JATROPHA SUPPORT PROGRAMME

Pipal Limited

THE ECONOMIC VIABILITY OF GROWING JATROPHA CURCAS AS A SUSTAINABLE BIOFUEL FEEDSTOCK IN EAST AFRICA

The DEGJSP press crushing *Jatropha curcas* L at Rea Vipingo, Kilifi 2011

ANNEXES

MAY 2012

Annex one: The project set up and main activities

DEG- the strategic alliance contributes to DEG's mandate of promoting effective development projects in the private sector of developing countries.

DEG:-

- Supported the planning, design, liaising and promotion of the strategic alliance both internally and externally.
- Maximized development impacts.
- Co-financed the required measures from the PPP Facility which is financed by the Federal Ministry of Economic Cooperation and Development of the Federal Republic of Germany.

Pipal Ltd has been responsible for the management and coordination of the PPP– Project.

Pipal:

- Controlled the cost and performance, supported and ensured that the companies fulfill the trials and obligations.
- Set up a project team with expert advice from Dr. George Francis.
- Ensured information exchange and coordinated the steering committee meetings and Executive summary of the findings.

The 9 companies

Kenya

- Lesiolo Grain Handlers Ltd. (LGHL) – Grain storage – Nakuru.
- Kreative Roses East Africa (Kenya)– Rose Farm partnered with Saffron Energy – Medicinal herbs-Laikipia.
- Rea Vipingo Plantations Ltd. – Sisal estate- Kilifi Kenyan coast.
- Kocfinaf Company Ltd. – Coffee Farm –Thika.
- Tropical Farm Management (Kenya) Ltd. – Coffee Estate Management – Makuyu.
- Vegpro Kenya– Horticultural products – Naivasha.

Tanzania

- Minjingu Mines and Fertilisers Ltd. – Fertiliser production, part of Mac Group – Arusha.
- Tanganyika Wattle Company Ltd. – Forestry products Part of Raiply- Njombe South Mbeya.

Uganda

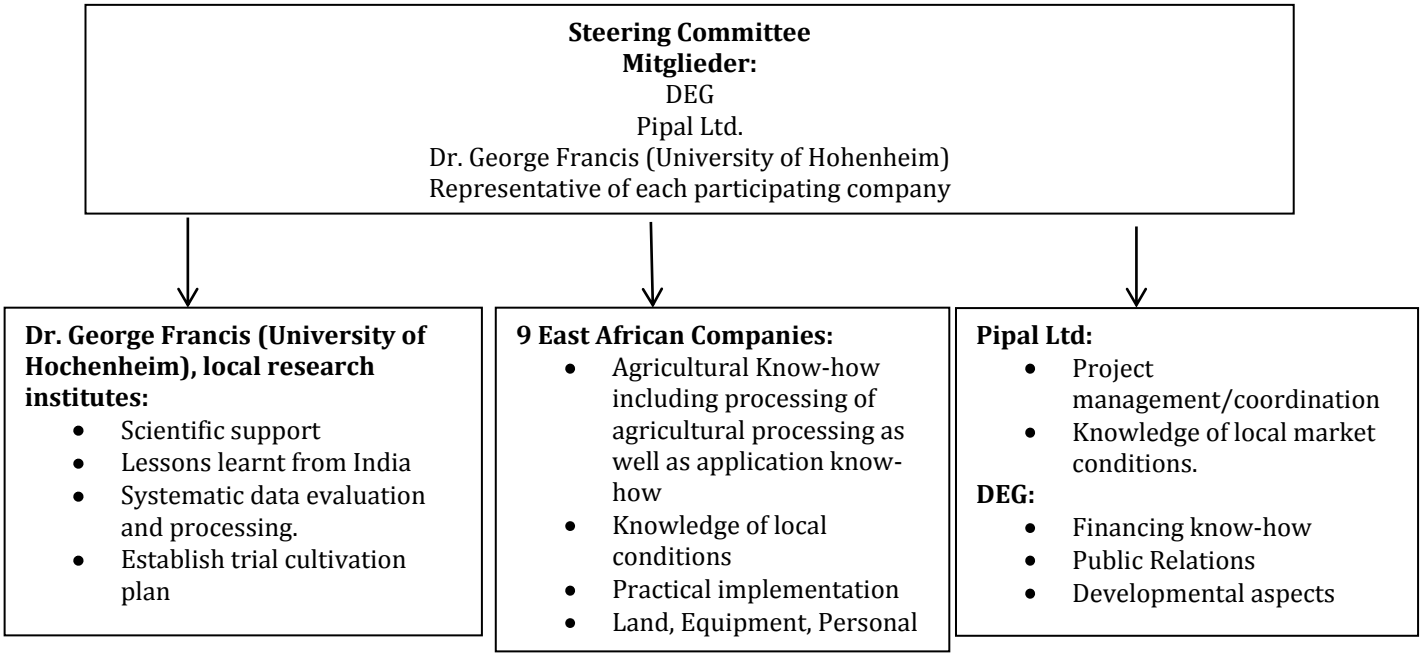
- Multiple Hauliers (EA) Ltd. – Transport and Haulage Company- Masindi.

The companies conducted the field trials and collected the data.

They:-

- Brought in 10 Hectares of previously marginal land,
- Set up comparative field trials,
- Kept detailed records,
- Appointed a person in charge and
- Kept Pipal Ltd informed of any difficulties, delays etc.

Organisational Arrangement:



Main activities carried out

Five steering committee meetings were held and well attended during the project period. Activities in these meetings included training on jatropha oleo-chemistry by Jan Hoitsma of Solarix, a discussion on bees with Ernest Simeoni and a demonstration of ' Fieldbook' by Joseph Kasango of CIMMYT. (International Maize and Wheat Improvement Centre)

The project managers visited each site, some a few times, except TFM (Tropical Farm Management Ltd.) in Makuyu. The agronomists travelled extensively to set up and support data collection from the sites. A case study was made of Sunbiofuels Mozambique and Tanzania. Pipal Ltd has been a representative of the project and the private sector on the Kenyan National Biofuels committee, research and policy sub-committees and engaged fully in policy and strategy development. Beryn Otieno of KEFRI (Kenya Forestry Research Institute) supported the project with pest and diseases research. The project also responded to requests for information and discussion on the potential of jatropha as a biofuel feedstock in East Africa. Numerous presentations about the project were made by the project managers and in some cases, an agronomist, at national and international conferences during the project duration. The project co-hosted a workshop on 'Biodiesel in Kenya' for visiting Brazilian ministers with ICRAF (International Center for Research in Agroforestry, World Agroforestry Center)

Annex Two – Short summary of the performance at each site

This section captures a brief overview of each site.

