioner (4)
11	Brush collection points
12	Brush separator
13	Waste Channel
14	3-way tensioner
15	Small drum
16	Tensioner to roller
17	Feeder belt

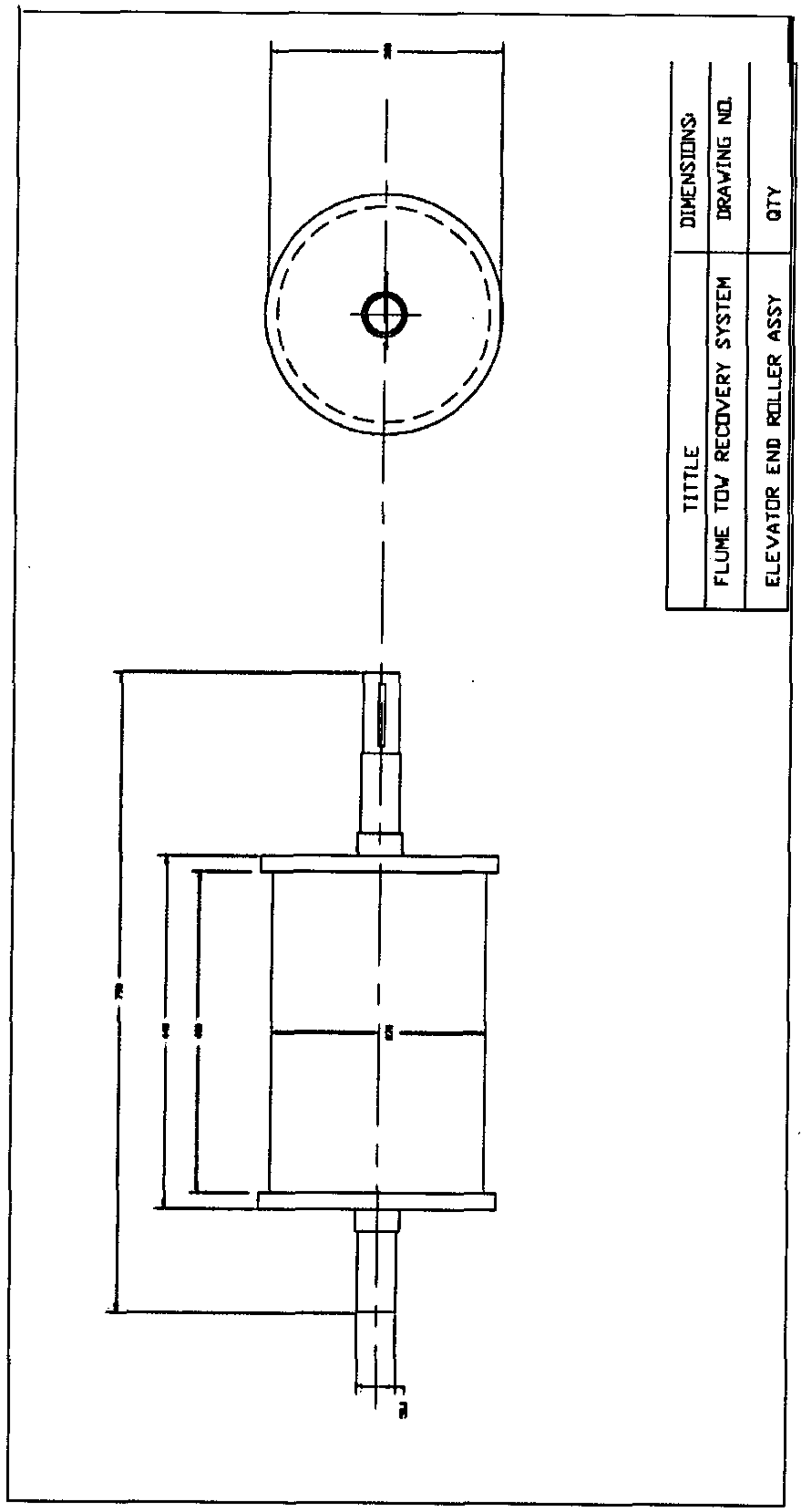
Annex 2A. Flume tow recovery plant design (Kwaraguru Estate)



