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Waste wood to heat and electricity in the Southern Highlands of Tanzania

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Author(s)
Ueli Scheuermeier, Rural African Ventures Investments (RAVI)
Anton Küchler, Büro Weichen stellen
Thomas Müller, Holzenergie Emmental

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Written by
Rural African Ventures Investments (RAVI)
Amelia House
Crescent Road
Worthing
West Sussex
BN11 QR, UK
Phone: +41 31 352 09 61
uscheuermeier@yahoo.com, www.ravinvest.biz

Büro Weichen stellen
Bahnhofplatz 10
CH-3555 Trubschachen
Tel: +41 34 495 65 50, Fax: +41 086 34 495 65 50
anton.kuechler@weichenstellen.ch, www.weichenstellen.ch

Holzenergie Emmental
Hinter Schwarzenegg
CH-3453 Heimisbach
Tel. +41 34 431 18 68
masi_mueller@bluewin.ch, www.holzenergie-emmental.ch

On behalf of:
REPIC Platform
c/o NET Nowak Energy & Technology SA
Waldweg 8, CH-1717 St. Ursen
Phone: +41(0)26 494 00 30, Fax: +41(0)26 494 00 34, info@repic.ch / www.repic.ch

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Contents

1. Executive Summary

CB Company Ltd. is a Tanzanian company based in Mafinga in the southern highlands of Tanzania. CB requested Rural African Ventures Investments (RAVI) to support them in exploring the **use of wastewood from forestry operations in the highlands**. RAVI then identified the association Holzenergie Emmental whose members have the right type of technology and operational experience for the Tanzanian context for chipping wood and transporting the chips to where they can be converted to energy. As a first major client the large paper factory in Mgololo was foreseen. This project introduced a wood chipper as a pilot venture to study the technical and economic viability of mobile chipper trains (chipper plus tractor and trucks for transport) in Tanzania. The project is understood as a first step in a longer effort to build forestry ventures in the area.

The **immediate objectives** of this project were to

1. Assess the technical feasibility of the Emmental technology and operations in the Tanzanian context, resulting in proof of technical and operational concept.
2. Assess the potential for wood energy and the parameters for commercial viability that would lead to proof of commercial concept and then to investment proposals for scaling up.
3. Propose next steps/ventures

The **technical proof of concept has been achieved**: A suitable chipper was found, ie. a FARMI 260, directly attached to 3-point hydraulics of a 75 hp New Holland tractor and powered directly through the PTO. It could be imported, assembled and successfully operated in the local conditions. The logistics for maintenance and replacements are locally in place and feasible.

The **operational proof of concept could also be achieved**, even though direct deliveries of chips could not yet be made. Still, the transport of chips is not expected to be a problem as trucks are easily available.

The **economic proof of concept could not yet be achieved**. On the one hand calculations from first operational experiences indicate that wood chips can be produced at competitive prices. But on the other hand the large paper factory turns out to be an unreliable client with tricky negotiations. It is still the only client. Large steam turbines are promised to be coming online later this year. Once they operate there will be a large immediate demand for chips. Only if and when this happens is it feasible to consider investing in scaling up a venture that only produces and sells wood chips.

Contacts between forestry entrepreneurs in southern highlands of Tanzania and the Emmental have been established. They are planning to together further explore how to tap the vast potential of forests in Tanzania for diverse decentralized small-scale ventures in villages and towns. The Emmentalers have established a consortium to keep the momentum going.

The **potential for wood energy** has been estimated, but based on very rough figures. The emerging potential for wood energy is still poorly understood and very little data is available. This should be analysed in more detail. However, the project could make extrapolations from own observations, interviews and some scant data. We come to the conclusion that waste wood for energy is available in large quantities and will even grow in the future due to the strong push by private companies and farmers in planting trees.

Film footage of the process so far is available. **A short documentary film** has been put together. Filming will continue as the story further evolves.

During the course of the project a **consortium** became established consisting of the Emmental actors involved in the effort. Together with RAVI they intend to explore follow-up ventures for energy and forestry in Tanzania.