1. Rea Vipingo is located north of **Kilifi** in the coastal region of Kenya and recorded reasonably promising performance of various provenances among trials and especially on a small plantation previously set on an old cattle boma.

Figure 1. Rea Vipingo Cattle Boma 2009, 2010, 2011

This was driven by a number of factors including annual bimodal rainfall of about 1200mm and mean annual temperatures range between 22^{0}C and 37^{o}C. The provenance and agronomic trials planted on loamy sandy soil showed reasonable growth throughout the period even throughout a drought.

Figure 2. Rea Vipingo provenances May 2010 and July 2011

These pictures also begin to demonstrate how controlling weeds in fertile areas becomes a major management issue and most commercial companies resort to spacing that allows tractors to spray minimal quantities of glysophates. Most of the Rea Vipingo economic trial was planted on sandy soil during the drought and performed very poorly, especially at first. Rea Vipingo recorded some of the highest incidences of pest and diseases, in particular flea beetles.

Figure 3. Rea Vipingo economic trials in 2010, 2011 set in the drought of 2009.

Sisal waste had been left on a patch of soil in the middle of an economic trial field and the growth of the plants on the more nutritious soil was significantly better than those on the same row, but in less fertile soils.

Figure 4. The difference between sisal waste addtion and no fertlisation

2. Tropical Farm Management and Kofinaf The central region of Kenya covers Tropical Farm Management in **Makuyu** and Kofinaf in **Thika.** Along with Rea Vipingo, these two farms set their trials early in 2009. Despite good management practices by the farm agronomists, the performance has been poor.

Figure 5. Germination, planting out and review activities in Tropical Farm Management and Kofinaf

As shown in the report, the most limiting factor has probably been the number of nights below 15^{o}C along with acidic soils with a low pH average of 5.4 and an annual average rainfall of about 971mm.

A few provenances recorded flowering at TFM while the other trials showed poor performance. Initial stunted growth in the 2009 drought meant that even when some rainfall occurred, in these limiting conditions, the plants were very slow to recover.

Saffron in **Laikipia, Lesiolo Grain Handers** in **Nakuru** and **Vegpro in Naivasha** lie in the central rift valley part of Kenya. Coupled with the especially minimum temperatures associated with high altitude of over 1800m above sea level, the soils are relatively low in organic matter, phosphorus, calcium and sulphur. Annual rainfall varies between 400mm and 750mm and temperatures vary between 9 ^{o}C and 26 ^{o}C. It was noted that in colder areas, the dormancy and leaf shedding during the cold dry summers seems to be longer and the leaves tend to take longer to return.

Figure 6. Saffron Jatropha curcas site in Laikipia from planting out late 2009 to July 2011

3. Saffron in Laikipia was well managed and the trial site well prepared. However this area has suffered from extended droughts in 2009, 2010 and 2011 and the jatropha plants experienced poor growth. With most plants being short with single stems and bearing no fruit, what was anecdotally noticeable was the very positive impact of underground anthills on the neighbouring trees. These trees were multi-branched and much higher than surrounding trees and the only ones to yield fruit in the first two years in limiting conditions.

4. At Lesiolo Grain Handlers in Nakuru at 2000metres above sea level (masl) in potentially limiting conditions, it has been possible to see the differences caused by soil depth. In the second picture, the leafless small jatropha plant on rocky soil in the foreground is very small compared to the intercropped jatropha behind. Any slight irrigation benefits between one plant and another were very visible, as well as the ultimate benefit of intercropping with maize due to perennial grass removal and fertilization.

Figure 7. Germination, intercropping and provenance trials in Nakuru.

Anecdotally there seemed to be a slight increase in seeds per bunch within the proximity of populated beehives to the trees.

Figure 8 . Beehives close to the Lesiolo provenance trials in Nakuru November 2011.

5. Extended **Lesiolo** small-holders site in **Bungoma**

Figure 9. Land preparation and the smallholder trial in Bungoma.

While Bungoma and Western Kenya have some potential in terms of adequate rainfall, the small holder open ground trials suffered from a lack of management. The soils had also been depleted through extensive sugar cane planting and the jatropha was damaged by the inter-cropping and livestock. The agronomist had planted two trees in the hedge of his domestic compound 10 km away close to a small well kept banana plantation. In contrast to the open field trials, reached over 2metres and fruited within in the project time

Figure 10. The small holder trial May 2012.

6. **Vegpro** provenance and agronomy trials in **Naivasha** and economic trials in **Kibwezi**

The provenance trials in Naivasha were well set out and managed. As demonstrated in the report, this area was too dry with too many nights below 12^{o} C and with lower days temperatures. The plants failed to flourish as anticipated.

Figure 11. Vegpro provenance trials in Naivasha.

The economic trials were laid out on 7 acres in Kibwezi. The site was too dry and towards the end of the project the weeds overcame the plants. The weeds have since been cleared, however initial growth was poor as, except in exceptional El Nino years, it is too dry for jatropha. Some termite damage was seen.

Figure 12. Vegpro economic trials in Kibwezi suffering from weeds.

7. **Multiple Hauliers** trial site, located in **Masindi** Uganda, has good agro-ecological conditions of overall agricultural farming. The area experiences a bimodal annual rainfall of about 1200mm and average temperature of 25^{o}C. Although the initial growth has been the most optimal of all the sites, due to poor field management and logistical issues, performance of the various provenances as well as agronomic and economic trials is below the expectation. Nevertheless some first year trees produced measurable quantities of seed and the tree will continue to grow well.

Figure 13. Masindi trials set up and height by November 2011

8. Tanganyika Wattle (TANWAT) located in Njombe **Mbeya** in Southern Tanzania at an altitude of 1900masl.Tanwat experiences mono-modal rainfall with average temperature ranges of between 9 ^{o}C and 21 ^{o}C. The site suffers from frost especially during the months of June to August. Despite the inhospitable climate, the provenance trial survived to reach 0.5m -1m in soft loamy soil close to the factory, with some plants showing vigour in the circumstances. What was noticeable here is that with generally low pest attack, the plants nearest the hedge suffered more mildew and fungal attacks.

Figure 14. The provenance trials in TANWAT Mbeya with Aza Mbaga.

The agronomy trial was planted in an old wattle nursery where the top soil had been removed and showed poor performance and a susceptibility to fungal and mildew diseases.

Figure 15. The nursery and agronomy trials in the previous wattle nursery and the economic trials on a hillside.

The 'scraping' and flattening of the site probably also compacted the highly acidic soils. In other commercial sites where land preparation has entailed removal of top soil in the clearing, Jatropha has also not seemed to perform well. Early *Jatropha* curcas growth may depend initially on the four lateral roots before the tap root is strongly established. Removing and compacting of the top soils with large machinery and earth diggers may limit initial lateral root development and so overall growth, especially in potential fair or limiting conditions.

