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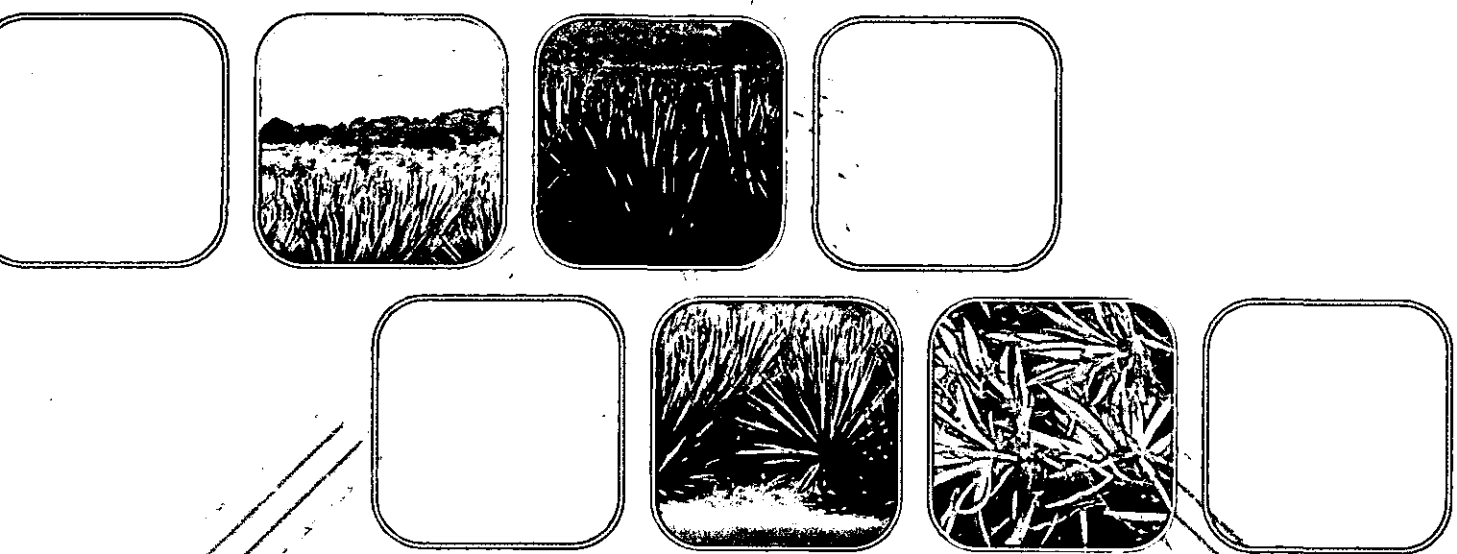
COMMON FUND FOR COMMODITIES

Project CFC/FIGHF/07

Product and market development of sisal and henequen



Animal feed trials

Project completion report/Addendum B.2

Kenya, February 1998–June 2001

UNIDO

COMMON FUND FOR COMMODITIES

FAO FIAT PANIS

KENYA SISAL BOARD

COMMON FUND FOR COMMODITIES

Product and market development of sisal and henequen

Project completion report, Addendum B.2

Animal feed trials

Kenya
February 1998–June 2001

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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Project Completion Report

Sub-component B.2
"Animal Feed Trials"

CONTENT

Abbreviations and acronyms

Ca	Calcium
CF	Crude fibre
CFC	Common Fund for Commodities
CTA	Chief Technical Advisor
Cu	Copper
DM	Dry matter
EE	Ether extracts
Fe	Iron
ILRI	International Livestock Research Institute
KRRC	KARI Regional Research Center
KSB	Kenya Sisal Board
Mg	Magnesium
Mn	Manganese
NPO	National Project Officer
P	Phosphorous
PCC	Project Coordinating Committee
PEA	Project Executing Agency
SED	Stand Error of Difference
TOR	Terms of Reference
UNIDO	United Nations Industrial Development Organization
Zn	Zinc

I. Project sub-component summary

1. Title: Animal Feed Trials

2. Location: Kenya (Kilifi Plantations)

3. Starting Date: February 1998

4. Completion Date: June 2001

5. Sub-component external financing – excluding counterpart contributions

Total sub-component cost:	US$ 183,136
Of which:	
CFC Financing:	US$183,136

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

II. 1 Background

During project design it was found that limited exploration of using boles and decorticated wastes as animal feed had been undertaken in Kenya and Tanzania, but that the results had been encouraging. It was also identified that there were needs for further refining the bogas (green material in the waste) recovery machinery and for testing the effectiveness of feeding fresh and ensiled bogas to dairy and beef cattle, sheep and goats.

The sub-component B.2 "Animal feed trials" was conceived, taking into consideration that:

(i) One of the broad objectives of the project was the valorization of decortication waste to increase the value-added of sisal plant and reduce pollution;

(ii) If the viability of using sisal bole and bogas as animal feed were proven, sisal could turn out to be a useful resource for animal producers, particularly smallholders in drought-prone areas in Africa and other regions.

II.2 Context

Farmers in the tropics have limited resources for feeding their ruminant livestock. The main feedstuffs available are natural pastures, agro-industrial by-products and crop residues. Where the animals are kept close to a source of bogas, it can be fed fresh or ensiled for dry season feeding.

The growing sisal industry in Mexico, South America and Africa generates growing amounts of by-products. Casso and Castro (1998) reviewed the utilization of sisal by-products in Mexico. The review indicated that drying or ensiling where fermentation is completed in 10 days could preserve the bogas. The review also indicated that the main limitation to the productivity of animals fed sisal by-products was intake and that supplementation with molasses, protein and forages resulted in improved productivity. The review also reported studies that showed that ensiled sisal waste appeared to be a poor source of fermentable organic matter, and that there was little advantage gained from ensiling where fresh bogas was available. The authors of the review concluded that for reasonable animal performance, sisal waste should be fed together with a source of rumen un-degradable protein, a source of readily available energy like molasses and a source of fibre to ensure optimal rumen function.

The earliest recorded use of sisal waste in Kenya was by Frank (1957) where it was used as a supplement for cattle rations. A study by Rodeseth (1965) showed that Boran beef cattle fed fresh sisal waste as a supplement to natural pastures during the dry season maintained a better body condition than the non-supplemented group.

Bogas has been used for cattle feeding since the mid 1960 in Kilifi Plantations in Kenya. It has been used to supplement natural grass silage fed to the cows during the dry season, which can last up to eight months.

II.3 Objectives, outputs and targeted beneficiaries

The sub-component objectives were:

- to develop viable animal feed using boles and bogas,
- to test the effectiveness of the feed through animal trials and
- to design a follow-on program.

The expected outputs were:

- a technical manual on compounding feed rations using sisal waste as a main constituent taking into consideration the feed trial results for cattle (beef and dairy), sheep and goats;
- the design of feed machine and equipment and the feasibility study for an animal feed production unit based on sisal waste products.

Considering the very poor results achieved as part of the trials, the expected outputs (technical manual, feasibility study) were not produced and only a final report was prepared.

The target beneficiaries are the farmers and livestock keepers, particularly small holders in rural, drought-prone areas in Africa and other regions.

III. Implementation and results achieved

The project stakeholders decided to search for a company to take the overall responsibility of animal feed trials experiment. The Terms of Reference (TOR) for the contract were prepared following the protocol of experiments and activities described in the Appraisal Report. The protocol conditions were as follows:

- Duration: five years
- Number of treatments: three (fresh bogas, ensiled bogas and control)
- Type of animals: dairy cows, beef steers, goats and sheep as indicated in Table 1 below.

Table 1: Ownership and number of animals per treatment (original protocol)

Animals	**Fresh bogas**	**Ensiled bogas**	**Control**		**Total**
	Project-owned animals	*Project-owned animals*	*Contractor-owned animals*	*Project-owned animals*	
Dairy cows	10	10	10		30
Beef cattle	10	10	10		30
Goats	10	10	10		30
Sheep	7	7		6	20

The contractor was responsible for the purchase of 10 animals of each group (seven sheep) in the first year, for the tests with fresh bogas and of 10 animals of each group (seven for sheep) in the second year for the tests with ensiled bogas. The control animals, with the exception of the sheep, were supposed to be supplied by the contractor. The contractor was also responsible for recording and collecting all revenues from the sales of the milk produced by the dairy cows owned by the project and from the sales of the animals owned by the project at the end of the feeding experiments.

The contract was awarded through competitive bidding. Eight companies in Kenya and Tanzania were invited for bidding. Two proposals were received; one from Kilifi Plantations Ltd. (US$ 271,500) and one from Bacas, Tanzania (US$ 212,586). The proposals were presented and discussed during the Project Coordinator Committee (PCC) meeting held in Tanga in December 1997. The proposal presented by Bacas was incomplete and the PCC members requested the Kenya Sisal Board (KSB) to negotiate with Kilifi's management a reduction in the price. After the negotiation, UNIDO received confirmation from Kilifi that the services could be provided as per the TOR for the amount of US$ 238,660. CFC was consulted and agreed with the total cost proposed by Kilifi to be disbursed in five years:

Year 1: US$ 80,220
Year 2: US$ 58.040
Year 3: US$ 43,540
Year 4: US$ 46,500
Year 5: US$ 10,360
Total: US$ 238,660

Kilifi signed the contract (No. 97/100) in February 1998 (US$ 80,220). During the review workshop held in Tanga, in April 1998, the Chief Technical Adviser (CTA), experts from ILRI and from KARI Regional Research Center (KRRC), Mtwapa, expressed their concern whether 10 animals per treatment (seven sheep) were enough to provide a realistic statistical analysis of the trials. A meeting was held at ILRI in June 1998 to discuss the original protocol of experiments and to collect suggestions and recommendations for a new protocol, which could give more reliable statistic results. The meeting was attended by an expert in statistical analyses and design of similar experiments from ILRI, by the National Project officer (NPO), KSB Managing Director, the CTA, and by the UNIDO Project Manager.

A new protocol of experiments based on the suggestions and recommendations of the expert from ILRI was prepared. This new protocol and its implications for the total budget and for the contract TOR were then discussed with Kilifi's management in a meeting held at Kilifi estate in June 1998. The meeting was attended by an expert in animal nutrition from KRRC, NPO, KSB Managing Director, the CTA, and by the UNIDO Project Manager. The budget and the protocol were revised based on the issues agreed upon during the meeting at Kilifi estate; these changes were reflected in the newly amended TOR.

The main modifications in the protocol were as follows: the number of animals to be purchased by the project; the size of the buildings for sheltering all animals, including the control ones; the duration of the feeding trials and two lactations periods for the dairy cows. The details on the differences between the original and new the protocol are in Annex 1.

The Amendment A of the contract for the second year of implementation and based on the new protocol (US$ 72,680) was signed by Kilifi in May 1999. During this year UNIDO was informed that Kilifi was not able to inseminate the dairy cows as planned in the new protocol and that the expert from KRRC recommended to reduce the trials from two lactation periods to one. Since this reduction had implications in the total cost of the contract, a revised budget was prepared and sent to the contractor for evaluation. After some negotiation the total budget of the contract was reduced to U$ 194,465. The actual and planned duration of the trials is indicated in Table 2 below.

The Amendment B of the contract for finalizing the experiments (US$ 41,545) was signed by the contractor on 13 June 2000.

A draft final report was submitted to UNIDO and KSB in December 2001. Monitoring and supervision of the contract was carried out by KSB.

At the end of the contract the animals owned by the project were sold. The revenues (US$ 19,142) of the sale of the animals and of the milk produced by the cows owned by the project were transferred to the project after long negotiations with Kilifi management.

Table 2: Actual and planned duration of the experiments for one lactation

Animals	Starting Date	Ending Date	Actual duration (weeks)	Planned [1] duration (weeks)
Dairy cows	30/10/99	19/06/00	33	106
Beef cattle	29/09/99	09/06/00	36	36
Goats	29/09/99	19/03/00	24	24
Sheep	09/12/99	09/06/00	24	24

[1] New protocol

III.1. The bogas recovery system

In the sisal industry, the leaves are decorticated (decortication process) to extract the fibre. Decortication involves beating, crushing and scraping the fibres clean and it is done making sisal leaves pass through two-drum machinery. Jets of water, directed into the fibre as it passes through each drum, wash the fibre and carry away the waste.

The bogas is extracted from the waste with a bogas recovery system. The bogas recovery system consists of three working units: the squirrel cage to separate the bogas from the flume tow, the squeezer to remove the excess water in the recovered bogas and a system of belt conveyors for moving the materials. The system was manufactured according to the drawings presented in Annex 2. All the working parts (including the motors and the gear reduction units) are available locally and the other parts can be manufactured in most workshops of average ability.