The **proposals for the future** are:

1. Continue to use this chipper for developing the demand for chips. The market must be diversified and decentralized in order to avoid being dependent on just one or two major clients. Expand chipping once the demand becomes more steady and predictable.
2. Aim for electrifying wood chips and using the resulting heat for drying purposes. The immediate next venture would be a stationary small saw-mill that produces high-quality timber and which will become self-sufficient in electricity by using the offcuts from its own operations, and using the resulting heat to dry the timber for higher quality and reduction of transport costs.
3. Consider wood energy in the larger picture of rural development, most importantly for electrifying stationary machinery in villages (mills, pumps, processing, etc.) and if possible also for replacing diesel for running tractors. This must go hand in hand with R&D efforts concentrating on small scale forestry by farmers, as these have been observed to be fast expanding the overall area under forests. Also, a program that allows forests to be seen as growing assets that can act as collaterals for credits have been proposed by local villagers.
4. Monitoring of area coverage of various types of forests should be done in order to better understand the ongoing dynamics of the expansion of private (farmer) forests. Also studies into the dynamics of the use of fire in the local agriculture and forestry need to bring forward the implications for soil fertility and resource protection.

2. Objectives

A. The goal of the consortium is to establish wood energy as a viable commercial operation in Tanzania, to be operated by CB energy Ltd. linked with small rural entrepreneurs.

B. The mid-term goal is to build an investment proposal for commercial investors such as the investment funds managed by responsAbility. The investment proposal must be based on analysis of collected data, and on the operational/financial monitoring of real pilot experiences on the ground.

C. The immediate objective of this proposed project is to verify or falsify the following hypotheses:

1. There is enough waste wood lying around in the southern highlands forests that can be profitably tapped for energy
2. There are sufficiently large clients available who are interested to buy chips, and with whom pilot operations can be launched.
3. Chippers, as they are used in the Emmental, can be adapted to the operational conditions in Tanzania (technical proof of concept), and then integrated into chipper trains together with locally available equipment and successfully operated there (operational proof of concept).
4. It is realistic to assume that small rural enterpreneurs in the forested areas will be able to profitably sell wood chips to the paper factory by renting the chipper trains from CB energy Ltd at rates that are profitable for CB energy Ltd. Each operating chipper train creates 3-5 new rural jobs
5. It will also be possible to adapt the heating arrangements in tea factories to also burn chips. The tea factories will gladly buy chips.
6. There are good chances to upscale the venture in a next phase to a level that can show commercial viability, and thereby to build a business plan for both CB energy Ltd as well as the small rural entrepreneurs for submitting to investors for large scale replication, ie. many such chipper trains operating throughout the area.

The immediate quantifiable result of this project is 1 chipper train operating in the Mafinga area, allowing to assess the operations for later upscaling. There will also be some data and analysis available that assesses the potential of wood chips in southwestern Tanzania.

This project shall inform the design of the ensuing upscaled project. The upscaled project may, or may not, be a separate follow-up project with REPIC or any other interested agency, depending on the results of this project.

3. Technical Solution / Applied Method

As key part of the whole investigation, a chipper (Type Farmi 260, made in Finland) was exported from Switzerland to Mafinga.

The chipper is manually fed and is equipped with a no-stress control, which prevents the plugging of the ejector. Together with the chipper, security equipment (helmets, gloves), maintenance tools and spare blades were delivered.

The chipper was purchased via Christian Hüsler, member of the project team, at the main importer of Farmi in Switzerland and delievered as sea freight via DHL to Dar-es-Salaam. At the port, the parcel was collected by an employee of CB energy Ltd. and transferred by truck to Mafinga. The import formalities to Tanzania did not cause any significant problems.

The chipper subsequently was prepared for operation by Christian Hüsler in Mafinga. He found the necessary basic infrastructure for maintenance and repairs in place and operational. A workshop for repairs is available in Mafinga, and is equipped with the necessary tools. Whatever was not available in Mafinga had already been imported together with the chipper.

During the stay of our technician Christian Hüser, the necessary personnel for operation and maintenace of the chipper in Mafinga was ready and capable of taking over the assigned duty. Our local partners from CB Energy Ltd. and the sister company CB Company Ltd. organised the personnel together with the necessary infrastructure (tractor, workshop, fuel etc.).

Christian Hüsler works together with the Swiss importer of Farmi chippers. Christian will therefore be in charge of supplying spare parts, follow-up on maintenance and instruction of the mechanics in Mafinga when necessary.

Anton Küchler and Thomas Müller both explored the potential for wood energy and the operational challenges, making interviews with main actors in the scene, both in the field in villages as well as with directors of important companies, and collecting whatever data was available. They looked beyond the chipper operations per se into general sustainability and forestry management strategies to come up with suggestions for further action.

4. Results

The exporting operation was successful, and the chipper arrived within 50 days in Mafinga, including the expected delay.