The TANWAT economic trials were planted out a bit later in rows with deep holes across a sloping hillside. As the first frost descended on the very young plants, the cold sat in the holes and 7000 seedlings died. On the few that remained, it was recommended that the holes were filled with mulch to protect the seedlings. It is recommended that if Jatropha or other cold sensitive plants are planted on hillside that they are planted on raised ridge running down the slope with some cross drainages to hold the slope in the rains. The frost will tend to collect at the base of the ridges as it moves to the base of the hill. (Peter Whitehead, pers. comm. 2010).

9. Minjingu Mines is based in **Manyara** in **Tanzania** and experiences bimodal rainfall with annual precipitation of between 500 mm to 700mm. The mean annual temperature of the area is 25^{o}C. This area was too arid to record any significant growth and any available water was brackish. Although site has recorded flowering among and within the provenances, most of its agronomic and economic trial plants were lost to wild animals, in particular dik dik during the drought, and to weeds during the dry spell.

Figure 16. The raised seedbeds and strong seedlngs with Anup Modha at Minjingu Mines, Manyara and the economic trials amid brush on open dry land.

Annex Three: Full page versions of East African Agroclimatic Maps

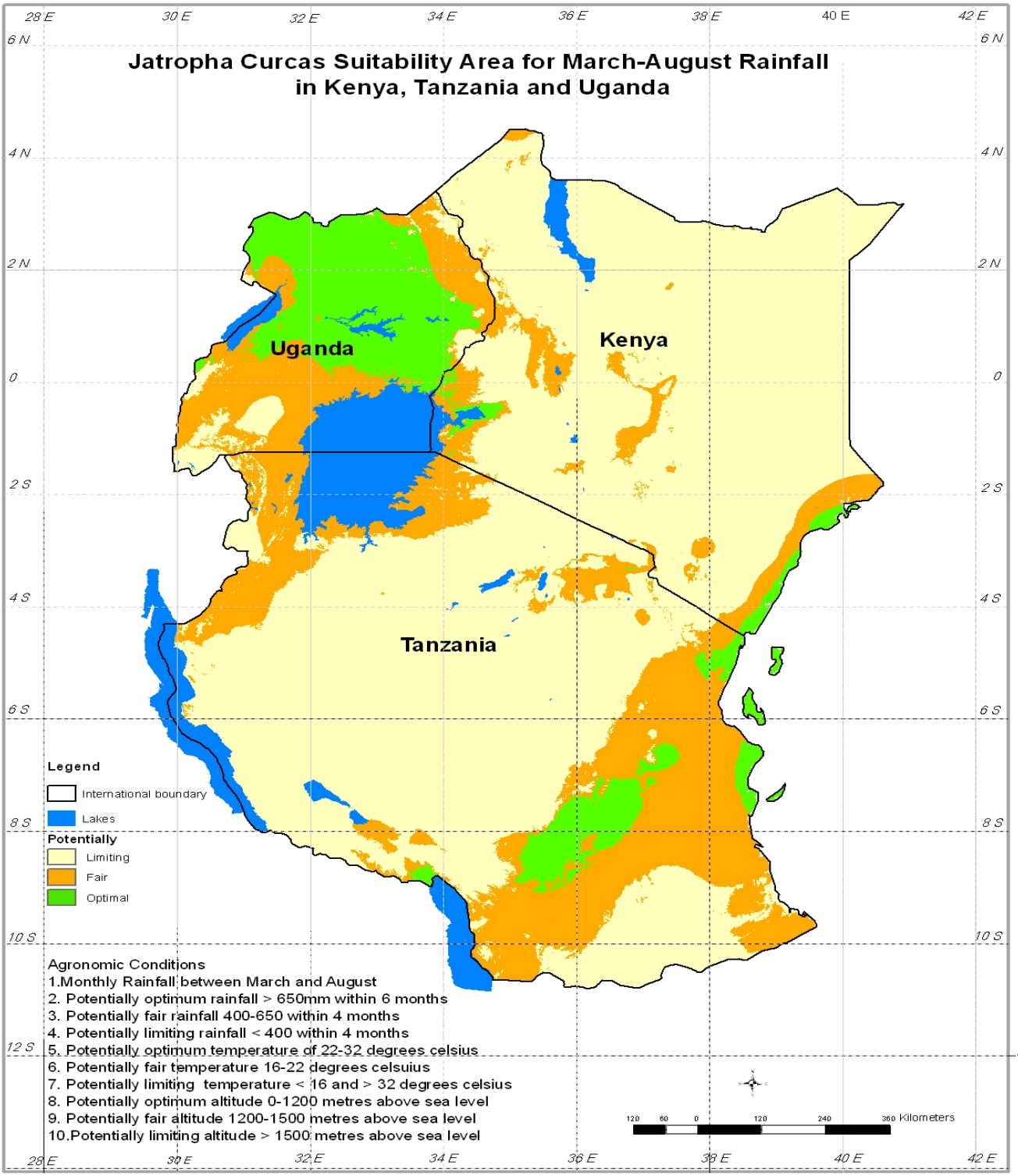


Figure 17. The potential for *Jatropha curcas L.* planting in East Africa in March based on monthly rainfall and temperature averges since 2000 and according to the parameters listed.

Details of other key limiting factors, such as areas of high conservation value, wildlife corridors, other agricultural activity, urban populations and protected areas in Kenya can be found in Mouk B., et al, (2010)