The bogas is a soft fleshy substance broken down into sizes of between 3 to 5 mm with waxy particles from the leaf surface. Fresh bogas is acidic (pH 3.9 - 4.5, Table 3)

Table 3: Chemical composition of fresh bogas

Bogas main characteristics	**Composition - percentage**
Dry matter (DM)	18.7
Crude fibre (CF)	28.1 - 30.7
Digestible nutrients:	
Crude protein (CP)	4.3 – 7.0
Ether extract (EE)	2.5 – 3.7
Ash	8.7 – 11.9
Soluble carbohydrates	26.6 – 30.7
Gross energy	3.70 kcal/kgDM
Minerals	**g/kg DM**
Ca	47.0
P	1.0
Mg	09.0
Minerals	**mg/kg DM**
Zn	1.5
Cu	1.0
Mn	1.0
Fe	0.3
Organic acids	**% DM**
Lactic	1.0
Citric	1.2
Oxalic	5.2
pH	3.9 – 4.5

Source: Kilifi Plantations, Kenya

The decorticator used for the study in the Kilifi Plantations processes 20,250 leaves per hour. During the period of the study, water was not used (dry decortication method) in order to avoid excessive dilution of the waste and to facilitate its collection and transport to the bogas recovery system. The designed production capacity of the system is 1 ton fresh bogas /hour. The figure in Annex 3 shows the mass flow of the bogas recovery system. The total investment cost for machinery was estimated at US$ 7,753 and additional monthly operational costs of US$ 225 and US$ 600 for labour and electricity respectively.

Upon recovery, the fresh bogas can either be compounded into a feeder and given directly to the animals, or it can be ensiled and compounded later for feeding the animals.

Three masonry pits of equal dimensions were built next to the squeezer for making silage from the fresh bogas. The dimensions of each pit were: 16m long, 3m wide and 1m high.

III.2. Ensiling the fresh bogas

Preserving and storing an adequate and nutritionally suitable feed supply is an essential part of livestock production. Feed costs make up a major proportion of total production expenses. Silage offers the opportunity to preserve high quality feed with minimal losses.

There are two main phases in the ensiling process. The first phase is an aerobic phase where the plant enzymes and microbes consume oxygen and burn up water-soluble carbohydrates (sugars). The second phase is initiated when all oxygen is used up and the anaerobic bacteria will begin to multiply rapidly and fermentation starts. Ideally, in the second phase, Lactobacilli species would dominate and would produce lactic acid using the water-soluble carbohydrates as an energy source.

Good quality ensiled products are obtained by minimizing the aerobic phase in order to contain the increase of the pH and the consequent development of undesirable bacteria of genus Clostridium (which grows under high pH conditions). The presence of bacteria of genus Clostridium would result in the formation of butyric acid, ammonia and various amines that are associated with poor ensiled bogas quality. In addition, the longer the period of aerobic activity the more the heat produced and the risk of heat damage.

After two to four weeks, the pH becomes so low that all microbial growth is inhibited and fermentation stops. The silage is then ready for use. The ensiling process does not affect the composition of bogas except for the DM, which increases from 19 to 25%. The cost of fresh and ensiled bogas on DM basis was assumed to be similar.

The method selected for production of quality ensiled bogas included: compression of the material in the pit, using a tractor, to further remove moisture and prevent air contact; covering of the compressed material with black, heavy gauge plastic sheeting properly secured on the ground to ensure an airtight environment and also to prevent water and sunlight from interfering with the silage process. The silage time adopted was 14 days.

At Kilifi Plantations, bogas was ensiled in pits measuring 16 x 3 x 1m for length, width and depth respectively. The capacity of the silage pit was 33 tons of bogas, which was estimated to be adequate for 100 cows for 22 days.

III.3. Implementation trials and diet selection

The animals were housed in well-ventilated stalls with individual feeding and watering facilities (Annex 4). The structures were made of blocks, iron roofed and a concrete floor, which had a slope to allow drainage of urine and wastewater used for cleaning.

Diets were selected for beef and dairy cattle, sheep and goats in cooperation with a national expert in animal nutrition from KRRC, Mtwanga. Details of diets and chemical analysis of the fresh bogas are shown in Annex 5.

III.3.1 Beef steers

Three groups of ten healthy beef steers aged 5-7 months and weighing an average of 83 ± 3, 84 ± 3 and 89 ± 3 kg were selected from Kilifi's herd for fresh bogas, ensiled bogas and control diet respectively. They were of mixed genotypes of Friesian, Sahiwal and their crosses.

The composition of the treatment diets is shown in Annex 5. The 8.3 kg daily feed was offered in two equal proportions in the morning and afternoon. Refused feed was removed before fresh feed was offered the following morning. Clean water was provided at all times. The animals were offered treatment diets for nine months and they were weighed every three months.

III.3.2 Dairy cows

The dairy cows were selected from a herd grazing natural pastures in Kilifi estate. It was proposed to start the experiment before the cows reached peak production (3-4 months) but this was not possible. The lactation parameters and genotypes are shown in Table 4 below.

The project purchased 36 cows, 12 for each treatment. The number of animals used per treatment was not the same as planned because four cows did not acclimatize with the treatments (two fed ensiled bogas and two control diets) and one cow on ensiled had low milk production (1.3 kg/day). These five cows were removed from the trial.

The cows were assigned and randomized to the three treatments diets on the basis of genotype and current yield. This aimed at having similar genotypes and milk yield at the start of the experiment; however, this did not happen. The composition of the diets is shown in Annex 5.

The cows were hand milked twice daily at 0400 hours and at 1500 hours. The experiment was carried out over a period of 33 weeks, one lactation only. For all the animals, feeds were offered in two equal proportions in the morning and afternoon. The control, ensiled bogas and fresh bogas were offered in a different feed trough from the concentrate. Refused feed was removed before fresh feed was added in the morning. Clean water and a mineral lick were provided at all times.

Table 4: Summary of lactation parameters and genotypes

	Treatment		
	Fresh bogas	**Ensiled bogas**	**Control**
Total Number of animals	12	10	9
Friesian	5	2	2
Sahiwal	2	5	2
Crosses	5	2	5
No. lactation	1-3	1-2	1-2
Average Initial milk yield (min-max) (kg/day)	10.3 (6.9-14.6)	8.6 (5.4- 10.9)	10.1 (8.1- 12.1)

III.3.3 Goats

A total of 42, one-month old, male only, small East African goats were selected for the study. The number of goats purchased by the project was 28. The other 14 were owned by the contractor and were used as control. These were divided into three groups and the mean weights are indicated below:

- Fresh bogas: 14 goats, mean weight: 20.5 ± 0.9
- Ensiled bogas: 14 goats, mean weight: 19.1 ± 1.1
- Control: 14 goats, mean weight: 18.0 ± 0.7

The goat is mainly a browser, which depends on shrubs for its feed. The diet composition is shown in Annex 5. The total amount of feed offered daily was 0.58 kg. Clean water and a mineral lick were available at all times to the animals. Monthly live weights were recorded and the treatment diets were offered to the animals for six months.

III.3.4 Sheep

A total of 41, 10-month old Dorper sheep were used in the experiments. The mean weights at the start and numbers used in the experiments were as follows:

- Fresh bogas: 14 sheep, mean weight: 21.5 ± 0.63
- Ensiled bogas: 13 sheep, mean weight: 20.5 ± 0.9
- Control: 14 sheep, mean weight: 25.2 ± 0.5

The actual number of sheep to be purchased by the project was 42, 14 sheep per treatment. This number was recommended by the national expert in animal nutrition from KRRC, because there was some indication that some of these animals might die during the trials.

The diet composition was similar to the one fed to goats (Annex 5). The sheep were offered treatment diets for six months. All the other procedures were as for the goats.

Data collected during the experiments are included in Annex 7, extracted from reports received from Kilifi. Annex 6 presents some literature references on the subject.

III.4 Dissemination of results

A representative of Kilifi Plantations presented a technical paper during the Dissemination Workshop held in Tanga in February 2003. The negative results obtained, especially for goats, were highly criticized, as it is common practice in East Africa and in other sisal producing countries to feed goats with sisal waste.

A presentation on B.2 results was given at the International Dissemination Workshop held in Tanga in November 2004.

IV. Lessons learned

IV.1 Results achieved

All experimental animals consumed all the concentrate, which was offered in a separate trough. Left over forage was difficult to quantify due to spillage from the troughs and tramping. It was therefore difficult to determine DM intake. An attempt was made to determine intake for the cows, which had minimal spillage. Live weight data is reported for sheep, goats and steers while DM intake and milk yield is reported for the cows.

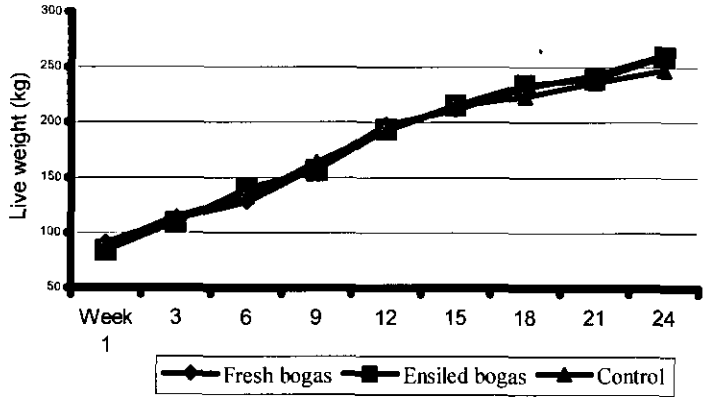
IV.1.1 Beef steers

The experiments were conducted for 36 weeks (29 September 1999 to 30 June 2000), but results were reported for only 24 weeks. The animals were in good health and none died throughout the experiment. Growth rates were calculated for each animal by linear progression of body weight on week of measurement. The average growth rate was statistically similar between the three groups (7.2 ± 0.2 kg/week) and equivalent to one kilogram daily. The live weight measured every three weeks is shown in Figure 1.

Table 5: Growth of beef steers

Treatment	No. of animals	Initial weight (kg)	Final weight (kg)	Average growth rate (kg/week)
Fresh	10	83 ± 3	239 ± 9	6.9 ± 0.44
Ensiled	10	84 ± 3	260 ± 8	7.6 ± 0.37
Control	10	89 ± 3	247 ± 8	7.0 ± 0.25

Figure 1: Growth (live weight) of beef steers



IV.1.2 Dairy cows

The experiments were carried out over 33 weeks and during one lactation period only, because the contractor was not able to inseminate the cows as planned. The results are shown in Table 6 and Figure 2.

The mean daily DM intake for cows fed bogas was significantly lower ($P<0.01$) than that of cows fed the control diet. The effect of the diet on live weight and body conditions was not quantified but cows fed bogas were generally weak and this may have been associated to low DM intake. Eight animals suffered from ailments such as abscesses, hind limb and food rot Of these, six were fed fresh and two ensiled bogas.

The average milk production from cows fed fresh bogas tended to be lower than the production of those on the other two treatments. The 0.5 kg difference in milk production however was not statistically significant ($P>0.05$). The decline in milk yield for each cow was calculated by linear progression of milk yield on week of experiment. Effects of other factors like lactation number, stage of lactation and genotype were also examined but none were found to be significant. Four cows (one from the group fed on ensiled bogas and three from the Control group) did not acclimatize to the experiment and were removed from the trial. This is why the initial daily milk yield per treatment was not similar.

Table 6: Dairy cows – one lactation period

	Fresh bogas	**Ensiled bogas**	**Control**	**Average SED[(a)]**
Number of animals	12	10	9	
Mean DM (kg/d)	4.3	4.4	7.0	0.24
Mean milk yield (kg/d)	7.8	8.3	8.3	0.50
Mean decline in milk (kg/d)	0.072	0.097	0.11	0.0220
Number with clinical ailments	6	2	0	
Number dried off before 32 weeks	7	3	2	

(a) Average standard error of difference between fresh bogas feed and control

The decline in milk yield per week for the cows fed bogas also tended to be lower than that of cows fed the control diet (0.072 vs. 0.11 kg/day). Figure 3 shows the daily average milk yield for every fortnight. Over the 33-week experimental period, the cows fed fresh bogas produced less total milk than cows on each of the other diets.

The constraints associated with the use of sisal waste as feed for ruminants relate partly to the organic acids (mainly lactic and oxalic; Preston and Leng, 1987). Naseveen and Harrison, (1981) found that cattle fed sisal waste developed acidosis and barely maintained body weight. Bogas used in the current studies had high lactic and oxalic acids (1 and 5.2% in DM respectively).