In the first days of operation, the chipper was used to process a stock of offcuts at a local sawing lot in the Mafinga area. The experience showed that a daily production of up to 150 m3 wood chips (=50 m3 of solid wood) can be expected. In order to reach this high performance, the raw material must be prepared, so that the chipper can be fed at a constant speed.

This is given in the area with the large amounts of available offcuts at sawing lots. For handling of the material and operation of tractor and chipper, a team of 4 is optimal.

The experiences made with operating the chipper on-site led to the formulation of a business-case for the production of wood chips. The case is stated in Table 4.

As long as the wood chips can not be used on-site, the transport of the produced wood chips can be assigned to local transport companies. Trucks are widely available and can easily be converted to maximise the amount of wood chips that can be loaded. Our local partner CB company Ltd. runs a transport business.

The most effort in a short-term view must now be placed in the marketing of the wood chips. Our local partner Cyprian Tweve has established several promising contacts, but no sales agreement has been reached yet. The following potential buyers have been contacted so far:

- **MPM**: Mufindi paper mill has a demand for clean chips for paper production (from debarked wood) and regular chips for energy generation. A 10 MW steamturbine for generation of electricity and heat is in place and operational. For July the start of operation of an additional 35 MW unit is planned. MPM has its own stationary chipping unit installed on-site. However, MPM officials have suggested, that the additional supply of chips may be desireable to cover peaks in demand and shortages of supply.
- **Mbeya Cement Factory**: First contacts have shown that this factory is interested in purchasing wood chips. A main challenge will be to find an economically and ecologically vialble solution for the transport over 300 km to the plant. In this context the option of using the Tazara railroad must be investigated.
- **Local vegetable producer**: During the operation of the chipper, a passer-by adressed our local project partner Cyprian Tweve and expressed his interest to purchase wood chips for using them as mulch in his cultures (non-energetic use)

Further, the project team proposes to develop a venture for using wood chips for substituting diesel generators which are very widely used in rural areas. This could be implemented in a modernised sawmill as proposed in the outlook in chapter 6.

Conclusions from the on-site experience

The experience on-site lead the project team to the conclusion that **working hypothesis No. 3** has only partly been confirmed:

«Chippers as they are used in the Emmental can be adapted to the operational conditions in Tanzania (technical proof of concept), and then integrated into chipper trains together with locally available equipment and successfully operated there (operational proof of concept).»

The technical concept is therefore **achieved**. The operational concept could not yet be demonstrated due to lack of main buyers of the chips. A large buyer will be operational by July 2012 (see chapter 2.4.).

Conclusions from the on-site visit

- The feasibility of the technical concept has been confirmed by the experiences on-site: import of a chipper, setting-up of operation and the operation itself have proven to be appropriate and viable for the circumstances in Tanzania.
- Tools and tractors are available on-site and can be provided by local partners. The basic competence of the workers in charge of operating and maintaining the chipper is sufficient for a successful and sustained operation.
- The contact with the supplier of the chipper is established and the supply with spare-parts and services is ensured
- A feasible operational concept has been achieved, even though direct deliveries of chips could not yet be made. Still, the transport of chips is not expected to be a problem. Suitable transport facilities are available through the local partner CB company Ltd. The logistic cooperation between production and transport still needs to be developed.
- The economic proof of concept could not yet be achieved. On the one hand calculations from first operational experiences indicate that wood chips can be produced at competitive prices. However, the market for a production of wood chips is not yet developed. More potential buyers need to be identified and developed.
- The production can be cost-effective at a market price of 12’500 TSH per metric ton excl. transport.

Images 1 & 2: Unloading and assembling of the chipper at its arrival in Mafinga by Christian Hüsler and local partners (19.4.2012)

Images 3, 4 & 5: Introduction about use, maintenance and safety (19.4.2012).

Image 6: Test run at local sawing lot in the area of Mafinga (20.4.2012)

5. Impacts

5.1. Potential of the use of energy wood

«The Southern Highlands of Tanzania are
one of the best places in the world to grow trees.»

Sangito Sumari, Managing Director of Green Ressources, Sao Hill

5.1.1. Characteristics of the area visited[1]

The visited area is located around the town of Mafinga in the Mufindi District of the Province of Iringa in the south-western highlands of Tanzania. Mafinga is at about 580km south-west from the city of Dar-es-salaam, which is situated at the coast of the Indian Ocean.