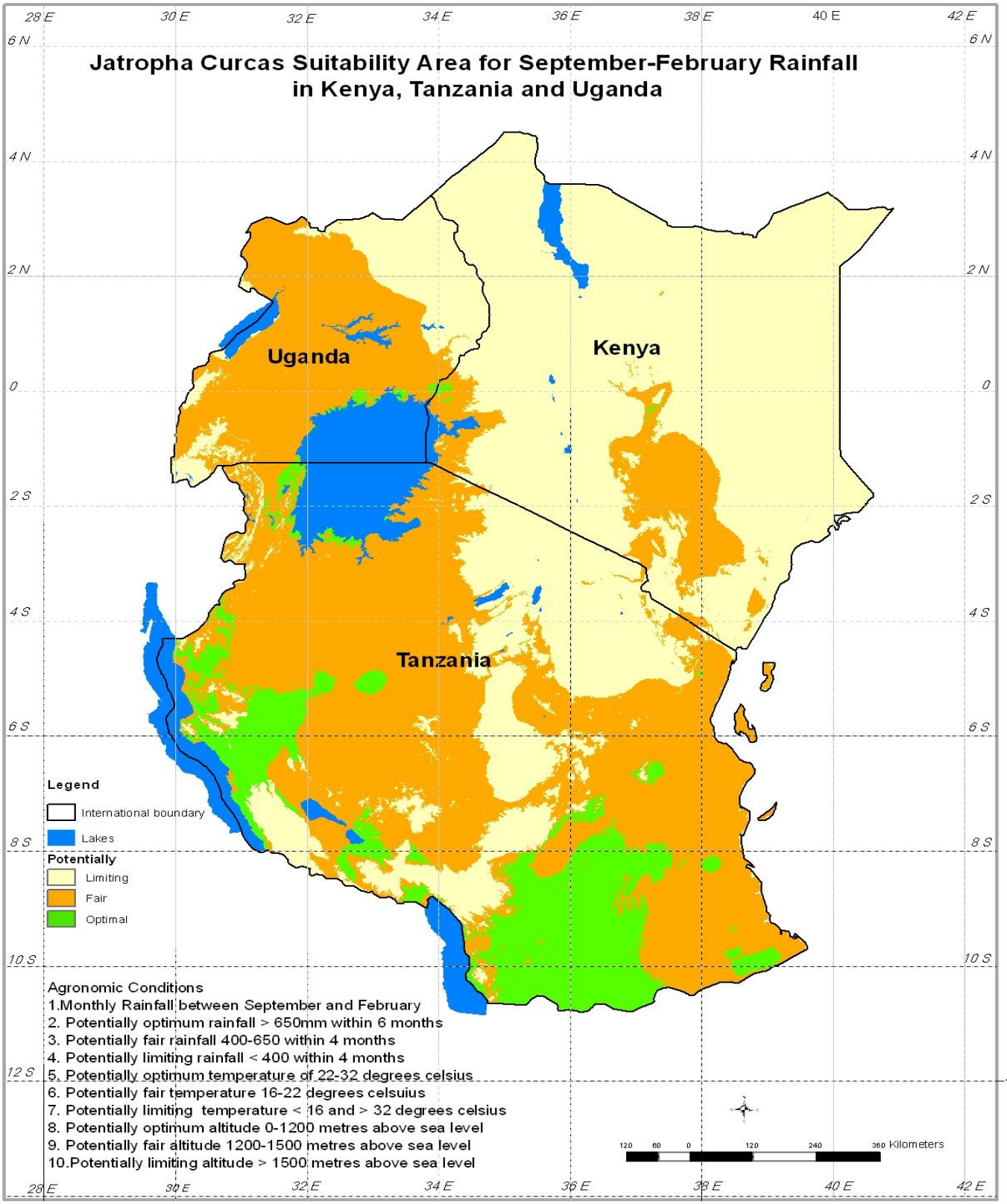


Figure 18. The potential for *Jatropha curcas L.* planting in East Africa in September based on monthly rainfall and temperature averges since 2000 and according to the parameters listed.

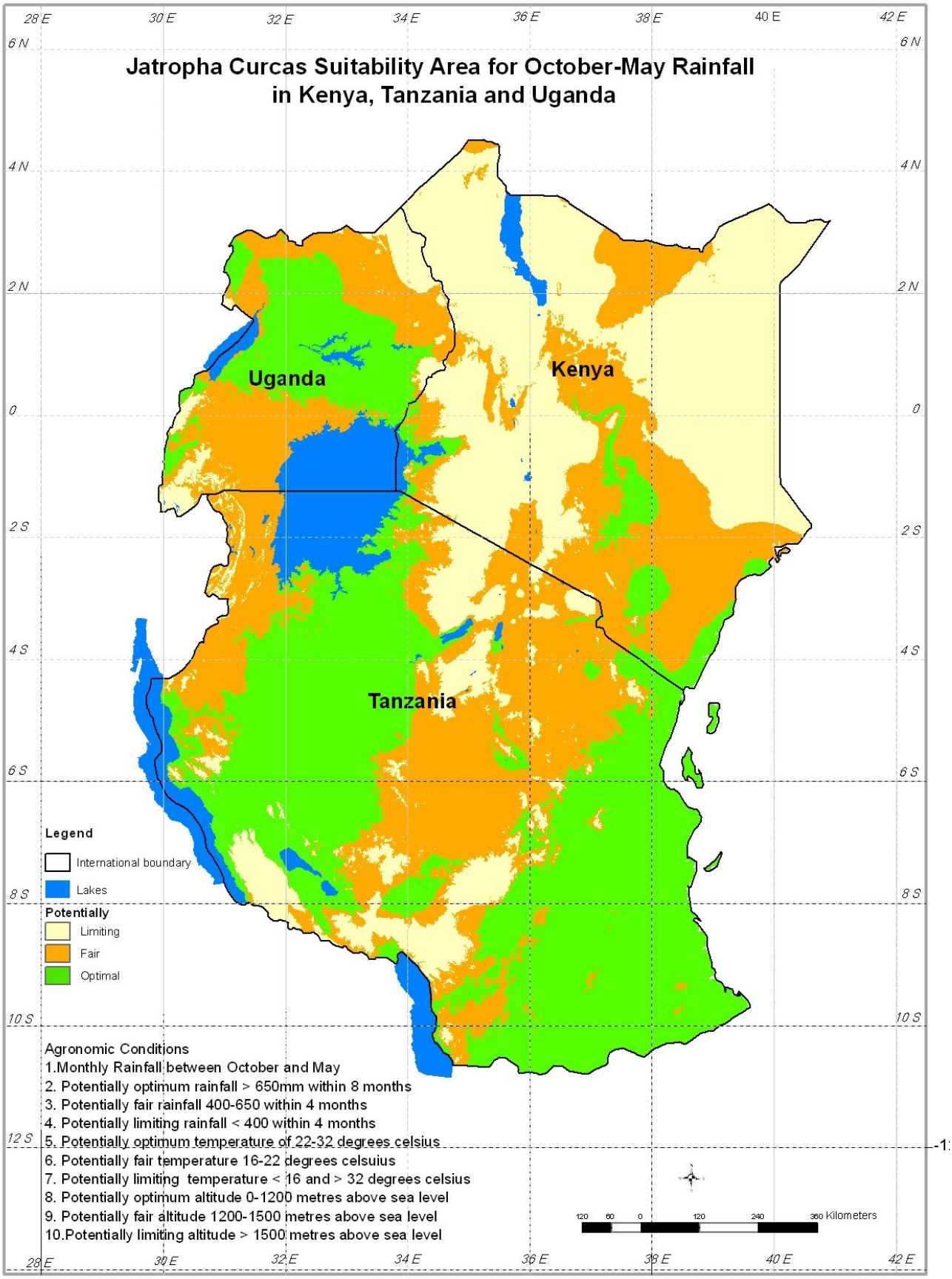


Figure 19. The potential for *Jatropha curcas L.* planting in East Africa in October with 'steady rainfall' assumed through to May the following year, based on monthly rainfall and temperature averges since 2000 and according to the parameters listed.