Figure 2: Live weights (kg) for cows fed fresh bogas, ensiled bogas or control

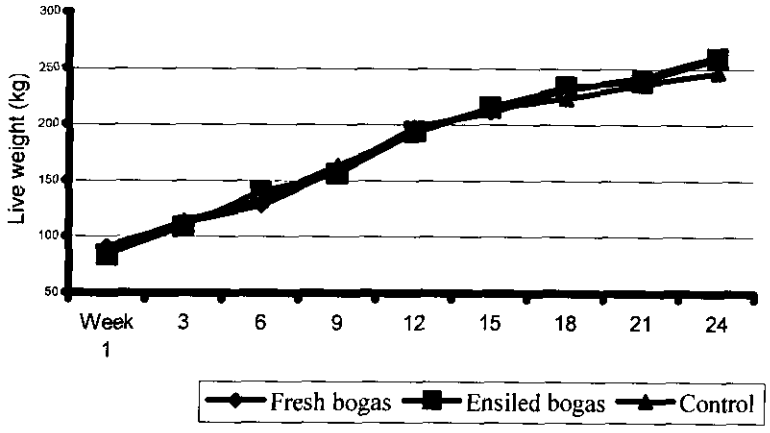
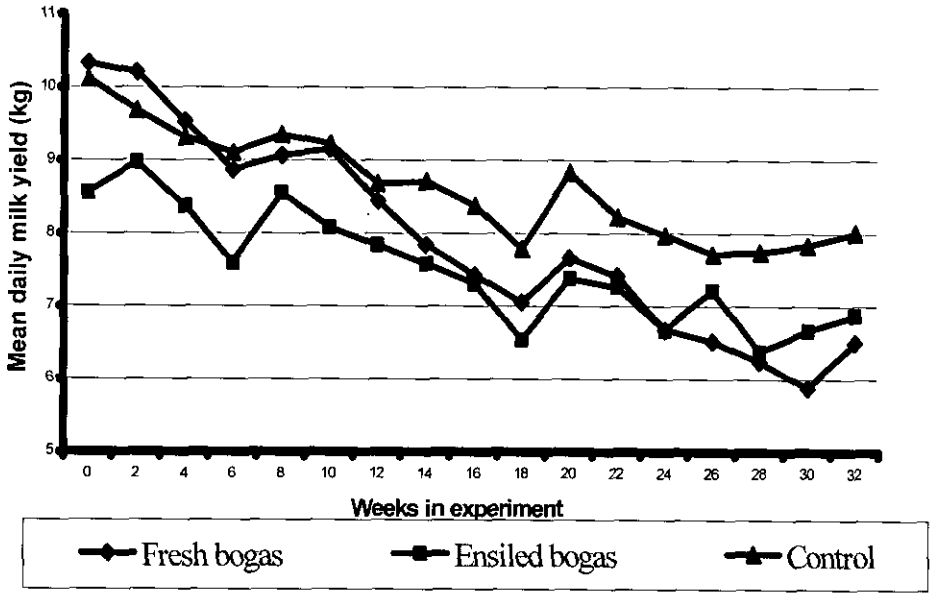


Figure 3: Mean daily milk yield (kg) of cows fed fresh bogas, ensiled bogas or control



IV.1.3 Goats

Feed trials were conducted for six months (from 29 September 1999 to 31 March 2000), but results were reported for five months only. These are shown in Table 7 and Figure 4.

No analysis of variance was conducted because of the high mortality and lack of acclimatization to the experimental conditions. The means were calculated only for initial body weight, final body weight and weight change during the experiment

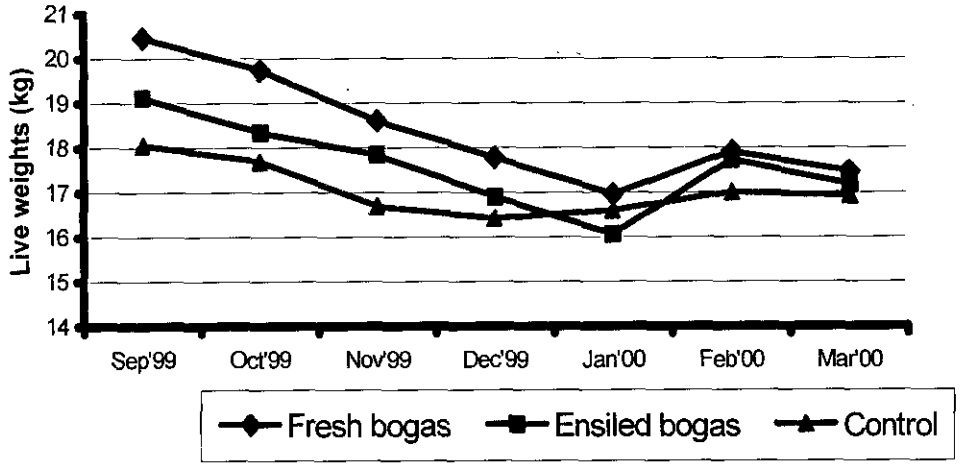
together with their standard errors. Goats were not weighed in March 2000 and data for this month was extrapolated from Figure 4.

Deaths due to lactic acidosis were caused by the fact that the goats preferred to eat the concentrate first leaving the forage part of the diet. A mixed diet (also for sheep) might have been a better option to avoid this problem. The other major cause of death was starvation and some of the animals that survived refused to eat and hence the losses in live weight. Goats fed on fresh or ensiled bogas lost between 15 and 10% of their initial weight compared to 0.6% weight loss for the control animals. Improvements towards the end of the experiments (Figure 4) were recorded.

Table 7: Summary of results obtained for goats

	Fresh bogas	**Ensiled bogas**	**Control**
Number of animals	14	14	14
Number that died and cause	1 starvation 1 acidosis 1 pneumonia	1 starvation 1 acidosis 3 pneumonia	2 acidosis 1 leg fracture
Number that survived	11	9	11
Initial weight (kg)	20.5 ± 0.9	19.1 ± 1.1	18.0 ± 0.7
Weight loss (kg)	3.0 ± 0.9	1.9 ± 1.1	1.1 ± 0.7

Figure 4: Live weights (kg) for goats fed fresh bogas, ensiled bogas or control



IV.1.4 Sheep

As for the goats feed trials were conducted for six months (from 11 December 1999 to 30 June 2000), but results were reported for five months only. These are shown in Table 8 and Figure 5.

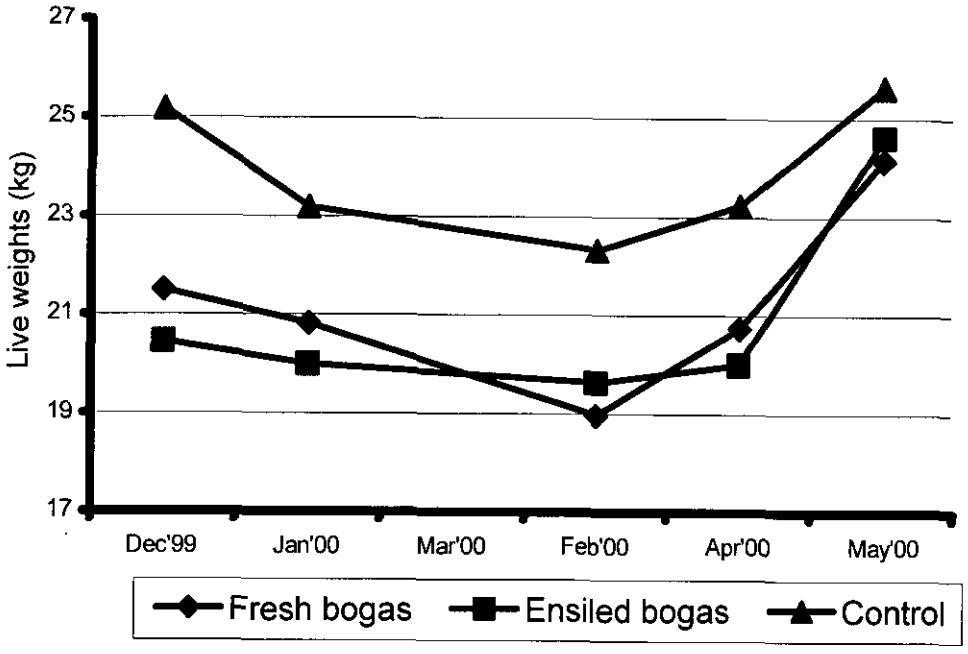
No analysis of variance was conducted and the means were calculated only for initial body weight, final body weight and weight change during the experiment together with their standard errors. The sheep gained some weight during the last two months

and this may be a result of the sheep acclimatizing to the experiments. The control trial presented higher mortality than the other two diets and the number of sheep that died by acidosis was the same in the 3 diets.

Table 8: Summary of results obtained for sheep

	Fresh bogas	**Ensiled bogas**	**Control**
Number of animals	14	13	14
Number that died and cause	1 acidosis	1 acidosis	2 asphyxiated, 1 acidosis
Number that survived	13	12	11
Initial weight (kg)	21.5 ± 0.63	20.5 ± 0.9	25.2 ± 0.5
Weight gain (kg)	2.7 ± 0.6	4.2 ± 0.6	0.5 ± 0.3

Figure 5: Live weights (kg) for sheep fed fresh bogas, ensiled bogas or control



The initial weight of sheep fed the control diet was higher than sheep fed other diets. The weight gain for sheep fed control was lower than for animals fed other diets. Expressed as a percentage of the initial weight, sheep fed either fresh or ensiled bogas gained 13 and 20% respectively compared to those on the control diet (2%). At the end of the experiment the live weights were similar in the three groups. This seems to indicate that sheep accepted, after an acclimation period, the bogas diets better than the control one.

IV.2 Development lessons

The first Terms of Reference were based on the specifications included in the project Appraisal Report. These, as indicated in section III, were modified during the first year of implementation, which entailed additional work for the PEA and the counterpart. During the revision of the protocol of experiments with ILRI, Kenya, it was recommended to keep all the animals confined in the same environment to avoid the introduction of external factors that could influence the final results. Additional buildings had to be built for sheltering all animals as the original protocol only envisaged to shelter the animals being fed bogas. This caused some delay in the implementation.

Goats and sheep seemed to be more difficult to acclimatize to confined conditions and the feed trial period for those animals should have included an acclimatization period. Difficulties in the identification of the heat period of the dairy cows might have been caused by confinement.

Despite the consultations conducted before and during the implementation of the trials, the protocol of the experiments was often criticized and the reliability of the results achieved raised many reservations. In particular the negative results obtained with goats were discussed; the diets for goats and sheep needed to be improved and a period for acclimatization to adapt to the new diet and to confinement conditions should have been allowed.

The difficulties experienced were beyond the control of the PEA, the counterpart and the subcontractor; and will have to be taken into consideration in the design of future studies. Therefore, it is recommended that during the design and formulation of similar projects/subcomponents special attention be given to the issues mentioned above in the preparation of the protocol of experiments.

The main lessons learned are:

(i) Experiments with dairy cows should include measurements on DM intake and its influence on the health condition and milk production, as well as studies on the influence of the diet composition in the rumen fermentation and nutrient metabolism;

(ii) The cows selected for the experiments should be at the same lactation stage or in a narrow range;

(iii) A period for the acclimatization of the sheep and goats to the new diets/confined condition should be included in the experiments;

(iv) Diets for sheep and goats need careful evaluation in order to reduce the risk of deaths;

(v) Statistical analysis of the results of the feed trials should be included in the protocol of experiments;

(vi) An international expert in animal feed from sisal waste should join the national team of experts in fine-tuning the protocol and the diet and in defining the relevant statistical analysis to be conducted.

IV.3 Operational lessons

The main difficulties in implementation were related to the technical aspects of the experiments. The implementation arrangements and subcomponent management were appropriate despite the difficulties experienced in recovering the revenues from the sale of the milk and the animals. The difficulties were partially due to the fact that the payment of the last installments of the subcontracts was not related to the sale of the animals and of the milk and partially to the fact that project suffered from changes of the PEA project managers.

A preliminary estimation of the amount to be returned to the project (US$ 29,594) was prepared by the PEA and submitted to the management of Kilifi Plantations Ltd., that proposed a different evaluation (US$ 19,142). The offer from Kilifi Plantations was accepted by UNIDO and CFC and Kilifi managers agreed to transfer the money in four installments.

The technical manual (one of the subcomponent outputs) was not prepared. Even though the final report submitted by the subcontractor (Kilifi Plantations Ltd.) includes information and recommendations about the ensilage method and compounding of rations, this information has not been presented as a manual. Drawings of the recovery system, and of the silage pits characteristics were prepared and are included as annexes to this report.

The complete feasibility study planned in the Appraisal Report was not prepared either. The contractor final report only presents a simplified financial appraisal (Annex 8) based on:

(i) The equipment investment;

(ii) Estimates of some operational costs, namely: depreciation, labor, power and feed costs for dairy cows (30 animals), beef steers (36 animals), goats (42 animals) and sheep (42 animals) and purchase costs of animals, except dairy cows;

(iii) Estimates of the revenues accrued from the sales of sheep and goats each year, beef steers in the second year and milk. The calculations were done for five years and within this period the break-even point was not achieved.

V. Conclusions and recommendations

V.1 Conclusions

- Bogas can be used as an additional source of fodder or as a "replacement' to non-existent fodder during the dry season;
- There was no major difference between fresh and ensiled bogas;
- The studies indicate that the sheep and goats took a long time to acclimatize to all the diets probably due to the mode of presentation and confinement. Acclimatization time should be allowed in future experiments and the diet should be reviewed;
- The steers gained one kilogram daily irrespective of the diet offered;
- The mean milk yield was statistically similar for cows fed on the three diets, an indication that bogas can be used to feed dairy cows;
- In many occasions the design of the experiments was questioned and considered unsatisfactory.