The city center of Mafinga lies at approximately 1850 meters asl. The area can be described as part of the Miombo biome. These woody grasslands cover about 10% of the African landmass in the countries of Tanzania, Zambia, Malawi, Zimbabwe, Mozambique und Angola. The area of Mafinga can be described as semi-arid with a dry period of 3-4 months (Mid June-Mid October) and an average annual rainfall of 1000 mm. Yearly mean temperatures reach a pleasant 23° C, with a temperate dry period (20°C) and a warm rain season (25°C)

The south-western highlands of Tanzania are regarded as the forest district for the nation. In this woody grassland with favourable climatic and soil conditions for forests, already the first German settlers who arrived around the end of the 19th century recognized the potential of the area and began to plant trees. The British administration of the Tanganijka colony in the 1950s decided to establish large forest plantations. After gaining independance in 1961 the government of newly formed Tanzania continued this policy to provide supply with timber and energy wood for the new nation. Besides the Iringa province visited, forest plantations also are in other provinces such as Njombe, Kilimanjaro, Mbeya,

[1] Sources: Malmer, A. (2007): General ecological features of miombo woodlands and considerations for utilization and management., Salcito, K. (2010): Green Resources Human Rights Impact Assessment.

After establishing the plantations, the government subsequently started to build large industrial combinates in the 1970s in order to process the resource into tradable goods, such as paper. In the process of this policy, the Mufindi Paper Mill (MGM) in Mogololo and the Sao Hill Industries (SHI) saw mill in the area of Mafinga were established.

After a first phase of successful operation, the government run industry had to be taken out of service in the early 1990s. Reasons were the failure to operate economically and to cover the costs of production through the sales.

In the 2000s, the government handed over the operation of both MGM and SHI to private investors. In the case of MGM the operation lies in the hands of Indian investors, SHI is operated by a Norwegian company (Green Resources).

5.1.2. Plantations and species used

The plantations in the visited area (Mufindi district) are mainly composed of different varieties of Pinus and Eucalyptus. Besides, also plantations with Black Wattle (lat. Acacia mearnsii) have been established but which are in quantity negligible compared with the Pinus and Eucalyptus plantations. However, Black Wattle could be a good pick for the future, because it makes good soils through nitrogen fixation and gives an excellent wood for the production of charcoal.

The commercial use of endemic species is banned by legislation in order to protect the remaining natural growth forests.

The plantations are to a substantial part government owned. The main area of government plantation is the Sao Hill forest reserve, around 30 km south of Mafinga. The Sao Hill forest reserve comprises 43'000 ha of plantation.

In the past years since the large industrial processors have restarted their operations, also planting operations and harvesting in the government owned plantations was restarted. Also, private company plantation activities have been intensified. Green Resources alone is currently replanting more than 4'000 ha in the area. Mr. Sangito Sumari, Managing Director of Green Resources in Sao Hill and a well-informed expert on the plantation business in the region, estimated the total private company plantation area in the Mufindi district alone to be around 30'000 ha.

During our visit we found evidence of a remarkable and significant increase of plantation activities through private farmers and local communities. Our interview partners in the villages stated that they would even reduce the planting of maize because they get a higher economic yield from forest plantations which would allow them to buy their maize on the market. This is partly due to poor soils in Lupembe that are not conducive to grain farming. The plantation activities observed in the village communities Lupembe and Magunguli cover a surface of at least 1000 ha each, so that Mr. Sumari roughly estimated the total private plantation activities in the Mufindi district alone to presently around 50'000 ha. However, these are very rough estimates of a fast changing picture. We have not found any indication that this new phenomenon of wide-spread private plantations by farmers themselves is being monitored.

Besides the Mufindi district, large plantations also exist in the districts of Kilolo, Njombe, Rungwe and Kilombero. From these regions, our partners from Mufindi district reported of similar developments with an increase of plantation activities and surface.

Table 1: Estimate of the total plantation area in Mufindi district accorindg to ownership[2]

Total Area (Mufindi district)	**7'123 km^2**
Government plantation (Sao Hill)	430 km^2
Private company plantations	300 km^2
Local community plantations	500 km^2
Total plantation area (Mufindi district)	**1'230 km^2**
(Pinus 60%, Eucalyptus 40%)	

Images 7 & 8: Examples of Pinus plantations in the government managed Sao Hill Forest Reserve (above, 26.3.12) and by private farmers in Lupembe village (below, 29.3.12)

[2] Interview with Sangito Sumari, Managing Director Green Resources Ltd., 28/3/12