Annex Four: Full germination table and nursery notes: Percentage germination of each provenance (P1-22) on each site

Provenances	Thika	Makuyu	Nakuru	Laikipia	Tanwat	Manyara	Bungoma	Naivasha	Masindi	Kilifi	Percentage range
P1	18%	6%	23%	40%	69%	40%	56%	72%	56%	91%	6-91
P2	14%	5%	21%	23%	32%	35%	19%	58%	36%	83%	5-83
P3	25%	8%	35%	44%	62%	83%	67%	72%	70%	100%	8-100
P4	63%	73%	0%	39%	63%	78%	74%	49%	91%	100%	49-100
P5	15%	36%	59%	37%	53%	64%	66%	65%	80%	98%	15-98
P6	28%	43%	79%	47%	33%	76%	43%	52%	47%	100%	28-100
P7	40%	38%	51%	28%	46%	76%	78%	70%	96%	78%	38-96
P8	35%	42%	0%	23%	74%	84%	70%	86%	85%	87%	23-87
P9	18%	66%	51%	68%	64%	56%	68%	58%	63%	78%	18-78
P10	40%	0%	57%	50%	49%	54%	68%	85%	70%	67%	40-85
P11	2%	12%	3%	29%	4%	51%	9%	70%	14%	80%	2-80
P12	42%	43%	42%	76%	65%	60%	68%	56%	75%	87%	42-87
P13	38%	95%	52%	59%	46%	64%	63%	84%	69%	87%	38-95
P14	49%	85%	56%	70%	58%	66%	69%	69%	65%	87%	87-49
P15	27%	0%	51%	73%	34%	64%	58%	0%	69%	98%	27-98
P16	25%	40%	55%	20%	54%	88%	64%	75%	87%	100%	20-100
P17	26%	42%	56%	57%	56%	58%	72%	57%	67%	87%	26-87
P18	51%	56%	71%	54%	44%	70%	72%	49%	87%	84%	44-87
P19	8%	1%	27%	20%	18%	25%	31%	61%	58%	91%	1-91
P20	18%	9%	49%	8%	27%	62%	52%	52%	47%	100%	9-100
P21	8%	20%	60%	20%	45%	86%	86%	66%	91%	100%	8-100
P22	10%	35%	20%	20%	47%	60%	73%	0%	56%	53%	10-73
Overall Average	**13%**	**14%**	**29%**	**41%**	**50%**	**58%**	**60%**	**64%**	**67%**	**88%**	
Date of planting	29/1/09	22/3/09	13/5/09	3/3/09	10/9/12	5/5/09	24/7/09	5/3/09	23/7/09	13/2/09	
Main technique used	Poly tunnels	Poly tubes	Plastic cover	Crates +plastic	Troughs	Open beds	Raised open beds	Plastic cover	Open beds	Open beds	
Maximum Temp first 30 days	28.60	28.60	25.70	28.20	28.8 (24)	29.80	26.90	28	29.00	32.4	
Minimum Temp first 30days	12.9	12.9	11.7	11.2	10.78 (12)	10	13.5	8.2	17.9	23.8	

Nursery Notes: Observations and nursery notes from each site.

1) THIKA: SOCFINAF/Kofinaf Company Ltd

The jatropha seeds were soaked overnight.
The seeds were sown on 23/2/2009 and 16/3/2009.
Germination was observed from the 5th day and continued up to the 28th day.
The seedlings were transferred into polybags containing a mixture of soil: sand: manure (1:1:1)
Chlorosis of the leaves was observed and treated by magnesium.
The seedlings were kept under 70% shade net.

2) MAKUYU: Tropical Farm Management (Kenya) Ltd.

The seeds were soaked for 24hrs in a warm cow dung solution.
Germination was poor. They were then soaked at room temperature plain water for 12 hrs.
They were sown in polybags containing a mixture of sand, manure and soil at a ratio of 1:1:2 and kept in shade net for 21 days. Watering was done regularly.
Germination was observed between 7 and 9 days.
Altitude is 1500m while mean temperature was 24° C.
The P11 seeds were older. (more than 6 months). They germinated earlier (24/4/09) than the rest.
Others germinated on 7/5/09.
P19, P20, P21 seeds had been treated with an insecticide.
The rest of the provenances were healthy freshly harvested seeds.
No reported pest and disease attack in the nursery.

3) NAKURU: Lesiolo Grain Handlers Ltd.

The seeds sown in polybags containing a mixture of soil and manure at 3:1
The polybags were placed in the open.
Germination was observed between the 7th and 22nd day.
Altitude is 1720 m while mean temperature was 21° C.
P4, P8, P19, P20, P21, P22 were sown on 13/5/2009.
P5, P6, P7 were sown on 15/5/2009
P2, P7 sown on 16/5/2009.
P1, P9, P10, P12, P13, P14, P15 were sown on 25/5/2009.
P3, sown on 27/5/2009.
P11, sown on 30/5/2009.
Stem borer attacked the seedlings in the nursery.
The seedlings were vigorous.

4) LAIKIPIA: Saffron Energy Ltd. Kenya

The seeds were sown in polybags containing a mixture of sawdust, soil, wormcast and manure at 1:1:1:1 and 3 kg of NPK fertilizer.
The polybags were placed in crates kept outside under the open sky.
Later they were covered with plastic under shade netting.
Germination was observed between 6–15 days.
The altitude is 1850 masl. while mean day temperature was 26° C.
All were sown on 3/3/2009.
Powdery mildew attacked the seedlings in the nursery and was controlled by use of Rodazim.
The seedlings were generally healthy but had to stay long in the nursery due to drought.

5) MBEYA: Tanganyika Wattle Company Ltd.

The seeds sown on troughs consisting of sand: soil: manure (1:1:1).
The seeds were sown on 1/10/2009.
First emergence was observed on 15/10/2009.
Healthy seedlings with no disease/ pest incidence were observed apart from P4 which seemed to have an attack of leaf spot.
P11 had slow rate of germination.

6) MANYARA: Minjingu Mines and Fertilisers Ltd.
The seeds were sown on 1ft raised sandy soil mixed with manure.
The seeds were sown after overnight soaking and air drying in the sun for 1 hour on 5/6/2009.
Germination was observed on the 7th day and continued to the 27th day.
No pest and disease incidences were observed.

7) BUNGOMA: Western Kenya (with Lesiolo Grain Handlers Ltd)
The seeds sown on loamy soil mixed with manure and raised to 1ft in the open air by the field site.
They were sown on 24/7/ 2009 and germination was observed on 29/7/2009 and
continued up to the 28th day.
The altitude is 1500m while temperature ranged between 20-30°C.
P2 had very low germination.
Pests observed included grasshopper, leaf miners and whitefly.