The results obtained should be compared with other studies undertaken in other sisal processing countries (Brazil / Tanzania).

V.2 Recommendations

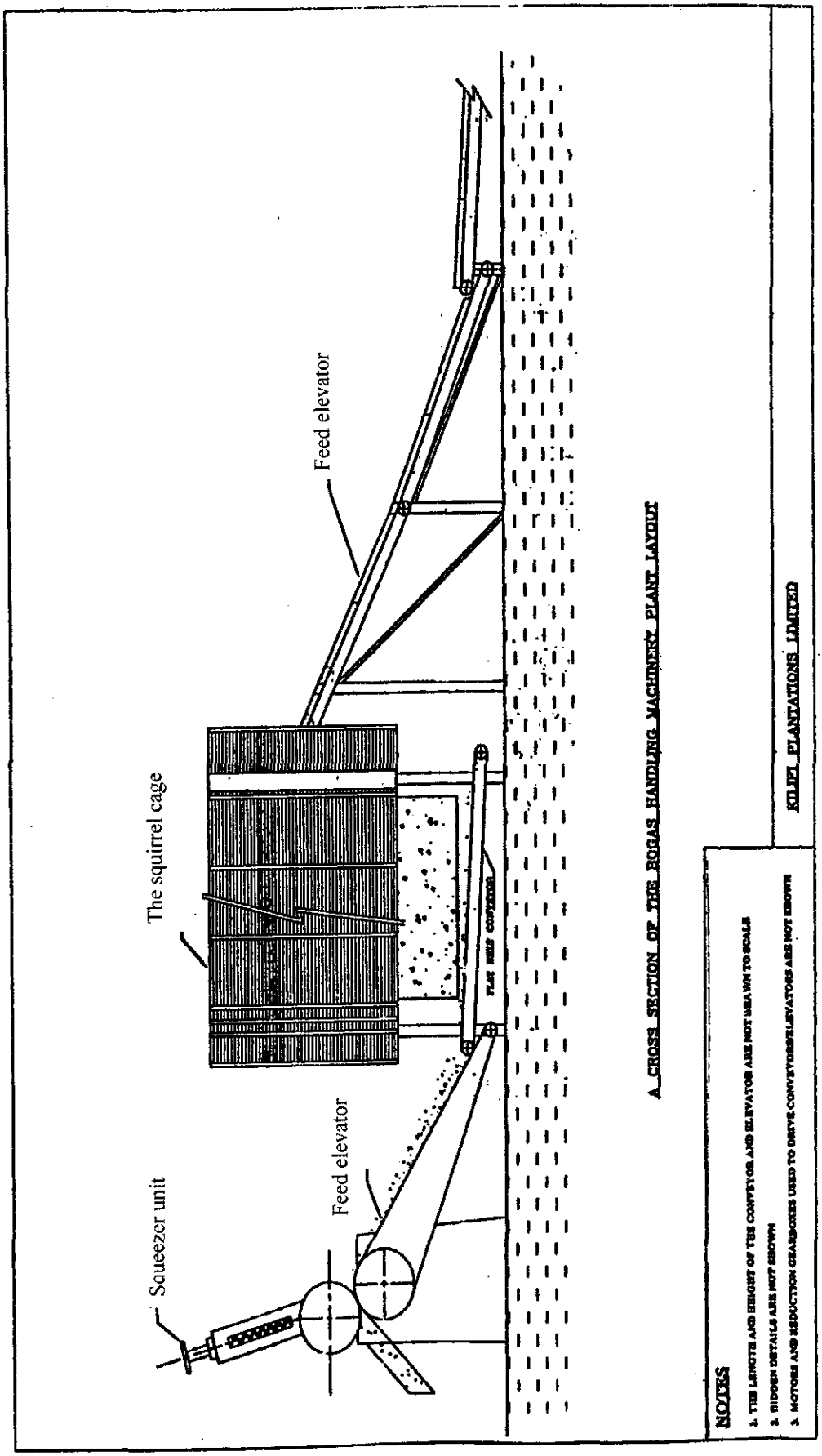
- Bogas is bulky and should be fed to animals near the source;
- Bogas should be ensiled during the wet season for use during the dry season;
- Bogas is low in protein and fibre, and it should therefore be fed together with supplements high in protein and other forages;
- Further studies are recommended to verify the results from this study and to establish the effect of bogas on rumen fermentation and nutrient metabolism;
- The economics of drying bogas to reduce cost of transportation should be evaluated for it to be availed to farmers around sisal estates or stored for use during the dry season;
- Further experiments should be conducted following a revised design.

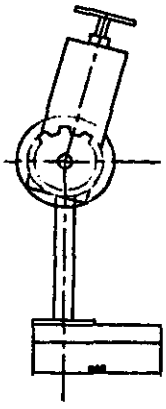
The financial appraisal prepared by Kilifi Plantations assumed that the diets using bogas were suitable for the beef steers, sheep and goats and that the sale price of the animals would be higher than the purchase price due to weight gains. The results of the experiments conducted indicate that this assumption might be true for beef steers, and for sheep that presented some weight gain in the two last months of the trials. While for goats it is still not well defined. Considering the poor execution of the experiments it is suggested to review this financial appraisal in the future.

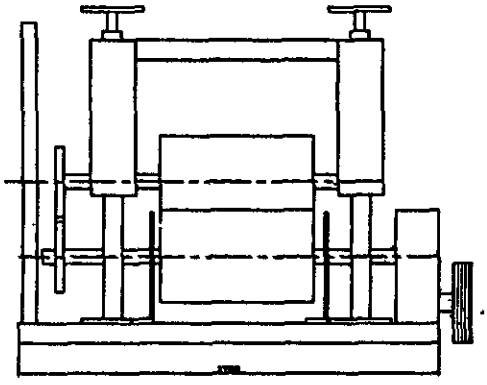
Annex 1. Original and revised protocol of experiments

	Original	New protocol
1. Treatments (No.)	3	3
2. Animal/treatment (No.)		
- Dairy cows	30	36
- Beef cattle	30	30
- Goats	30	42
- Sheep	20	42
3. Animals to be purchase by the project		
- Dairy cows	20	36
- Beef cattle	20	20
- Goats	20	28
- Sheep	20	42
4. Animals to be sheltered		
- Dairy cows	20	36
- Beef cattle	20	30
- Goats	20	42
- Sheep	20	42
5. Duration of the trials (months)		
- Dairy cows	48	26 (2 lactations)
- Beef cattle	48	9
- Goats	48	6
- Sheep	48	6
6. Cost/year (USD)		
1998 (year1)	80,220	80,220
1999	58,040	72,680
2000	43,540	48,540
2001	46,500	37,220
2002	10,360	
Total Cost (USD)	238,660	238,660

Annex 2. Bogas recovery system design drawings

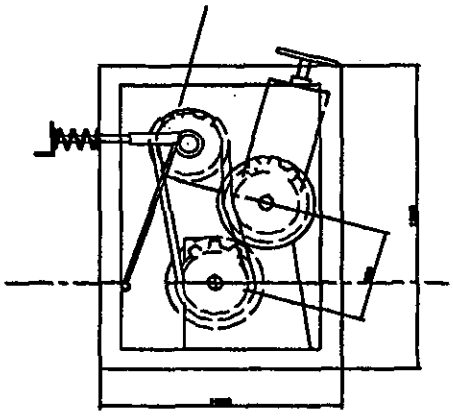




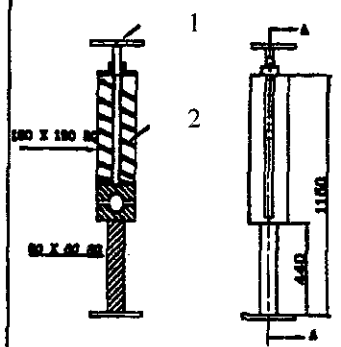


ASSEMBLY OF THE SQUEEZER
[the engine details not shown]

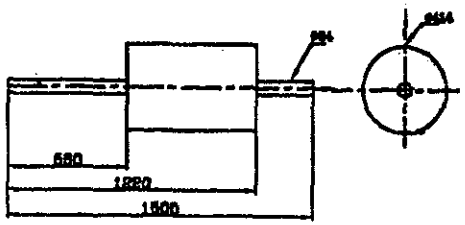
Chain tensioning sprocket



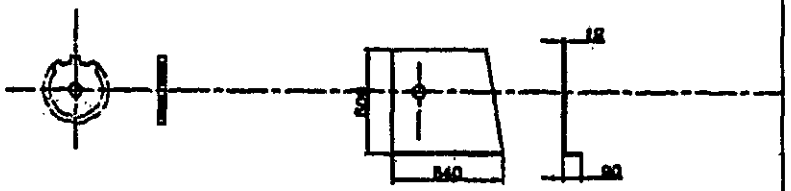
AN END ELEVATION OF THE ASSEMBLED SQUEEZER SHOWING THE DRIVING MECHANISM AND CHAIN TENSIONER



UPPER ROLLER SUPPORT
(2 OFF)

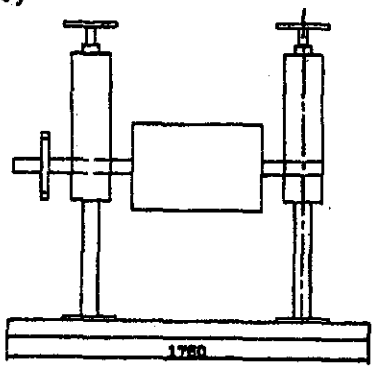


SQUEEZING ROLLER (2 OFF)

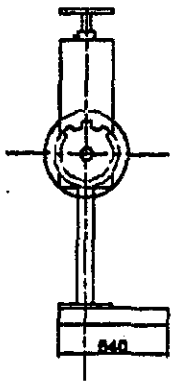


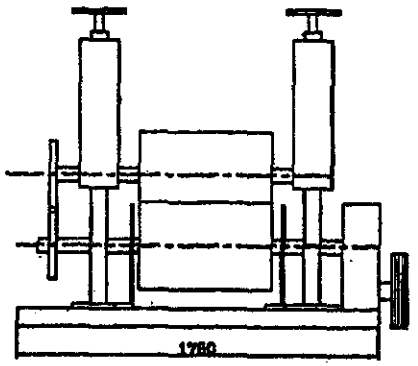
ROLLERS DRIVING
SPROCKET (2 OFF)

LOWER ROLLER SUPPORT
(2 OFF)