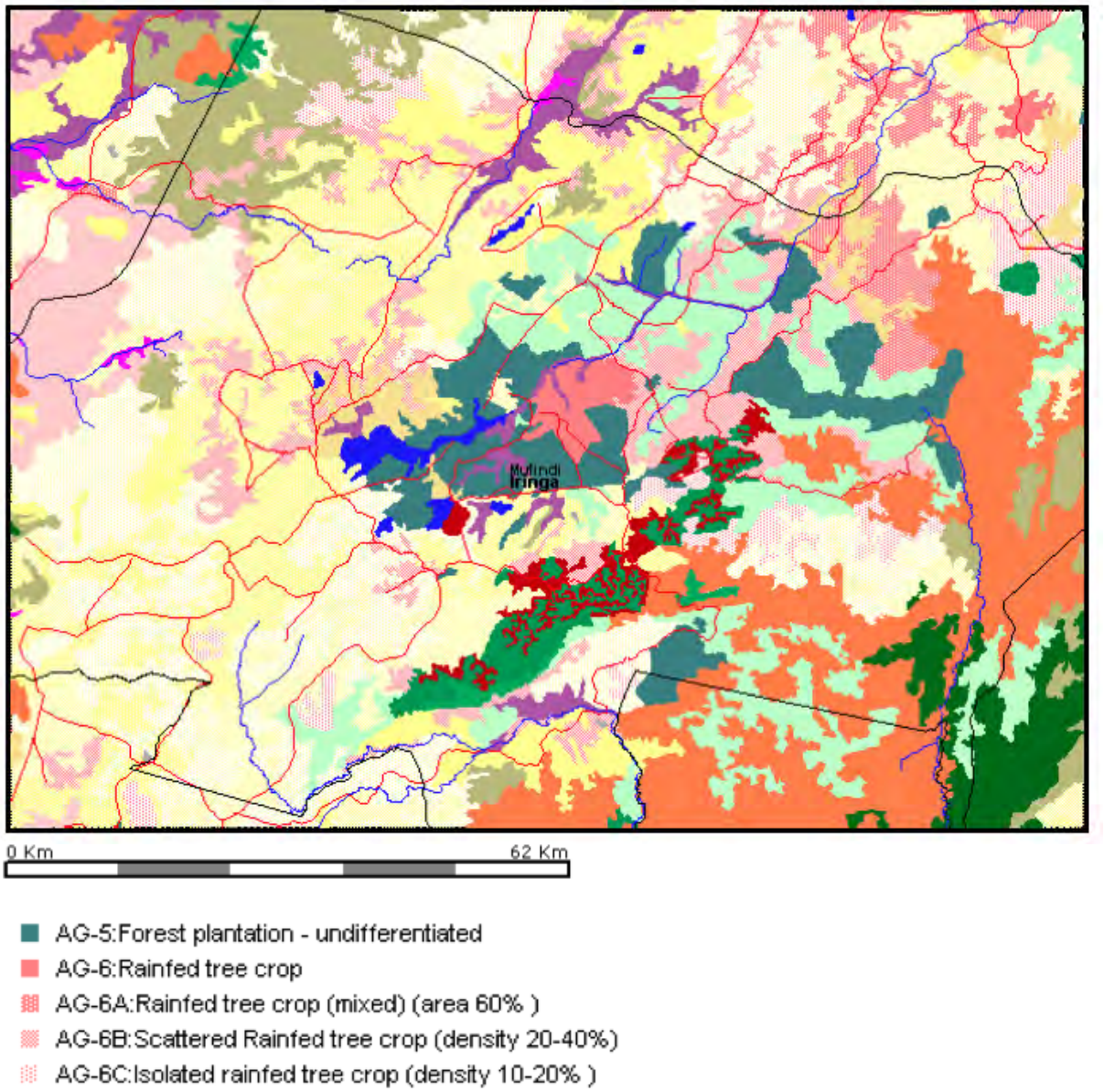

Image 9: Map from satellite image interpretation of the land use in Mufindi district. The relevant shadings are AG-5 to AG-6C as marked in the legend.[3])

Table 2: Comparison Pinus / Eucalyptus

	Eucalyptus	Pinus
Botanical names	Eucalyptus grandis, E. saligina, E. maidenii / globulus, E. camaldulensis	Pinus patula, P. elliotii, P. carribea
Plantation Area	Ca. 500km2	Ca. 700km2
Annual growth*	25-35m3/ha*a	20-25m3/ha*a
Use	Transmission poles, timber, energy wood	Timber, energy wood
Stock at time of harvest (20 yrs. After planting)	Up to 700m3/ha	Up to 500m3/ha

[3] Source: Africover, www.africover.org

Images 10 & 11: Examples of Pinus plantations (4 years since planting, 29.3.12) and Eucalyptus (8 years since planting, in the process of the first selective harvesting for transmission poles, 30.3.12)

The follwing table states the fraction of different wood sortiments according to their usage. The total amount is calculated for the total plantation area (ca. 1230km2) and cumulated for Pinus and Eucalyptus. The amount is calculated for the sustainable yield according to an average annual growth.