8) NAIVASHA: VEGPRO Kenya
Seeds were soaked overnight in a cow dung solution (1:5).

9) MASINDI: Multiple Hauliers (EA) Ltd
The seeds were soaked in plain water overnight and sown on 1ft raised loamy soil mixed with manure.
Seeds sown on 23/7/2009.
Germination was observed between 7–28 days.
There were few seeds of P7.
Grasshopper, leaf miners, white fly were observed.
The water used for irrigation has a high Fe concentration.
P11 performed poorly. This provenance had slow germination rates.

10) KILIFI: REA Vipingo Plantations Ltd.
Seeds were soaked overnight in sisal waste water at a ratio of 1:5.
They were sown in a raised sand soil nursery. Watering was done regularly. Few seeds germinated.
Germination was re-done by soaking in plain water for 12 hours.
Germination observed between the 15-27th day.
Altitude is 15m while mean temperature is 24.5 degrees Celsius.
P1 and P11 were old seeds (more than 6 months).
The rest of the provenances were healthy freshly harvested seeds.
Unidentified pest attacked the seedlings in the nursery by perforating the leaves. It was controlled by spraying with Folimat (broad spectrum insecticide) twice a week.

Annex Five: Percentage oil test results

		Original seed 2009	Masindi 2010/	Killifi 2010	Manyara 2010	Nakuru 2011/	Masindi 2011	Masindi 2011	Laikipia 2011
			Optimal	Fair-optimal	Limiting (dry)	Limiting cool/ dry	Optimal	Optimal	Limiting cool/dry
P1	740	27.34					42.4		
P2	1500	25.12					26.3		
P3	1000	28.77	29.9	40.5	30.3	[44.11]	40.1	32.74	
P4	1000	26.87	33.3	36.3	37.5		24.06	[47.9]	
P5	900		36.8	30.3	33.7		40.82	[47.4]	
P6	35	28.55	35.5	42.2	43.8		44.9	40.83	
P7	30	29.81	33.5	35.7	34.6		43.8	43.1	
P8	180	34.86	28.8	35.3	31.4	31.7	28.7	[49.68]	
P9	1500		36.9	35.1	27.3	32.6	42.9		
P10	1500	33.2	37.8	22	34.4	32	32.7	40.53	
P11	500	34.4	35.8		35.4	36.9	30.9		
P12	1300	31.83	35.7	37.1	33.4	34.5	27.2	[42.8, 42.9]	
P13		34.68	37.7	31					
P14	200	35.05	29.6	28					
P15		32.44	28.4	27.2					
P16		25.07	36.9	34			32.69	[50.8]	38.2*
P17		30.94	33.3	31.7			33.31	[50.8]	
P18		24.2	32.7	43.6			36.3	[50.43]	
P19		36.57	31.4				32.4	40.80	
P20		37.12					33.1		
P21							23.11		
P22			41.5					[44.45]	
Average		30.9	34.2	34.0	34.2		33.8		

The percentage oil content increased dramatically with the daughter seeds in the second season [in parentheses]. The oil extraction was done by chemical hexane extraction. The comment of the university laboratory was that the later seed was in much better condition than the earlier seeds given.

Annex Six: Soil analysis tables for all sites.

	WESTERN			**KILIFI**			**MASINDI**		
PARAMETER	SUGGESTED GUIDE	ACTUAL RANGE	AVERAGE	SUGGESTED GUIDE	ACTUAL RANGE	AVERAGE	SUGGESTED GUIDE	ACTUAL RANGE	AVERAGE
pH	5.8-7	5.00-5.30	5.24	5.8-7	5.95-8.60	6.87	5.8-7	5.93-6.94	6.4
Phosphorus	40-100	1.0 -1.4			1.0-49	25		7.0-40.0	23.5
Potassium	74-247	67-213	85	74-247	223-899	430	177-591	75-232	153.5
Calcium	760-950	454-952	454	226-501	994-19118	10056	1817-2272	2703-4296	3499.5
Magnesium	76-152	22-120	81	76-80	247-1392	819.5	182-363	218-339	278.5
Manganese	100-250	10.0-93		100-250	231-609	420	100-250	141-242	191.5
Sulphur	30-200	10.30-14.69	12.4	30-200	11.36-71.01	40.2	30-200	9.71-16.76	13.2
Copper		1.46-1.60	1.5		1.21-82.99	42.1		3.78-4.11	3.9
Boron	0.8-2	0.10-0.31	1.2	0.8-2	0.66-3.47	2.06	0.8-2	0.20-0.74	0.47
Zinc		1.78-2.35	2.14		3.83-21.72	12.7		1.93-5.77	3.85
Sodium	<73	50-116	83	<38	10.00-77.00	43.5	<174	55-53	54
Iron	100-300	108-119	113.5	100-300	94-134	114	100-300	152-168	160
C.E.C	15-30	6.33-14.32	10.3	15-30	8.03-48.94	28.4	15-30	9.23-18.45	13.8
Aluminium	<1200	1718-2055	1886.5	<800			<1200	1284-1494	1389
EC (SALTS)	<800	50-96	73	<800	59-682	370	<800	43-142	92.5
Organic matter	2.00-8.00	3.07-3.36	3.2		0.93-5.12	3.02		3.72-4.87	4.3
Nitrogen	0.2-0.5	0.08-0.09	0.08	0.2-0.5	0.03-0.06	0.04	0.2-0.5	0.15-0.21	0.18
Sand	30-55	29.28-58.92	44.1	30-55	79.12-91.48	80.04	30-55	52.20-67.00	59.6
Silt	30-50	3.28-4.92	4.1	30-50	0.20-10.56	5.3	30-50	9.00-20.20	14.6
Clay	20-55	35.80-37-80	36.8	20-55	8.32-10.68	9.5	20-55	23.00-29.60	26.3