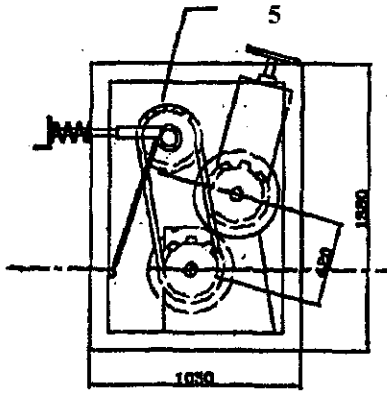


ASSEMBLY OF THE UPPER ROLLER
AND ITS SUPPORT

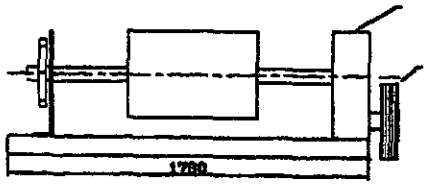




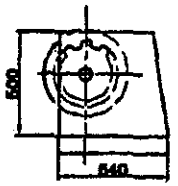
ASSEMBLY OF THE SQUEEZER



AN END ELEVATION OF THE
ASSEMBLED SQUEEZER
SHOWING THE DRIVING
MECHANISM AND CHAIN
TENSIONER

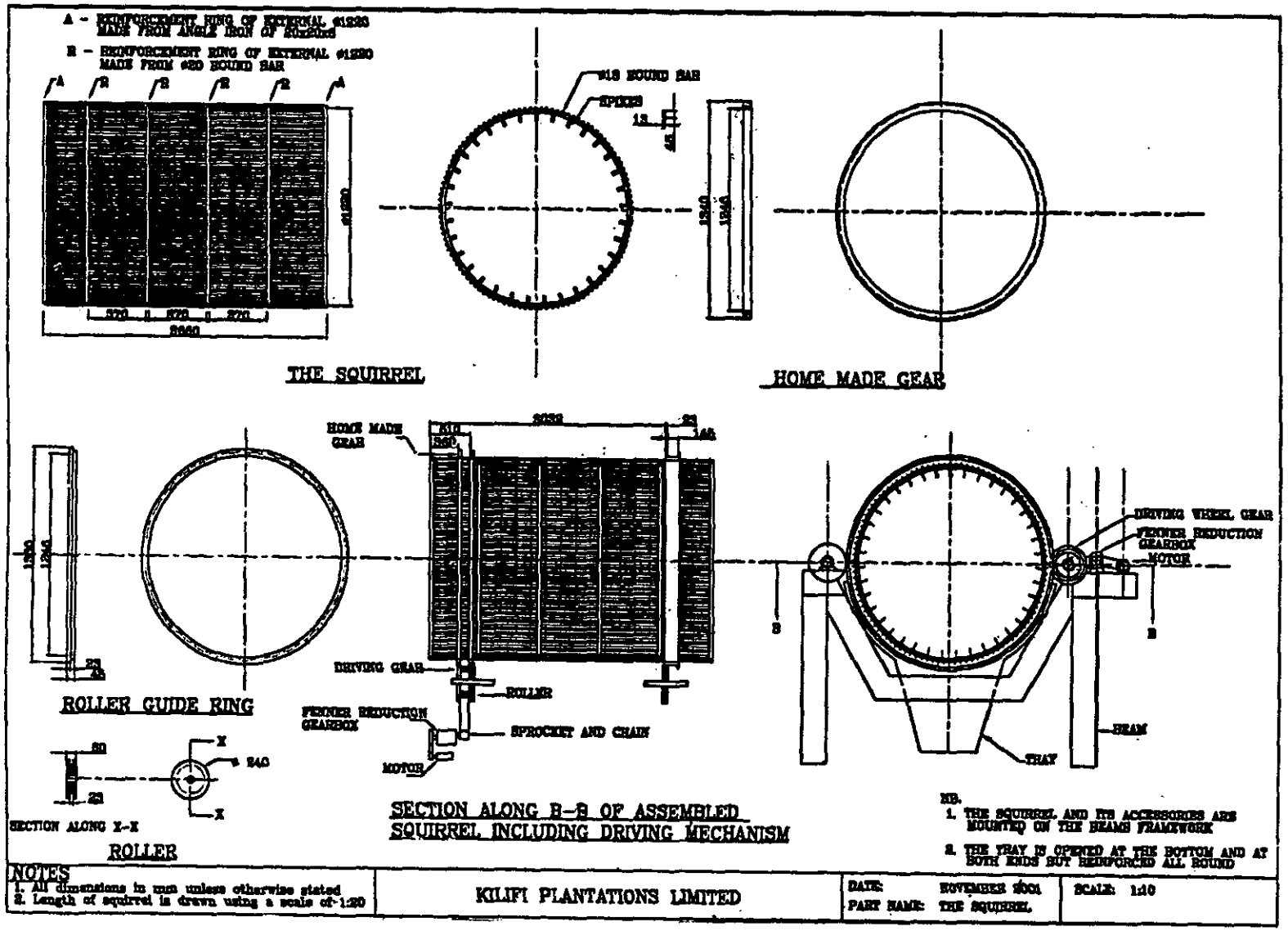


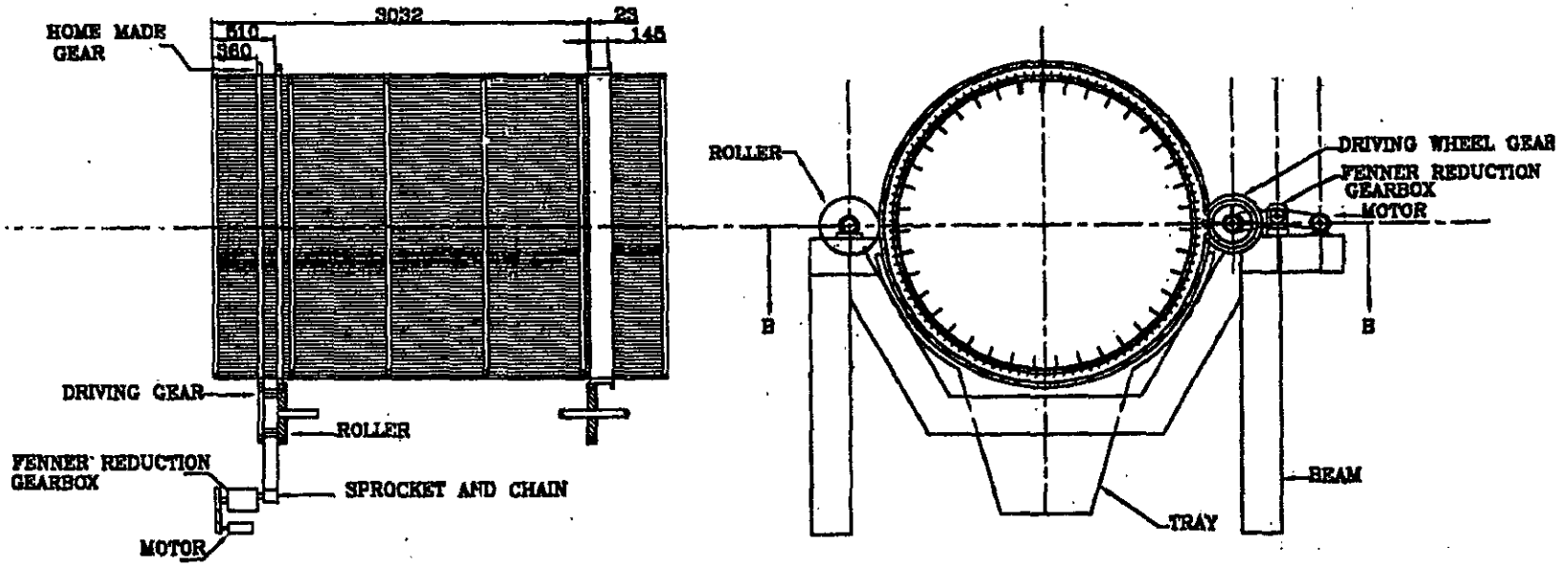
ASSEMBLY OF THE LOWER ROLLER
AND ITS SUPPORT



1 Clamping screw
2 Compressing ring
3 Fenner reduction gearbox
4 Driving pulley
5 Chain Tensioning Sprocket

NOTES	KILIFI PLANTATIONS LIMITED	DATE: NOVEMBER 2001 PART NAME: SQUEEZING UNIT	SCALE: 1:10

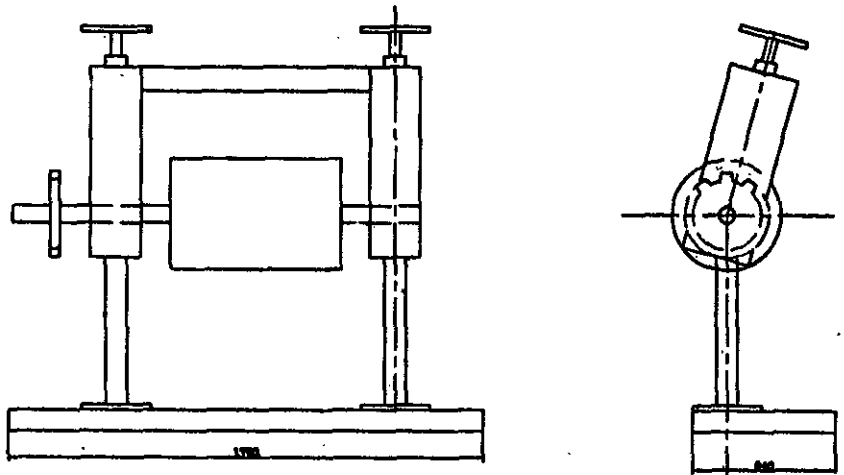

A - REINFORCEMENT RING OF EXTERNAL ø1220 MADE FROM ANGLE IRON OF 50x50x6
B - REINFORCEMENT RING OF EXTERNAL ø1200 MADE FROM ø20 ROUND BAR
ø18 ROUND BAR
SPIKES
THE SQUIRREL
HOME MADE GEAR
HOME MADE GEAR
DRIVING WHEEL GEAR
FENNER REDUCTION GEARBOX
MOTOR
ROLLER GUIDE RING
DRIVING GEAR
ROLLER
FENNER REDUCTION GEARBOX
SPROCKET AND CHAIN
MOTOR
TRAY
BEAM
SECTION ALONG X-X
ROLLER
SECTION ALONG B-B OF ASSEMBLED SQUIRREL INCLUDING DRIVING MECHANISM
NB.
1. THE SQUIRREL AND ITS ACCESSORIES ARE MOUNTED ON THE BEAMS FRAMEWORK
2. THE TRAY IS OPENED AT THE BOTTOM AND AT BOTH ENDS BUT REINFORCED ALL ROUND
NOTES
1. All dimensions in mm unless otherwise stated
2. Length of squirrel is drawn using a scale of 1:20
KILIFI PLANTATIONS LIMITED
DATE: NOVEMBER 2001
PART NAME: THE SQUIRREL
SCALE: 1:10



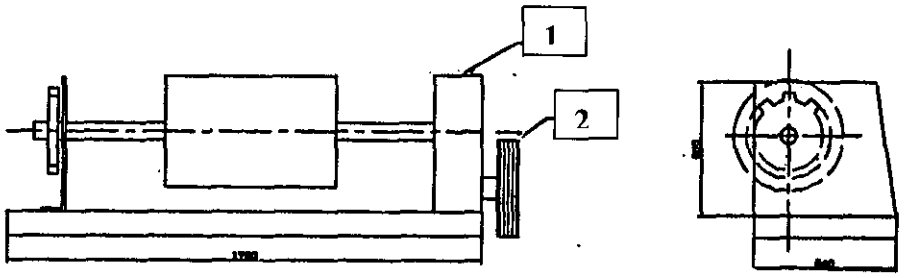
SECTION ALONG B–B OF ASSEMBLED SQUIRREL INCLUDING DRIVING MECHANISM

NB,

1. THE SQUIRREL AND ITS ACCESSORIES ARE MOUNTED ON THE BEAMS FRAMEWORK
2. THE TRAY IS OPENED AT THE BOTTOM AND AT BOTH ENDS BUT REINFORCED ALL ROUND