*Table 3: Rough estimate of the fractions of wood harvesting and processing (total surface = 1230km2, annual growth = 2500m3 /km2*a)*

Potential (rough estimate)	Fraction	m3 per yr.
Offcuts in the forest	10%	300’000
Industrial wood (paper)	10%	300’000
Offcuts at sawing lots	25%	750’000
Sawdust at sawing lots	20%	600’000
Timber	35%	1’050’000
Total annual growth	*100%*	*3'000’000*

In the forests, tree tips and branches are left and subsequently burned before the lots are used for plantation of maize for one year, with trees planted inside the maize. Also in the forest, the sawable timber is separated from industrial wood which is too thin to process in a saw mill and is therefore allocated to the paper mill.

At the sawing lots, we observed large amounts of offcuts and sawdust. These fractions are larger than what can be expected from similar operations in Switzerland. There are several reasons for this observation:

- the diameter of the timber processed is rather small (max 35 cm diameter) due to necessary manual labor during hauling and loading of trucks. This means that more offcuts are produced than with larger logs.
- The most popular sizes of timber are 1’’ by 8’’, 1’’ by 6’’, 2’’ by 4’’ and 1’’ by 2’’ (1 inch = 2.7 cm). These timber sizes need many cuts so that there is a lot of sawdust produced.
- The circular saws blades are often slightly damaged which increases the amount of sawdust.

The total potential of energy wood is composed of the offcuts left on forest lots or stocked on the sawing lots and from the sawdust produced. For the Mufindi district, we estimate a total potential of ca. 1'650'000 m3 of energy wood per year.

Images 12 & 13: Offcuts and sawdust at Kalinga sawing lot set aside during a period of 6 months (above, 26.3.12), harvesting residues left to be burned on newly harvested lot (below, 26.3.12)

5.1.3. Typology of forest management

In the visited area, big differences exist among forested areas. As a basis for further investigation we propose a tentative typology of forest management. This could also serve as a basis for the development of a GIS-based monitoring system as described in chapter 5.1:

1. **Government** forest: Large-scale aligned plantation with clear-cuts every 15-25 years. Harvesting operations by local concessionaries.
2. **Private** companies: Same management system like government forest. Harvesting operations by local employees.
3. **Farmer's plantations**: Small lots (0.5-10 ha) with similar management like the large-scale plantations of government and private companies.
4. **Farmer's mixed forest**: Forests with a variety of native and exotic species which are planted aligned or freely. The harvest is usually selective by removing the largest trees or entire rows in order to give the upcoming trees more space for growing.
5. **Line plantings**: Mostly planted by farmers along fields or tracks
6. **Natural forest**: mostly extensively used, partially overused, especially for the production of charcoal.

5.1.4. Present demand for wood energy

The use of Energy wood is strongly linked to the harvest and processing of timber. Energy wood is currently mainly a by-product of the harvesting and processing operations. The demand for timber has significantly increased since the beginning of the 2000s. Therefore the availability of energy wood is good but the demand is still at the very beginning. By far the most available energy wood is presently burned or left to rot at sawing lots without being used.

Before the end of the 1990s, the big timber consumers Mufindi Paper Mill (MPM) and the saw mill of Sao Hill Timber Industries were out of service. Privatization led to a restart of the respective businesses. Timber is mainly hauled by trucks and to a small extent also on the Tazara Railway to Dar-es-salaam. From there timber is also exported, mainly with markets in Kenya and the Gulf region.

Currently, the large processing industries in the area are investing in large steam trubines which should help them cover their own demand for electricity and at the same time allow them to feed the excess electricity into the national grid.

MPM is planning the installation of a 35 MW unit, driven with wood chips, which according to the General Manager Mr, Chugo should be installed and come online June or July 2012. The technical equipment was already on site by the time of our visit, but still needed to be assembled. This turbine will be added to the existing turbine and will increase MPM's electric generation capacity to 45 MW. Sao Hill Industries is planning a 15 MW turbine, which should be operational until the end of 2013 or in 2014.