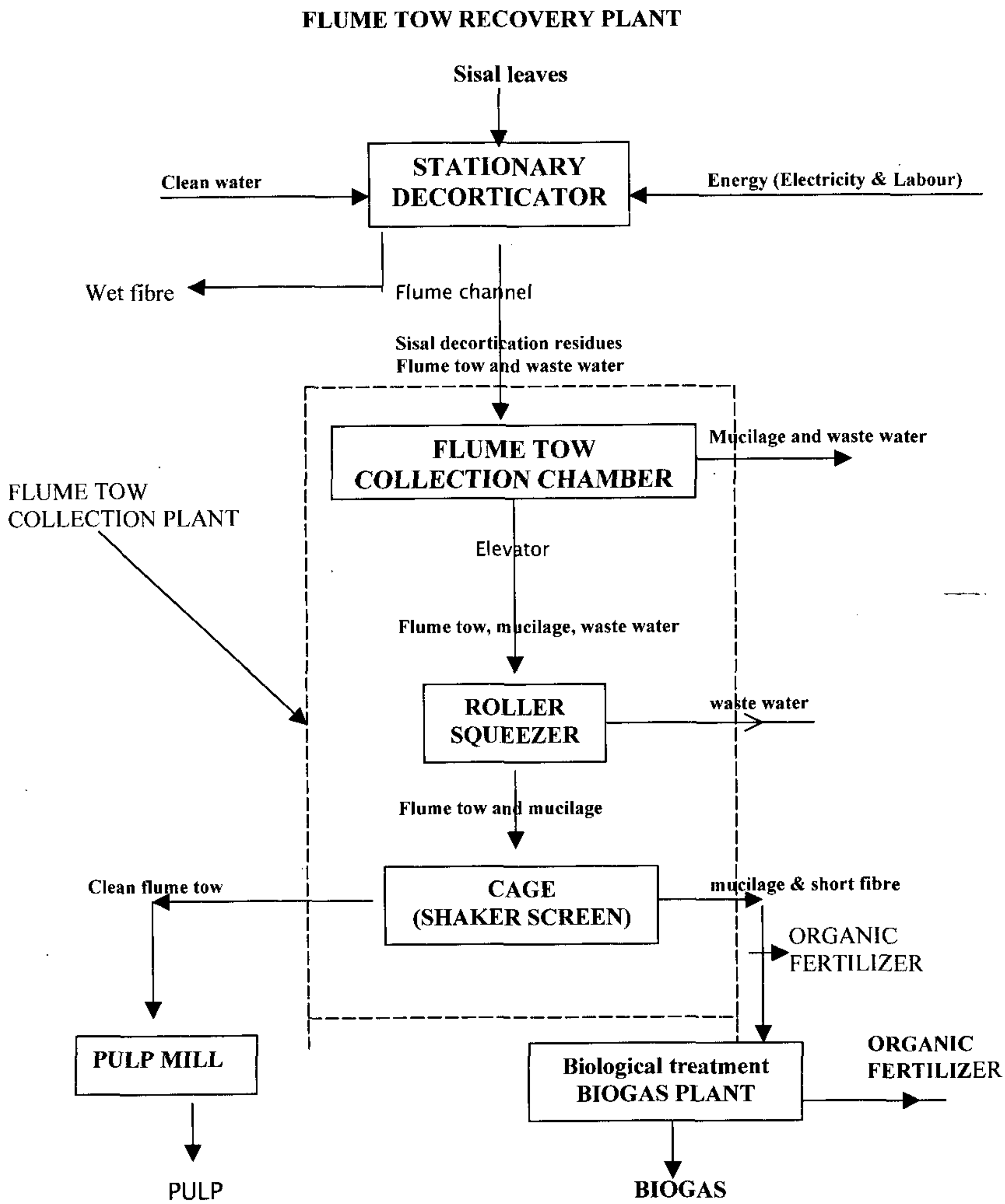
Annex 2B – Flume tow plant assembly



Annex 2C – Elevator end roller assembly



Annex 3. Flume tow recovery, process flow diagram (Kwaraguru Estate



Annex 4. Full shift production runs (Rea-Vipingo plantations)

Full shift production runs (Rea-Vipingo plantations) Final output of carded flume tow *One shift is an average of 13,330 bundles of sisal leaves*								
Date	**Flume tow recovered in Kg.**	**Total shift hours /min**	**Flume tow Kg/ hour**		**Date**	**Flume tow recovered in Kg.**	**Total shift hours/ min**	**Flume tow Kg/ hour**
28/08/00	365	11.25	31.98		21/09/00	395	12.05	32.69
29/08/00	504	11.00	45.81		23/09/00	400	13.05	30.58
30/08/00	460	13.50	33.26		24/09/00	400	14.15	28.07
31/08/00	540	14.40	42.65		25/09/00	436	11.25	38.21
01/09/00	411	11.20	36.27		26/09/00	512	12.15	41.79
02/09/00	436	12.15	35.59		27/09/00	505	12.00	42.08
04/09/00	455	11.30	39.56		28/09/00	506	12.05	41.88
05/09/00	450	11.07	40.50		29/09/00	509	11.30	44.26
06/09/00	474	11.05	42.77		30/09/00	514	11.35	44.38
07/09/00	420	12.00	35.00		02/10/00	505	11.45	42.97
08/09/00	449	13.25	33.48		03/10/00	506	10.40	47.46
09/09/00	480	13.45	34.90		04/10/00	507	11.05	45.75
11/09/00	484	12.05	40.06		05/10/00	501	11.45	43.75
12/09/00	442	11.00	40.18		06/10/00	504	12.30	40.32
13/09/00	420	10.50	38.78		07/10/00	509	11.55	42.73
14/09/00	465	11.15	41.33		09/10/00	501	11.20	44.21
15/09/00	402	11.30	34.95		11/10/00	511	11.10	45.78
16/09/00	463	11.30	40.26		12/10/00	500	11.30	43.47
18/09/00	400	11.25	35.05					
20/09/00	428	11.08	38.45					