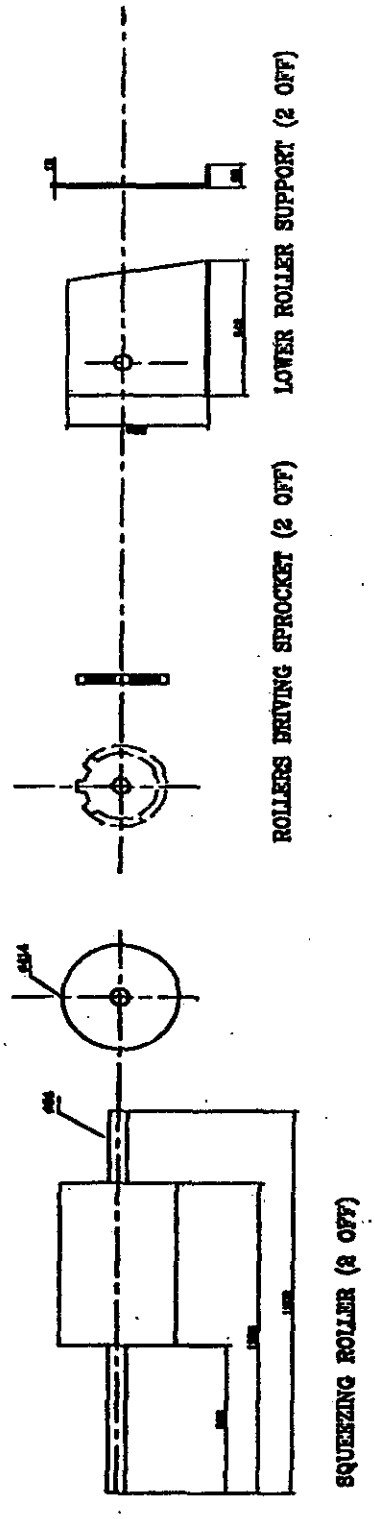


ASSEMBLY OF THE UPPER ROLLER AND ITS SUPPORT

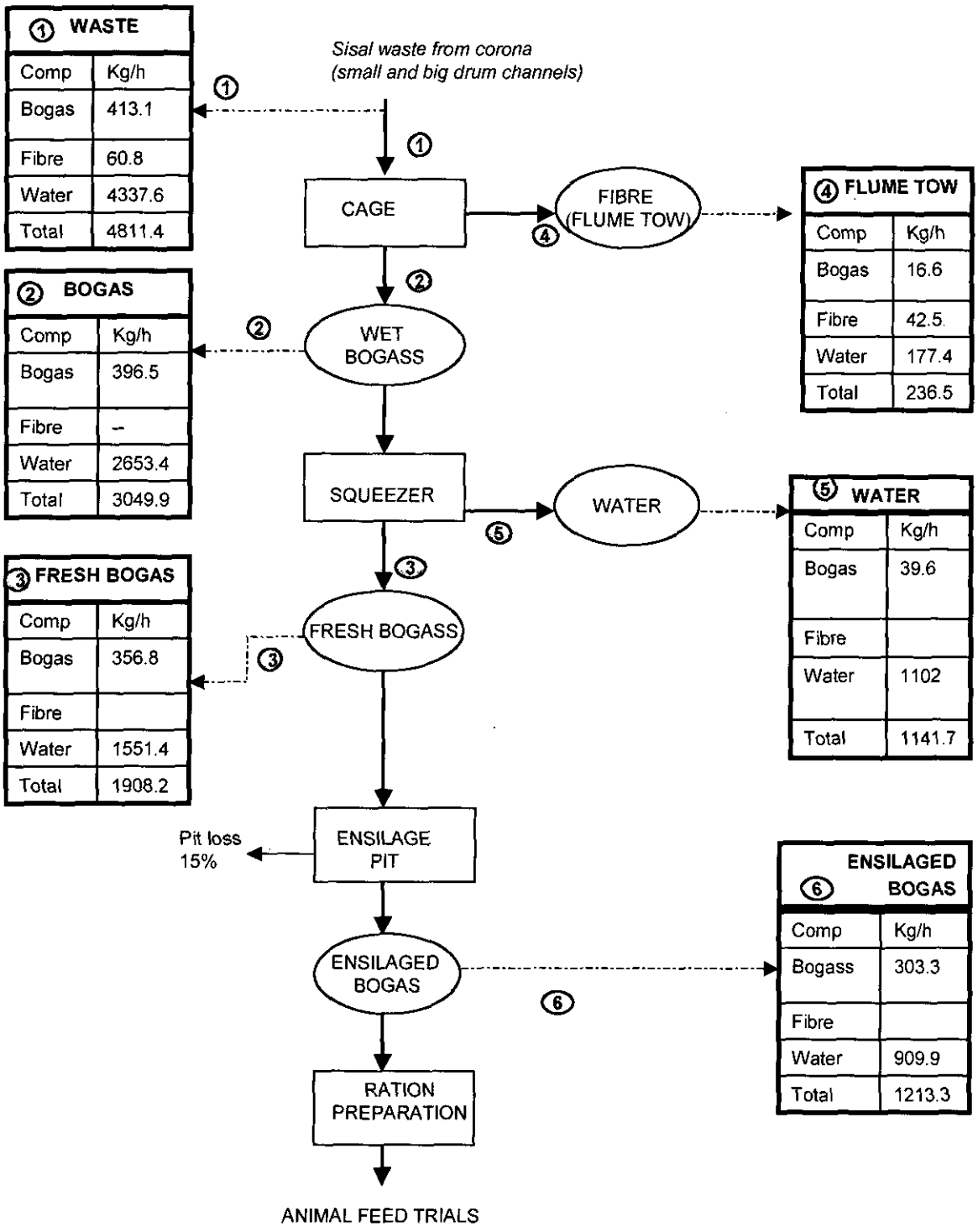


ASSEMBLY OF THE LOWER ROLLER AND ITS SUPPORT

1 – Fenner reduction gearbox
2 – Driving pulley

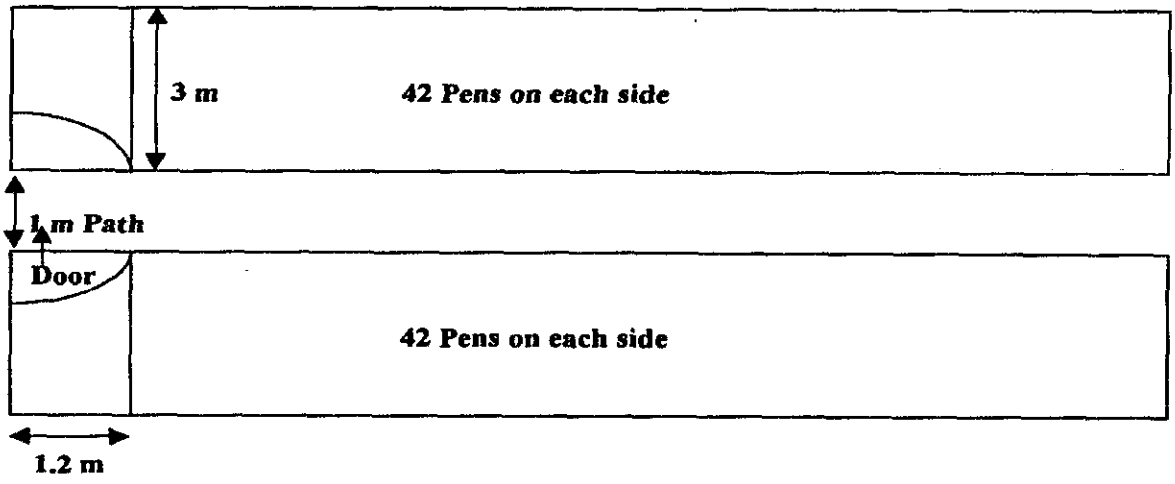

LOWER ROLLER SUPPORT (2 OFF)
ROLLERS DRIVING SPROCKET (2 OFF)
SQUEEZING ROLLER (2 OFF)

Annex 3. Mass flow diagram of the bogas recovery system

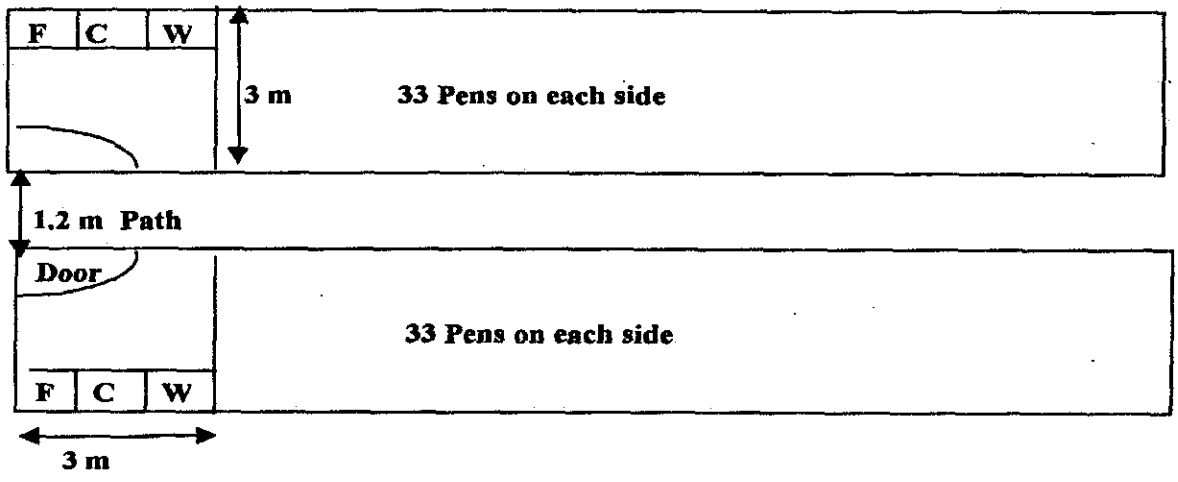


Annex 4. Stalls used to house animals

A. SHEEP AND GOAT PENS



B. BEEF AND DAIRY COW PENS



F fodder, **C** concentrate, **W** water troughs

NB
Store and milking parlour located close to the cow pens

Drawing not to scale

Annex 5. Diet composition

Table 1: Steers

Composition of the diets for steers [kg dry matter (DM)]			
	Treatment group		
Ingredient	**Control**	**Fresh bogas**	**Ensiled bogas**
Panicum infestum	3.60	1.00	1.00
Sisal boles	0.50	1.13	1.13
Cane molasses	0.60	0.23	0.23
Fresh bogas	-	1.80	-
Ensiled bogas	-	-	1.80
Maize bran	0.51	0.85	0.85
Maize germ meal	0.44	0.35	0.35
Wheat bran	2.73	2.64	2.64
Cotton seed cake	0.18	0.28	0.28
Urea	0.04	0.07	0.07
Total dry matter (DM)	**8.60**	**8.35**	**8.35**
Cost/steer/day (US$)	0.36	0.37	0.37
Metabolisable energy (MJ/kg DM)	9.20	9.50	9.50
Crude protein (g/kg)	135	141	141

Table 2: Dairy cows

Composition of the diets for dairy cows [kg dry matter (DM)]			
	Treatment group		
Ingredient	**Control**	**Fresh bogas**	**Ensiled bogas**
Panicum infestum	7.00	3.50	3.50
Sisal boles	0.25	0.25	0.25
Cane molasses	1.13	1.13	1.13
Fresh bogas	0	2.52	0
Ensiled bogas	0	0	2.52
Maize bran	1.31	1.31	1.31
Maize germ meal	1.32	1.32	1.32
Wheat bran	0.88	1.76	1.76
Copra cake	0.44	0.44	0.44
Cotton seed cake	0.93	0.93	0.93
Urea	0.06	0.06	0.06
Maclick plus	0.30	0.30	0.30
Limestone	0.0098	0.10	0.10
Total Dry Matter (DM)	**13.6298**	**13.62**	**13.62**
Cost/cow/day (US$)	0.62	0.61	0.61
Metabolisable energy (MJ/kg DM)	9.80	10.0	10.0
Crude protein (g/kg)	102	107	107

Table 3: Sheep and goats

Composition of the diets for sheep and goats [kg dry matter (DM)]			
	Treatment group		
Ingredient	**Control**	**Fresh bogas**	**Ensiled bogas**
Panicum infestum	0.40	0.20	0.20
Fresh bogas	0	0.2	0
Ensiled bogas	0	0	0.20
Maize bran	0.09	0.09	0.09
Wheat bran	0.09	0.09	0.09
Total Dry Matter (DM)	**0.58**	**0.58**	**0.58**
Cost/animal/day (US$)	0.01	0.01	0.01
Metabolisable energy (MJ/kg DM)	7.9	8.1	8.1
Crude protein (g/kg)	114	102	102

Annex 6. References

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Annex 7. Raw data

The raw data collected during the experiments and included in the final report prepared by Kilifi Plantations Ltd., is presented below.

Values used to calculate means reported for sheep

Animal No.	Treatment Group	Initial weight (kg)	Average weight (kg)	Weight gain (kg)
KS01	Fresh bogas (A)	22.0	22.3	5.0
KS02	A	25.0	23.5	1.0
KS03	A	24.0	24.1	3.0
KS04	A	20.5	20.5	3.5
KS05	A	24.0	22.4	1.0
KS06	A	24.0	23.0	3.0
KS07	A	21.0	19.4	2.0
KS08	A	19.0	20.1	4.0
KS09	A	20.0	21.6	5.0
KS11	A	19.0	19.3	4.0
KS12	A	21.0	22.4	5.0
KS13	A	20.0	18.7	-1.0
KS14	A	20.0	18.7	-1.0
KS15	A	23.0	22.0	2.5
KS16	Ensiled bogas (B)	20.0	19.4	3.0
KS18	B	20.0	22.0	7.0
KS19	B	14.0	16.2	8.0
KS21	B	20.5	21.9	5.5
KS22	B	24.0	21.2	1.0
KS23	B	24.0	24.6	4.0
KS24	B	23.0	22.9	4.0
KS25	B	19.0	19.7	3.0
KS26	B	21.0	21.8	4.0
KS27	B	16.0	18.7	6.0
KS28	B	21.0	20.9	2.0
KS29	Panicum (C)	24.0	24.3	3.0
KS30	C	26.0	26.1	4.0
KS31	C	27.0	27.0	2.0
KS32	C	22.0	21.3	3.0
KS34	C	24.0	23.1	-0.5
KS35	C	25.0	22.1	-3.0
KS36	C	26.0	23.0	-2.0
KS37	C	24.0	23.4	2.0
KS38	C	27.0	25.1	-1.0
KS39	C	27.0	24.1	1.0
KS40	C	25.0	23.5	1.5

Live weights (kg) recorded for sheep from which reported mean values were calculated

Sheep No.	KS01	KS02	KS03	KS04	KS05	KS06	KS07	KS08	KS09	KS11	KS12	KS13	KS14
Group	A	A	A	A	A	A	A	A	A	A	A	A	A
Dec 1999	22.0	25.0	24.0	20.5	24.0	24.0	21.0	19.0	20.0	19.0	21.0	20.0	20.0
Jan 2000	22.5	23.5	23.8	20.5	20.5	22.2	20.2	18.2	21.2	18.5	21.8	19.9	19.0
Feb	19.0	20.0	21.5	18.5	20.5	20.0	15.0	19.0	21.0	17.0	20.0	17.5	17.5
Apr	21.0	23.0	24.0	19.0	22.0	22.0	18.0	21.5	21.0	19.0	23.0	18.0	18.0
May	27.0	26.0	27.0	24.0	25.0	27.0	23.0	23.0	25.0	23.0	26.0	19.0	19.0

Sheep No.	KS15	KS16	KS18	KS19	KS21	KS22	KS23	KS24	KS25	KS26	KS27	KS28
Group	B	B	B	B	B	B	B	B	B	B	B	B
Dec 1999	23.0	20.0	20.0	14.0	20.5	24.0	24.0	23.0	19.0	21.0	16.0	21.0
Jan 2000	21.0	19.0	21.0	15.5	22.5	19.0	24.0	21.5	18.0	21.0	16.5	21.0
Feb	20.5	18.5	21.0	14.5	19.0	19.0	23.0	20.0	21.0	19.0	21.0	19.0
Apr	20.0	16.5	21.0	15.0	21.5	19.0	24.0	23.0	18.5	23.0	18.0	20.5
May	25.5	23.0	27.0	22.0	26.0	25.0	28.0	27.0	22.0	25.0	22.0	23.0