Together, the demand for energy wood will increase significantly. Annualy, the two sites will demand an amount of totally around 180'000-200'000 m3 of energy wood or near to 20% of the total potential.

Images 14 & 15: The existing 10 MW steam turbine at Mufindi Paper Mill (27.3.12)

5.1.5. Forest management, harvesting operations and government policy

Forest plantation in the Mufindi district has a long tradition. Plantations are usually harvested after a growing time of 15-20 years. After harvesting, local farmers are allowed to cultivate the plot for one year. Plots are cleared by burning the offcuts, then the ground is cultivated and maize is planted. This crop rotation also helps to prepare the ground for the new planting in the following year. This mode of operation has been upheld for the past 60 years. New techniques of plantation, e.g. intercropping with the energy wood species *Black Wattle* (Acacia mearnii) will have different effects on the ecology and the fertility of soils. Also the management of mixed forests by farmers is markedly different. We did not come across any investigation of the scope and ecological effects of such different forms of forest management.

The main issue in forest management is the protection from the frequent fires during the dry period from June to September. Fires regularly devastate large areas. Fires are an integral part of the local agriculture, ie. with available technology farmers have no alternative to burning crop residues and weeds/grasses after slashing as a preparation for cultivation. The challenge is how to manage such fires. There is a tendency among the plantation owners to support farmers to make their own private plantations. The company Green Resources, for example, gives away seedlings to local farmers for free. The company expects that thereby farmers will take more care in preventing the expansion of fires because their own private plantations will also be threatened.

Also in the village communities visited (Lupembe and Magunguli) families are encouraged to plant trees. Thereby the communities try to increase awareness and a sense of responsibility to keep the agricultural fires under control.

Further, the project team visited forest plantations by local farmers that have an apparent experimental character. In contrast to the monocultures of the plantations of the government and private companies, local farmers are experimenting with plantations in rows along the borders of cultivated areas, or with mixed forests with timber and energy wood and selective harvesting techniques (forest with mixed ages and periodic selective extraction of the largest trees, the traditional «Plenter» forest management also prevalent in the Emmental).

The project team gained the impression that the potential of farmer's plantations is highly underestimated and should be considered as highly significant for the further investigation.

After learning about the present methods of forest management, we propose to assess the feasibility of using the widespread leguminous species Black Wattle (very good for charcoal) as intercrop between plantation rows of timber trees. This could have the following benefits:

- Increasing the availability of energy wood after harvesting (ca. 5 years after planting)
- Reducing the effort necessary to prune the plantation trees
- Increasing soil fertility through nitrogen fixation

Black Wattle is an invasive species, which has been spreading in the area since the establishment of the large wattle plantation in the southern area of the province Iringa. Black wattle spreads through seeding. However, the problem seems controllable, since the Wattle trees are easy to uproot in the first years after germination.

In the past years, timber from the government and private plantations has been to a large part processed by mobile circular saw operators. These units operate small circular saws, driven by diesel motors. They either saw on communal sawing lots or directly in the forest plot when the terrain does not allow the extraction of entire logs.

According to our local project partners, the vice-president of Tanzania announced on a visit to the forest reserve Sao Hill in February 2012, that operators of such mobile saws will not be granted concessions from next year onwards to use the government forests. The operation of these inefficient mobile saws will be banned by the end of 2012. Thereby the government wants to increase the value generation by increasing the percentage of sellable timber and reducing the percentage of the offcuts and sawdust. Since local sawing operations are profitable and are an important source of job opportunities for local communities it is likely that the local operators will be interested in modernizing their equipment in order to comply with the new government policy.

During our visit to the Kalinga sawing lot we could see at least 6’000m3 of offcuts which had been set aside during a period of 6 months on demand of Cyprian Tweve by the local saw mill operators, specifically for the operation of the chipper introduced. Mr. Charles Akyo, the operator of the Kalinga site runs another large and two smaller sawing lots. In the area around Mafinga several other operators like Mr. Akyo are active. For the future it seems evident that raw materials will remain available, either on site in forests or at local saw mill operators.

5.1.6. Conclusions from the analysis of the potential

For the working hypothesis, the project team draws the following conclusions:

Hypothesis 1:
«There is enough waste wood lying around in the southern highlands forests that can be profitably tapped for energy.»

==> Confirmed. However, there is scope for better understanding the potential of the fast expanding private plantations by rural households.

Hypothesis 2:

«There are sufficiently large clients available who are interested to buy chips, and with whom pilot operations can be launched».