Annex 5. Main chemical and nutritional characteristics of sisal waste

Moisture at 95% and crude fibre at 25%				
			Analyzed average	
TEST	METHOD	RESULT	COAST HERBAGE	GOOD GRASS HAY
Moisture	Dried at 100 D. Centigrade	95.9%		
Protein	Cal. as N_x. 6.25 on dry basis	5.6%		15
Ether extracts	On dry basis	2.9%		2.8
Crude fibre	On dry basis	25.4%		20.9
Ash	On dry basis	11.4		10.8
Iron	As Fe (PPM)	324		
Copper	As Cu (PPM)	112		
Zinc	As Zn (PPM)	61		
Sodium	As Na (PPM)	2152		
Potassium	As K (PPM	4450	4200	
Calcium	As Ca (PPM)	32904	1500	12000
Magnesium	As Mg (PPM)	5833	470	
Phosphorus	As P (PPM	1246	10000	8000

Fresh sisal waste effluent is distinctly acid (pH 4.8 to 5.2)

Annex 6. Flume tow recovery plant test datasheet (Kwaraguru Estate)

Table 1. Weight of sun-dried samples obtained each in 1-hour operations

Test batches for flume tow recovery plant	Dry weight in 60 minutes (kg)
1	49.44
2	40.08
3	45.84
4	44.40
5	43.20
6	43.68
7	46.80
8	41.11
9	47.22
10	41.40
11	40.80
12	48.90
13	41.10
14	44.52
15	46.80
16	40.50
17	49.62
18	42.60
19	48.24
20	46.56
21	44.40
22	44.64
23	49.44
24	45.65
25	43.20
26	44.52
27	43.32
28	48.06
29	50.52
30	55.50
31	50.40
32	42.60
33	50.76
34	47.64
35	46.80
36	48.90
37	40.92
38	42.30
39	40..80
40	40.20
41	42.90
42	47.76
Average	**45.44**

Table 2. Evaluation of waste produced by the decorticator: Standard Dry Decortication Test

		Sample 1	Sample 2	Sample 3	Sample 4
1	Leaf weight (kg)	100	100	100	100
2	Average length (cm)	98	100	125	115
3	Number of leaves	250	300	375	333
a	Weight of dry line fibre	3.0	3.35	2.9	3.0
b	Weight of dry small drum waste fibre	1.50	1.68	1.50	1.90
c	Weight of dry big drum waste fibre	0.75	0.80	0.80	0.70
d	Total Weight (a+b+c) = 100%	5.25	5.83	5.20	5.60
e	Percentage waste from small drum (b/dx100%)	28.60	28.81	28.80	33.90
f	Percentage waste from big drum (c/dx100%)	14.30	13.72	15.40	12.50
g	Total waste (e+f)	42.90	42.53	44.20	46.40
h	Decorticator efficiency (100 g)	57.10	57.47	55.80	53.60

REMARKS:

The above tests are normally carried out once every month to determine the technical condition of a decorticator. It gives out how much line fibre is extracted and how much is lost in the flume tow channel.

In a decorticator that is in a sound working condition, the amount of flume tow going into flume channel should not exceed 15%.

In the case of Kwaraguru tests, wastage is as high as 45%. This low efficiency is mainly caused by worn out saddle pieces, knives and drums, which have to be reconditioned to improve the efficiency to acceptable levels of 85% and above (i.e. wastage of 15% and below).

Use of Corona ropes instead of normal link V-belts to drive the drums further aggravated the situation.

Annex 7. Production costs of flume tow (Rea-Vipingo Plantations)

Average cost 1st approach	
Drying and handling labour	KES 5.50
Flume tow recovery plant labour	KES 1.30
Carding machine labour	KES 1.55
Baling machine labour	KES 0.25
Electrical costs	KES 5.10
Baling materials costs	KES 0.45
Total cost per Kg. flume tow	**KES 14.15**

Average cost 2nd approach - reduction of staff in the carding

Drying and handling labour	KES 5.50
Flume tow recovery plant labour	KES 1.30
Carding machine labour	KES 1.00
Baling machine labour	KES 0.25
Electrical costs	KES 5.10
Baling materials costs	KES 0.45
Total cost per Kg. flume tow	**KES 13.60**

Average costs 3rd approach – reduction of staff in the flume tow plant and drying and handling labour

Drying and handling labour	KES 5.05	39.30%
Flume tow recovery plant labour	KES 1.00	7.78%
Carding machine labour	KES 1.00	7.78%
Baling machine labour	KES 0.25	1.96%
Electrical costs	KES 5.10	39.68%
Baling materials costs	KES 0.45	3.50%
Total cost per Kg. flume tow	**KES 12.85**	100%

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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Telephone: (+43-1) 26026-0, Fax: (+43-1) 26926-69
E-mail: unido@unido.org, Internet: http://www.unido.org