Sheep No.	KS29	KS30	KS31	KS32	KS34	KS35	KS36	KS37	KS38	KS39	KS40
Group	C	C	C	C	C	C	C	C	C	C	C
Dec 1999	24.0	26.0	27.0	22.0	24.0	25.0	26.0	24.0	27.0	27.0	25.0
Jan 2000	23.5	24.5	26.5	20.5	22.5	22.0	23.5	23.0	24.0	21.5	23.5
Feb	23.0	23.0	24.0	19.5	23.0	21.5	20.0	22.5	24.0	22.0	23.0
Apr	24.0	27.0	28.5	19.5	22.5	20.0	21.5	21.5	24.5	24.0	22.5
May	27.0	30.0	29.0	25.0	23.5	22.0	24.0	26.0	26.0	26.0	23.5

Values used to calculate means reported for goats

Animal No.	Group	Initial weight (kg)	Average weight (kg)	Weight loss (kg)
KG01	A	24.0	21.6	2.0
KG03	A	17.0	18.6	+3.0 (gain)
KG04	A	26.0	20.1	9.0
KG05	A	20.0	16.9	5.0
KG06	A	18.0	16.1	2.0
KG08	A	19.0	18.6	0.0
KG09	A	19	17.1	3.0
KG10	A	22.0	19.8	3.0
KG11	A	20.0	19.4	4.0
KG12	A	25.0	21.4	4.0
KG13	A	15.0	12.7	4.0
KG15	B	25.0	21.7	3.0
KG18	B	19.0	18.1	2.0
KG19	B	17.0	15.4	4.0
KG22	B	15.0	17.5	+3.0
KG23	B	22.0	17.5	6.0
KG24	B	18.0	17.6	0.0
KG25	B	21.0	16.8	6.5
KG26	B	20.0	19.0	0.0
KG28	B	15.0	14.8	+1.0
KG29	C	19.0	19.1	0.0
KG32	C	20.0	17.1	5.0
KG33	C	21.0	19.6	1.0
KG34	C	15.0	15.1	+0.5
KG35	C	17.0	16.2	1.5
KG36	C	14.0	15.1	+4.0
KG38	C	18.0	16.9	1.5
KG39	C	20.0	18.4	2.0
KG40	C	20.0	19.7	0.0
KG41	C	20.0	18.4	2.0
KG44	C	14.0	11.9	4.0

Body weights recorded for goats from which reported mean values were calculated

Goat No.	KG01	KG03	KG04	KG05	KG06	KG08	KG09	KG10	KG11	KG12	KG13
Group	A	A	A	A	A	A	A	A	A	A	A
Sep	24.0	17.0	26.0	20.0	18.0	19.0	19.0	22.0	20.0	25.0	15.0
Oct	23.5	17.0	25.0	19.5	17.5	18.5	18.0	21.0	19.0	24.0	14.0
Nov	20.6	17.8	23.0	17.0	17.5	18.6	17.5	20.0	18.5	20.0	14.0
Dec	20.0	19.0	20.0	16.0	15.0	18.0	16.5	19.0	20.0	19.0	13.0
Jan	20.0	19.5	14.0	15.0	14.5	18.0	16.0	18.0	20.0	19.5	12.0
Feb	21.0	20.0	15.5	15.5	14.5	19.0	17.0	19.5	23.0	21.0	12.0
Mar	22.0	20.0	17.0	15.0	17.0	19.0	16.0	19.0	16.0	21.0	11.0

Goat No.	KG15	KG18	KG19	KG22	KG23	KG24	KG25	KG26	KG28
Group	B	B	B	B	B	B	B	B	B
Sep	25.0	19.0	17.0	15.0	22.0	18.0	21.0	20.0	15.0
Oct	24.0	18.5	17.0	15.0	19.0	16.0	21.0	20.0	14.5
Nov	22.0	18.0	16.5	16.0	20.0	16.0	19.0	19.0	14.0
Dec	20.0	18.0	15.0	18.0	16.0	17.0	15.0	18.0	15.0
Jan	26.0	18.0	14.5	19.5	14.5	18.0	13.0	17.0	14.0
Feb	23.0	18.0	14.5	21.0	15.0	20.0	14.0	19.0	15.0
Mar	22.0	17.0	13.0	18.0	16.0	18.0	14.5	20.0	16.0

Goat No.	KG29	KG32	KG33	KG34	KG35	KG36	KG38	KG39	KG40	KG41	KG44
Group	C	C	C	C	C	C	C	C	C	C	C
Sep	19.0	20.0	21.0	15.0	17.5	14.0	18.0	20.0	20.0	20.0	14.0
Oct	19.0	19.5	21.0	14.5	17.0	13.0	17.5	20.0	20.0	19.0	14.0
Nov	18.0	18.0	18.0	14.0	16.0	13.0	17.5	19.0	19.0	18.0	13.0
Dec	19.0	17.0	18.0	15.0	15.5	15.0	16.5	18.0	18.5	17.0	11.0
Jan	20.0	16.0	19.0	15.0	15.0	16.0	16.0	16.5	20.0	18.5	10.5
Feb	19.5	14.0	20.0	16.5	16.5	17.0	16.5	17.5	20.5	18.	11.0
Mar	19.0	15.0	20.0	15.5	16.0	18.0	16.5	18.0	20.0	18.0	10.0

Body weights recorded for steers from which values were calculated for statistical analysis

Steer No	J252	J406	J230	J256	J312	J390	J472	J258	J248	J574
Group	A	A	A	A	A	A	A	A	A	A
Week 1	95	105	97	95	87	94	75	96	97	70
3	130	109	118	127	107	107	99	108	129	88
6	126	150	120	130	125	120	125	105	125	150
9	150	175	148	150	160	160	168	140	163	179
12	255	185	195	220	210	170	180	195	220	150
15	240	210	220	220	230	190	210	220	220	150
18	255	255	235	250	250	180	240	230	250	170
21	280	275	235	250	255	200	245	250	250	185
24	300	265	250	270	260	245	270	270	285	195

Steer No	J232	J314	J582	J452	J468	J282	J414	J288	J284	J320
Group	B	B	B	B	B	B	B	B	B	B
Week 1	97	86	75	81	78	75	80	86	97	83
3	123	114	103	89	116	101	104	124	120	99
6	230	150	128	126	125	130	130	136	125	120
9	129	175	150	158	155	155	169	165	159	145
12	230	200	185	140	210	200	200	215	200	160
15	268	235	210	155	230	220	225	220	215	175
18	255	250	240	170	255	240	240	240	235	215
21	280	250	215	195	265	255	250	250	240	190
24	290	260	280	220	270	275	275	260	250	215

Steer No	J504	J404	J210	J336	J272	J498	J266	J304	J228	J576
Group	C	C	C	C	C	C	C	C	C	C
Week 1	82	78	95	92	101	83	90	85	103	77
3	104	103	125	107	134	95	129	119	139	86
6	139	130	130	148	120	130	135	128	120	145
9	170	175	164	159	149	168	160	150	160	180
12	185	180	190	220	210	150	200	200	220	170
15	205	215	210	250	230	175	240	205	245	175
18	255	225	225	190	180	255	240	215	255	195
21	230	225	235	270	250	200	255	235	255	205
24	250	250	235	260	270	210	280	235	270	210

Values used for statistical analysis for dairy cattle

Cow No.	Treat-ment group	Breed	Initial milk yield (kg)	Calving date	Month of lacta-tion	Lacta-tion number	Average milk yield (kg/w)	Average decline	Weeks milked	Disease
E408	A	Cross (C)	13.0	21/09/99	1	2	8.6	0.195	33	1
E581	A	Friesian (F)	10.0	16/08/99	2	2	8.8	0.187	27	1
F729	A	F	12.9	25/07/99	3	1	11.1	0.086	21	1
E933	A	F	8.3	18/06/99	4	1	7.8	0.096	17	
E277	A	C	14.6	20/10/99	0	2	11.2	0.208	28	1
E113	A	F	20.7	27/09/99	1	3	7.9	0.133	33	
G309	A	Sahiwal (S)	10.4	10/07/99	4	1	8.0	0.140	26	
D403	A	F	8.4	25/07/99	3	3	8.6	0.022	14	
E141	A	C	11.7	01/07/99	4	1	8.7	0.123	33	1
E929	A	C	9.0	23/07/99	3	1	7.7	0.077	32	1
D615	A	C	8.0	14/08/99	2	2	7.2	0.103	24	
G609	A	S	6.9	05/09/99	2	1	3.5	0.113	32	
E583	B	F	10.9	25/08/99	2	2	10.3	0.147	33	
F553	B	F	9.3	25/07/99	3	1	8.9	0.056	33	
E985	B	F	9.0	03/08/99	3	2	7.3	0.086	33	
F139	B	S	7.4	05/07/99	4	1	6.2	0.097	33	
F743	B	S	8.9	03/07/99	4	1	8.2	0.05	27	
F343	B	S	8.0	14/07/99	3	1	8.1	0.034	33	1
F933	B	S	7.6	14/09/99	1	1	7.5	0.015	33	
E267	B	F	9.4	31/07/99	3	2	7.8	0.089	28	
D271	B	S	9.6	05/08/99	3	2	7.1	0.154	33	1
E371	B	C	5.4	14/06/99	4	2	2.9	0.152	25	
E657	C	F	11.9	05/06/99	5	2	8.4	0.139	33	
E983	C	F	8.7	03/07/99	4	1	8.4	0.112	24	
F065	C	C	9.4	21/07/99	3	1	7.8	0.07	33	
E763	C	C	11.8	04/07/99	4	2	11.7	0.004	33	
F495	C	S	10.4	27/08/99	2	1	8.8	0.061	33	
E507	C	S	8.2	25/06/99	4	2	8.1	0.047	17	
F293	C	C	8.1	12/07/99	4	1	7.5	0.098	33	
E855	C	C	10.4	10/07/99	4	1	7.8	0.081	33	
F145	C	C	12.1	19/08/99	2	2	8.9	0.067	33	

Milk yields recorded for dairy cattle from which values were calculated for statistical analysis

Cow No.	E407	E581	F729	E933	E277	E113	G309	D403	E141	E929	D615	G609
Group	A	A	A	A	A	A	A	A	A	A	A	A
Week 1	13.0	10.0	12.9	8.3	14.6	10.7	10.4	8.4	11.7	9.0	9.0	6.9
2	12.9	10.7	12.4	8.1	14.9	10.3	9.0	8.0	10.6	8.7	8.0	4.5
3	13.0	12.7	12.6	9.0	13.6	10.7	9.1	9.6	12.0	9.3	9.0	6.1
4	11.1	11.0	12.4	8.6	13.9	8.1	9.0	8.4	11.0	9.0	7.8	5.0
5	12.7	10.9	11.1	8.1	12.6	8.9	9.0	7.9	10.4	9.1	7.6	5.0
6	11.6	8.9	11.0	7.4	12.6	8.7	8.1	9.0	9.7	9.1	7.3	4.6
7	10.7	8.4	10.4	7.9	12.3	8.9	8.1	9.7	8.4	8.7	6.9	4.4
8	11.0	9.3	8.9	7.6	11.7	8.7	8.9	8.6	10.4	9.6	8.3	4.0
9	11.3	10.9	10.3	8.6	12.6	9.6	9.1	8.6	8.9	7.2	9.0	4.5
10	9.1	11.3	11.0	8.0	12.1	9.7	8.6	9.0	9.9	6.3	8.4	3.6
11	9.7	11.0	11.0	8.4	12.7	8.9	8.3	8.6	9.7	9.0	7.9	7.3
12	10.7	9.7	10.5	7.7	11.2	8.7	8.1	9.0	9.1	8.9	8.0	2.9
13	8.6	9.6	12.0	7.0	11.3	8.0	7.9	7.9	8.3	7.3	6.8	3.3
14	7.4	8.0	11.4	7.4	10.9	8.3	7.3	7.9	7.6	7.7	6.3	2.9
15	7.0	8.3	11.6	8.4	10.9	8.3	7.3	-	7.5	7.0	7.0	3.7
16	7.6	8.7	11.0	6.6	10.9	7.3	7.3	-	7.9	5.0	6.7	3.9
17	7.0	7.6	10.9	6.2	9.9	8.3	7.1	-	8.1	5.5	6.5	3.2
18	6.6	5.5	9.0	-	10.4	7.4	5.9	-	7.9	5.9	4.4	2.1
19	7.4	7.1	11.3	-	9.9	7.3	7.1	-	9.3	7.3	6.9	2.3
20	3.4	7.3	11.0	-	12.0	8.8	7.3	-	10.0	9.7	8.3	2.0
21	4.7	7.0	9.6	-	10.3	7.4	7.0	-	7.7	10.1	7.4	2.1
22	6.1	7.6	-	-	10.9	8.4	8.0	-	9.3	9.3	7.0	2.4
23	7.3	7.3	-	-	8.9	7.6	8.0	-	8.4	7.9	7.0	2.0
24	6.9	7.6	-	-	9.6	8.0	6.9	-	7.7	7.4	3.5	2.0
25	7.0	6.5	-	-	7.7	7.6	7.1	-	8.1	7.8	-	2.0
26	7.2	7.4	-	-	8.4	5.1	7.1	-	7.6	7.0	-	2.6
27	7.5	6.5	-	-	8.6	5.4	-	-	6.9	6.9	-	3.6
28	8.9	-	-	-	9.2	5.6	-	-	6.7	6.0	-	2.6
29	7.4	-	-	-	-	5.9	-	-	7,6	6.5	-	2.5
30	7,3	-	-	-	-	5.9	-	-	7.6	5,6	-	2,7
31	6.8	-	-	-	-	5.8	-	-	7.0	7.4	-	2.7
32	7.6	-	-	-	-	5.7	-	-	7.4	6.1	-	2.70
33	7.3	-	-	-	-	7.3	-	-	6.9	-	-	-