	MBEYA			**NAIVASHA**			**MAKUYU**		
PARAMETER	SUGGESTED GUIDE	ACTUAL RANGE	AVERAGE	SUGGESTED GUIDE	ACTUAL RANGE	AVERAGE	SUGGESTED GUIDE	ACTUAL RANGES	AVERAGE
pH	5.8-7	4.39-5.33	4.8	5.8-7	6.82-7.26	7.2	5.8-7	6.18-6.43	6.3
Phosphorus	**40-100**	2.0-8.0	5	**40-100**	11.00-40.00	28	**30-100**	3.0-5.0	4
Potassium	56-112	20-58	39	368-1226	1565-1591	1578	116-387	387-423	405
Calcium	344-430	73-245	159	3773-4717	3848-4296	4072	1190-1487	1092-1391	1241.5
Magnesium	34-69	19-94	56.5	377-755	476-485	480.5	377-755	235-248	241.5
Manganese	100-250	4.0-13	8.5	100-250	81-116	98.5	100-250	165-187	176
Sulphur	30-200	7.48-20.27	13.8	30-200	9.57-13.88	11.7	30-200	6.61-8.15	7.34
Copper		0.17-0.42	0.29		0.42-0.49	0.45		3.85-5.07	4.47
Boron	0.8-2			0.8-2	0.74-0.75	0.74	0.8-2	0.34-0.49	0.36
Zinc		0.66-0.85	0.75		4.62-4.87	4.74		1.57-2.03	1.87
Sodium	<33	19-37	28	<362	105-125	115	<362	8.0-12.0	10.12
Iron	100-300	53-58	55.5	100-300	112-121	116.5	100-300	51-67	58
C.E.C	15-30	2.25-2.87	2.56	15-30	29.86-31.44	30.65	15-30	9.98-11.75	10.13
Aluminium	<1200	1383-1453	1418	<1200	841-1068	954.5	<1200	1129-1202	1160
EC (SALTS)	<800	49-85	67	<800	122-155	133.5	<800	54-73	61
Organic matter		2.57-2.93	2.75		4.87-6.06	5.46		3.01-4.29	3.22
Nitrogen	0.2-0.5	0.08-0.10	0.09	0.2-0.5	0.19-0.21	0.2	0.2-0.5	0.10-0.18	0.16
Sand	30-55	64-75	69.5	30-55	50.00-50.2	50.1	30-55	60-64	62
Silt	30-50	4.0-10.0	7	30-50	16.92-20.2	18.56	30-50	8.0-10	9
Clay	20-55	19-26	22.5	20-55	29.6-33.08	31.34	20-55	26-32	29

	LAIKIPIA			**NAKURU**			**MANYARA**		
PARAMETER	SUGGESTED GUIDE	ACTUAL RANGE	AVERAGE	SUGGESTED GUIDE	ACTUAL RANGE	AVERAGE	SUGGESTED GUIDE	ACTUAL RANGE	AVERAGE
pH	5.8-7	6.21-7.10	5.83	5.8-7	6.09-8.27	5.58	5.8-7	7.7	7.7
Phosphorus	**30-100**	1.0-3.0	1.2	**30-100**	1.0-7.0	4	**30-100**	9	9
Potassium	240-452	631-758	648	39-130	368-1327	747.5	39-130	475	475
Calcium	2458-3342	2061-2366	1748	401-501	1251-3026	2138.5	401-501	7565	7565
Magnesium	246-462	500-581	540.5	40-80	215-383	299	40-80	258	258
Manganese	100-250	230-286	258	100-250	43-67	55	100-250	225	225
Sulphur	30-200	7.25-14.75	8.4	30-200	4.30-7.91	6.1	30-200	0.52	0.52
Copper		0.79-0.97	0.87		0.45-0.73	0.59		2.76	2.76
Boron	0.8-2	0.33-0.53	0.43	0.8-2	0.13-0.28	0.2	0.8-2	1.7	1.7
Zinc		1.06-1.89	1.47		1.52-2.42	1.97		0.01	0.01
Sodium	<362	17-26	23	<362	111-743	427	<362	87	87
Iron	100-300	114-134	125	100-300	113-137	125	100-300	30	30
C.E.C	15-30	17.78-21.25	18.9	15-30	11.67-23.00	17.3	15-30	43.17	43.17
Aluminium	<1200	1300-1333	1324	<1200	1032-1278	1155	<1200		
EC (SALTS)	<800	42-73	57.5	<800	66-221	143.5	<800	231	231
Organic matter		2.07-2.34	2.25		2.03-3.71	2.87		0.21	0.21
Nitrogen	0.2-0.5	0.09-0.10	0.09	0.2-0.5	0.08-0.13	0.11	0.2-0.5	4.76	4.76
Sand	30-55	54-58	56	30-55	67.12-74.56	69.33	30-55	66	66
Silt	30-50	8.00-10.00	9	30-50	6.56-13.28	9.23	30-50	20.2	20.2
Clay	20-55	34-38	36	20-55	13.60-19.60	15.6	20-55	13.08	13.08
	CODE								
		HIGH							
		OPTIMUM							
		LOW							

Annex Seven: Set up costs

Nursery set up costs from Kirimiri farm, **Tropical Farm Management** in **Makuyu**

DATE	Kirimiri Makuyu set up	AMOUNT
	Nursery	
16.3.2009	Seedbed sand	10,000
23.3.2009	Potting sand	10,000
26.2.2009	Tank, hose pipe, gate valve, tap.	30,760
16.3.2009	Polythene pots 7,000 pieces	16,100
21.4.2009	Kinship 5 lts.	4,520
24.4.2009	Klinswip 5 lts.	4,520
27.4.2009	Klinswip 4 lts.	3,400
26.4.2009	Paper bags 25 pieces	250
6.5.2009	Transportation of seedlings	5,000
25.5.2009	Nursery labour	9,405
24.6.2009	Others e.g. paint etc.	1,860
	Total KES	248,484
	KES./ hectare (ha)	24,848
	Euro Cost / hectare	€ 230
	Planting out	
21.4.2009	Manure 2 lorries	60,000
24.6.2009	Kirimiri field labour March- June 09	92,669
		152,669
	KES/hectare	15,267
	Euro cost /hectare	€ 141
	Total Euro cost /hectare	€ 371

	Masindi economic trials				
No.	**Description**	**Units**	**Total units**	**Cost per unit(KES.)**	**Total cost (KES.)**
1	Cost of diesel for ploughing remaining 7.5 hectares	Ha	7.5	3,247	24,354
2	Man hours for ploughing remaining 7.5 hectares	mandays	1	445	445
3	Cross plough	Ha	7.5	615	4,612
4	Man hours for ploughing remaining 7.5 hectares	mandays	1	445	445
5	Marking holes	mandays	30	120	3,600
6	Hole digging-Economic (for remaining 7.5 hectares in May)	holes	12000	5	60,000
7	Sisal twine for alignment	pcs	2	240	480
8	Measuring Tape	pcs	1	300	300
10	Manure	tons	7	1,000	7,000
11	Cost of transporting manure	litres(diesel)	252	82	20,664
12	Manpower Planting	man days	120	120	14,400
					136,300
	KES. cost/ hectare				18,419 KES
	Euro cost / hectare				€ 170.55