Cow No.	E583	F553	E985	F139	F743	F343	F933	3267	D271	E371
Group	B	B	B	B	B	B	B	B	B	B
Week 1	10.9	9.3	9.0	7.4	8.9	8.0	7.6	9.4	9.6	5.4
2	12.7	10.4	8.4	7.3	9.7	9.0	7.6	8.5	8.4	5.5
3	12.7	11.0	8.4	8.3	9.8	10.0	8.4	9.4	8.4	5.5
4	11.9	9.4	8.0	7.5	7.6	9.0	7.5	8.5	8.6	5.1
5	12.3	10.1	7.9	7.9	8.8	8.0	7.8	8.5	8.9	4.1
6	11.2	8.1	8.0	7.1	9.1	7.0	6.8	7.6	8.3	3.3
7	10.9	8.3	7.7	6.6	7.8	8.0	6.3	8.3	8.0	3.5
8	13.0	9.9	9.0	7.5	7.8	9.0	8.5	8.9	8.8	4.0
9	12.1	10.3	9.1	7.4	8.8	8.0	8.5	9.0	7.6	3.8
10	12.4	10.7	8.7	7.1	8.1	8.0	7.6	8.4	7.4	3.0
11	11.6	9.1	8.1	7.0	7.8	8.0	7.8	8.8	10.0	1.9
12	11.9	9.3	8.0	8.1	8.9	8.0	7.8	8.1	9.4	2.3
13	11.3	8.1	7.9	6.3	8.3	8.0	7.4	7.6	8.1	1.9
14	10.9	9.0	7.6	7.4	8.1	9.0	7.5	7.9	6.3	2.0
15	20.9	8.9	7.9	5.1	9.1	8.0	8.0	7.8	7,3	2,8
16	11.1	9.0	7.0	6.1	7.4	8.0	7.1	7.9	8.6	2.0
17	10.6	10.1	6.1	5.4	8.0	7.0	6.6	7.6	8.5	2.0
18	8.3	5.0	4.1	2.8	6.1	9.0	6.4	6.1	5.6	2.0
19	10.4	9.0	6.9	6.3	8.0	10.0	7.4	7.9	7.4	2.0
20	11.3	10.3	7.1	6.3	8.8	7.0	7.8	7.6	8.4	2.0
21	8.9	8.8	6.9	6.3	8.1	7.8	7.5	7.4	7.2	2.0
22	9.0	8.0	7.7	5.4	7.5	8.0	8.0	6.9	7.1	2.0
23	10.3	9.1	7.6	5.8	8.6	11.0	7.6	7.1	7.6	1.9
24	9.3	8.3	6.7	5.4	7.8	7.0	7.4	6.6	6.4	1.9
25	8.9	8.1	6.6	6.0	7.0	7.0	7.6	7.1	6.4	2.0
26	8.6	8.3	7.3	6.8	7.6	8.0	8.4	7.1	6.8	-
27	8.1	7.4	5.7	4.9	8.1	7.0	8.1	6.8	4.8	-
28	7.9	8.3	5.7	4.0	-	8.0	7.8	6.5	3.7	-
29	7.7	7.3	6.3	5.6	-	6.0	6.6	-	4.3	-
30	8.1	8.6	6.4	4.8	-	8.0	7.1	-	4.9	-
31	8.2	9.0	5.4	4.5	-	8.0	6.5	-	3.8	-
32	9.4	8.4	6.4	5.0	-	8.0	7.1	-	4.0	-
33	8.4	9.0	7.1	5.3	-	7.0	6.9	-	4.3	-

Cow No.	E657	E983	F065	E763	F495	E507	F293	E855	F145
Group	C	C	C	C	C	C	C	C	C
Week 1	11.9	8.7	9.4	11.8	10.4	8.2	8.1	10.4	12.1
2	11.6	8.9	8.3	11.9	10.2	8.4	8.3	10.1	9.9
3	10.6	9.7	7.5	11.8	9.7	8.7	9.7	7.9	11.0
4	10.3	9.3	8.5	11.8	9.0	6.8	8.3	8.2	10.8
5	9.4	9.6	9.0	11.7	9.3	8.0	8.3	9.3	10.0
6	8.7	8.1	9.1	11.9	9.7	9.9	8.3	8.9	7.6
7	9.3	9.3	9.0	11.5	9.1	8.6	8.6	8.3	8.0
8	9.8	9.8	8.8	11.5	9.3	8.2	8.3	9.3	9.5
9	10.4	9.6	9.4	11.4	8.7	7.9	9.4	8.0	8.9
10	9.4	9.3	7.3	11.9	8.3	8.1	7.1	8.0	9.6
11	10.4	9.4	8.6	12.0	10.3	9.3	8.2	8.1	10.7
12	10.1	8.7	7.3	11.6	8.3	8.3	9.3	8.4	9.3
13	7.7	7.8	8.0	11.7	9.0	7.3	7.3	7.5	8.5
14	9.0	7.9	8.6	11.7	8.6	8.1	7.0	7.4	8.6
15	8.9	7.7	8.4	11.8	9.0	8.0	8.3	8.0	9.7
16	7.9	8.3	8.0	11.4	9.3	7.6	8.3	9.1	8.3
17	7.5	7.5	6.5	11.5	10.2	7.0	7.3	7.0	8.0
18	6.1	6.1	6.7	11.6	7.6	-	5.7	6.6	6.0
19	7.7	7.4	9.1	11.7	8.3	-	7.6	7.1	9.3
20	8.1	8.0	7.9	11.8	9.9	-	8.3	7.1	9.0
21	8.6	8.2	7.2	11.8	10.0	-	8.4	8.2	8.8
22	7.0	7.0	7.1	11.5	9.9	-	6.4	8.9	9.0
23	7.6	6.9	6.7	11.7	9.0	-	6.9	6.7	9.1
24	6.7	7.3	5.9	11.7	8.4	-	7.6	7.9	9.1
25	7.0	-	6.6	11.7	7.4	-	6.6	6.9	8.9
26	7.0	-	7.5	11.6	6.5	-	7.0	6.5	7.7
27	8.1	-	6.9	11.8	7.4	-	7.1	6.9	6.0
28	7.4	-	8.0	11.8	8.3	-	5.9	7.1	8.9
29	6.4	-	7.0	12.1	6.4	-	5.3	5.9	7.9
30	6.5	-	7.3	11.9	7.5	-	5.2	6.5	8.2
31	7.4	-	7.2	12.0	9.0	-	6.0	6.2	8.8
32	6.4	-	6.4	11.9	9.0	-	5.9	7.3	9.1
33	7.3	-	6.7	11.8	8	-	5.9	8.1	8.3

Annex 8. Financial Evaluation

The financial analysis presented in the final report prepared by Kilifi Plantations Ltd. is reproduced in this annex.

1.3 Investments and operational costs

1.3.1 Introduction

It is assumed that the farmer has 30 dairy cows, 36 steers, 42 sheep and 42 goats. Apart from the cows it is assumed that the animals are bought during the first year. The cost of a dairy cow is US$ 562.5 and this cost is not included in the reported calculations. It could be considered among the fixed assets and depreciated over 15 years.

Other assumptions have been made in study formulation as follows:

- 42 sheep and 42 goats are disposed after one year at US$ 31.25 each and replaced by similar numbers at a cost of US$ 18.75 per animal.
- All the beef steers are disposed after 2 years for US$ 187.5 each and replaced by a similar number at a cost of US$ 125 per animal. No beef animals are sold in the first year.
- The lactation period of each dairy animal is 320 days and a kg of milk is sold at US$ 0.225
- Exchange rate of 1US$ to Kshs 80 is used.

1.3.2 Investment costs

A Squeezing Unit.

2 pieces of squeezing rollers	=	US$ 25
3 tension sprockets/gears	=	US$ 25
1 driving pulley	=	US$ 5.6
1 Shaft for holding the rollers	=	US$ 37.50
1 Motor	=	US$ 562.50
Total cost of Squeezing Unit	=	**US$ 655.62**

B Squirrel cage.

2 Angles lines	=	US$ 12.50
4 Reinforcement rings	=	US$ 23.50
112 pieces of squirrel bars	=	US$ 1680
Labor & Welding costs	=	US$ 45
Stand for squirrel cage	=	US$ 125
1 motor	=	US$ 187.50
Gear reduction unit Small	=	US$ 306.25
Big	=	US$ 445
Total cost of squirrel cage	=	**US$ 2824.75**

C Mixer, conveyer belts and accessories.

66 meters conveyer belts	=	US$ 1072.50
11 meters stands of angle iron	=	US$ 137.5
8 Conveyer rollers	=	US$ 250
3 *motors*	=	US$ 562.50
1 Mixer	=	US$ 750
1 Electrical switch for the system	=	US$ 1500
Total cost of conveyer and accessories		**US$4272.50**

Total investment cost (A+B+C) is US$ 7752.88
Depreciation = 37% per year.

1.3.3 Operational costs

Labor cost

5 people per day	=	US$ 7.5
Labor cost per annum	=	US$ 2337.50
Monthly labor cost	=	US$ 225

Power/Electricity cost

20kw/hr	=	US$ 0.125/hr
Consumption per day	=	US$ 20
Annual power cost	=	US$ 7300

1.3.4 Bogas Ration (fresh/ensiled) costs for different animals

Dairy Unit

13.62 kg DM of the feed is offered to a cow daily costs US$ 0.61

30 cows use 30 x US$ 0.61 = US$ 18.45 / day.

Monthly cost US$ 553.50 or annual cost US$ 6642 per year

Beef unit

8.34 kg DM is offered to each animal daily at a cost of US$ 0.37

36 steers use 36 x 0.37 = US$ 13.23/ day.

Monthly cost US$ 396.90 or US$ 4762.80 per year.

Sheep/goat Unit

0.58 kg DM is offered to each animal at a cost of US$ 0.01.

42 sheep use 42 x 0.01 = US$ 0.4 / day.

Or US$ 12.6 per month or US$ 151 per year)

Revenue

Animal disposal

42 goats =US$ 1312.50

42 sheep =S$ 1312.50

30 beef =US$ 5625.00

36 dairy cows =36x 7 kg milk x US$ 0.225 x320days = US$ 19176 /year.

1.4. Financial feasibility appraisal

One criterion for selecting a viable project is to use the NPV (Net Present Value). If NPV>0 then select the project. This is shown in Table 1.2 for five years. Within the five years, the break-even point is not achieved. The costs are likely to be lower than in the calculations shown in Table 1.2 because the feed offered could equal to intake if better troughs were used to minimize feed wastage. The cost of the goats and sheep could also be reduced where breeding stock is maintained on the farm. There are too many assumptions and calculations beyond five years were found not to be useful. It

is however evident that the project is viable for the different types of animals. The most profitable enterprise is likely to be dairy, beef and sheep/goats in that order.

Table 1.2 A five yearly budget for the proposed sisal feed mill (US$)

EXPENSES Item	Year 1	Year 2	Year 3	Year 4	Year 5
Equipment	7753	2866	1806	1138	717
Salaries	2738	2738	2738	2738	2738
Power	7300	7300	7300	7300	7300
Feed Dairy	6642	6642	6642	6642	6642
Beef	4763	4763	4763	4763	4763
Sheep	151	151	151	151	151
Goats	151	151	151	151	151
Purchase					
Goats	777	777	777	777	777
Sheep	777	777	777	777	777
Beef	3500	3500	3500	3500	3500
Total	34552	29665	28605	27937	27516
REVENUE					
Milk Sales	19174	19174	19174	19174	19174
Sale-Goats	1312	1312	1312	1312	1312
Sheep	1312	1312	1312	1312	1312
Beef		5625	5625	5625	5625
Total	21798	27423	27423	27423	27423
BALANCE	**-12754**	**-2242**	**-1182**	**-514**	**-93**

NB

The financial calculations in Table 1.2 are obviously only descriptive of one case study. Every situation will warrant careful financial investigation . There are many factors not allowed for like:

1) Cost of buildings
2) Cost of money (loans/overdrafts)
3) Cost of land
4) General opportunity costs

Essentially it is apparently true to say that bogas and bole feeding gives extremely marginal returns and is not economically viable except in special circumstances.

Printed in Austria
V.05-91170—May 2006—200

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