Expenditure for site set up in Western Kenya					
No.	**Description**	**Units**	**Total units**	**Cost per unit**	**Total cost KES**
11	Nursery set up+sowing+mulching	mandays	4	250	1,000
12	Nursery Manure+transport	tons	1	1000	1,000
13	Ferrying+ watering nursery	Mandays	24	250	6,000
14	Spraying labour	Mandays	4	250	1,000
15	Insecticide-karate	sachets	4	150	600
16	Sprayer-2lt	pcs	1	300	300
17	Nursery labelling	pcs	22	20	440
18	Management labour costs	Visits	17	500	8,500
22	Nursery fence -materials+labour		1	1000	1,000
	Total KES. costs for 2.4 ha				19,840
	Total Euro cost/ hectare				€ 77

	Western Kenya Planting out costs				
	Costs of planting out 2.4 hectares (ha)				
		Units	Item	Cost KES	
1	Ploughing	acres	**Nursery set up**		
2	Field layout design	mandays	poly bags	8038	
3	Hole marking sticks	mandays	mixing medium	864	mandays
4	Hole digging-provenance	holes	Planting in polybags	518	mandays
5	Hole digging-provenance-non test plants	holes	nursery care	5256	
6	Hole digging-Agronomy	holes	overall KES	14676	
7	Hole digging-Micronutrient	holes	Euro / ha	13.6	
8	Jembes for hole digging	pcs	**Planting out**	KES/Ha	
9	Sisal twine for alignment	pcs	Land clearing	256	
10	Measuring Tape	pcs	Ploughing	2,903	
1	Planting labour in main field	labour	Cross plough	1,114	
2	Manure purchase-FYM	tons	De-stumping	2,491	
3	Manure Transport	trips	Marking	1,318	
4	Water ferrying+ application on planting	days	Holing	5,287	
5	Plant monitoring	mandays	6	250	1,500
6	Labelling-provenance	pcs	110	20	2,200
7	Labelling-agronomy	pcs	20	20	400
8	Labelling-micronutrient	pcs	10	20	200
9	Labelling -main trials	pcs	4	200	800
10	Management labour	visits	12	500	6,000
	Total costs KES. for 2.4 Hectares				**34,728**
	Equivalent Euro cost / hectare				€ 134
	Total set up and planting out Euro cost/ hectare				€ 211

Rea Vipingo set up costs		
Item	cost	
Nursery set up		
poly bags	8,038	
mixing medium	864	mandays
Planting in polybags	518	mandays
nursery care	5256	
Total KES. direct set up costs	14,676	
Equivalent Euro cost / hectare	€ 13.6	
Planting out	KES/Ha	
Land clearing	256	
Ploughing	2,903	
cross plough	1,114	
De-stumping	2,491	
Marking	1,318	
Holing	5,287	
Total KES/hectare	11,369	
Total Euro cost/ hectare	€ 106	

Annex Eight: Financial model showing replacement of current energy costs.

Medium Flower farm and Sisal plantation			
	Medium sized flower farm	Large Sisal Plantation	
Production area (ha)	28	12000	
Exchange rate (US$:KES)	83	83	
Energy cost (KES m)	26.70	38.70	per year
Energy price (KES/kwh)	15.10	15.10	
Energy usage (kwh/year)	1,768,211	2,562,913	
Jatropha equivalent			
Oil calorific value (kJ/kg)	39,700	39,700	
Generator efficiency	0.30	0.30	
Heat rate (kJ/kwh)	12,000	12,000	
Oil quantity required (kg/kwh)	0.30	0.30	
Annual oil requirement	534.47	774.68	Metric tonnes
Oil yield (tonne/ha/year)	1.00	1.00	
Jatropha plantation area required (ha)	534.47	774.68	

Model one: 300 hectares of jatropha planted

Year	1	2	3	4	5	6	7	8	9	10
Hectares jatropha planted	300	300	300	300	300	300	300	300	300	300
Oil yield	0	0.25	0.75	1.5	2	2	2	2	2	2
Oil production	0	75	225	450	600	600	600	600	600	600
Set up cost US$	225,000									
Operating cost – management US$	105,000	105,000	105,000	105,000	105,000	105,000	105,000	105,000	105,000	105,000
Operating cost – harvest US$		15,000	45,000	90,000	120,000	120,000	120,000	120,000	120,000	120,000
Operating cost – processing US$		1500	4500	9,000	12,000	12,000	12,000	12,000	12,000	12,000
Total cost US$	330,000	121,500	154,500	204,000	237,000	237,000	237,000	237,000	237,000	237,000
Total cost KES (M)	27.39	10.08	12.82	16.93	19.67	19.67	19.67	19.67	19.67	19.67
Electricity displaced	0	248,125	744,375	1,488,750	1,985,000	1,985,000	1,985,000	1,985,000	1,985,000	1,985,000
Value KES (M)	0	3.75	11.24	22.48	29.97	29.97	29.97	29.97	29.97	29.97
Net value KES (M)	-27.39	-63.38	-15.8	5.55	10.30	10.30	10.30	10.30	10.30	10.30
Cumulative value KES (M)	-27.39	-33.73	-35.31	-29.76	-19.46	-9.16	1.14	11.44	21.74	32.05

Model two: 500 hectares of jatropha planted.

Year	1	2	3	4	5	6	7	8	9	10
Hectares jatropha planted	500	500	500	500	500	500	500	500	500	500
Oil yield	0	0.25	0.75	1.5	2	2	2	2	2	2
Oil production	0	125	375	750	1,000	1,000	1,000	1,000	1,000	1,000
Set up cost	375,000									
Operating cost - management	175,000	175,000	175,000	175,000	175,000	175,000	175,000	175,000	175,000	175,000
Operating cost - harvest		25,000	75,000	150,000	200,000	200,000	200,000	200,000	200,000	200,000
Operating cost - processing		2,500	7,500	15,000	20,000	20,000	20,000	20,000	20,000	20,000
Total cost US$	550,000	202,500	257,500	340,000	395,000	395,000	395,000	395,000	395,000	395,000
Total cost KES (M)	45.65	16.81	21.37	28.22	32.79	32.79	32.79	32.79	32.79	32.79
Electricity displaced	0	413,541	1,240,625	2,481,250	3,308,333	3,308,333	3,308,333	3,308,333	3,308,333	3,308,333
Value KES(M)	0	6.24	18.73	37.47	49.96	49.96	49.96	49.96	49.96	49.96
Net value KES (M)	-45.65	-10.56	-2.64	9.25	17.17	17.17	17.17	17.17	17.17	17.17
Cumulative value KES (M)	-45.65	-56.21	-58.85	-49.61	-32.43	-15.26	1.91	19.1	36.25	53.42
Assume 5 years to 2 MT	2.00	2.00								
	267	387								
set up costs /hectare US$	200,427	290,506								
management costs per year US$/hectare	93,533	135,569								
Harvest cost US$/hectare										
Harvest costs/ ton of oil										
Processing cost US$/tonne										

Assume 1 ton oil = 3000kg seed = 50days@2$ a day picking 60kg a day = 100$ a ton of oil