==> There are large clients. But whether and how their demand develops remains to be seen. On the one hand if the large steam turbines are to come online this year they will have trouble getting enough chips to reach their capacity, and therefore the demand will look good. If on the other hand these large systems don't work out, there will be not enough large scale buyers to warrant a full push for expanding the number of chippers and their operation. It is strategically dangerous to rely on just 1-3 large industrial buyers. This indicates that the demand for woodchips must be developed further in order to reach a diversity of many smaller users of chips.

Conclusions from the analysis of the potential

- The raw material of waste wood is currently available in large and potentially growing quantities. In the case of local saw mill operators, waste wood is burned without further use, which makes a use for energy generation highly desirable.
- The potential is big enough so that energy wood will be available, even after the installation of the projected new energy generation units at Sao Hill and MPM.
- Local saw mill operators are pressured by government policy to modernize their equipment for processing of logs to timber.
- This opens a possibility of installing a "consolidated" saw mill that uses its offcuts to generate the electricity for its own operations and uses the resulting heat to dry timber to a high quality. **This consolidated saw mill will be further explained and proposed as follow-up project in chapter 6.**
- The planting of energy wood as intercrop between rows of timber trees can create synergies by reducing the work for pruning of plantations and increasing fertility of the soils. This aspect should be part of a collateral management for community credits as will be proposed in chapter 5.

5.2. Business case for chipper train

5.2.1. Analysis of demand for wood chips in the area

For the successful operation of a chipper with tractor (chipper train), both supply with raw materials and the demand for the chips produced must be given. The supply with wood chips has been analysed in chapter 2.

The interview with the potential buyer MPM has shown that currently the demand for locally produced wood chips in the area of Mafinga is not secured. The only consumer of wood chips is presently the Mufindi Paper Mill (MPM). This consumer has established an own supply with energy wood and is running a stationary chipper. MPM has signalled, that a demand for externally produced wood chips is presently only given, when the own supply chain is interrupted or can not reach the capacity of the installed steam turbines.

However, until 2014 both MPM and SHI plan to introduce large new electricity generation facilities fuelled with wood chips. Both companies plan to be producing their own chips. Given the large amount of wood chips required daily in order to run the facilities at maximum capacity, it seems plausible that a local producer will be able to deliver chips under certain circumstances.

But it is important to keep in mind that regarding the possible changes in conditions, the further development of supply and demand of energy wood does not seem reliable. This is especially true regarding the new major facilities:

First, it is predicted **that the rates of harvest in the government owned plantations at Sao Hill will dramatically drop around the year 2017**. The rates will take around 10 years time in order to be re-established. The reason for this shortage is that during the period of about ten years, when MPM and Sao Hill were not operational, harvest and replanting was not done. Besides losses to fire, the growth rate dropped under the stated optimum. Plantations have only been restarted since about 2008, with the effect that the new plantations will not be ready for harvesting before 2025. Private plantations will have to cover this supply gap, though it is not clear to what extent this will be possible. It is therefore to be expected that waste wood will increasingly become available from private forests (ie. Green Resources and farmer plots).

Second, it seems highly probable that **costs for transportation will continue to increase in the coming years** as prices for Diesel continue to increase. Already now, MPM is collecting wood in a large surrounding area with transport distances of up to 120km. The government of Tanzania does not subsidise the price for fuel, so that todays cost of diesel lies at 2200 TSH (= 1.20 CHF). Predictions of the International Energy Agency (IEA) state that costs for crude oil might increase from todays mean price of around 100 $ per barrel up to 150$ until 2015. The time and extent of the increase of the oil price is dependent of the political situation in the producing countries and the demand in accordance with the global economic situation. A prediction of the year by which such changes will occur is very difficult to make.[4]

Third, our local project partners stated that the paper production at MPM has failed to be profitable in the past few years. For the further development of supply and demand one must therefore **take into account the possibility that this large consumer goes out of service** especially if the conditions change (e.g. increased costs of transport).

The above three issues need to be taken care of before further investing in a venture that only produces and sells wood chips. This means that the demand for woodchips must first be diversified and decentralized.

[4] Source: IEA 2011: World Energy Report

The widespread planting activities of local farmers in the past years make it seem plausible to expect a potential for the use of energy wood in local communities. This will also help to reduce transport costs if the collection of logs can be limited to a range of 10-15 km around new modernized stationary sawmills. Further, decentralised operations may have favourable effects on work opportunities and the economy of local communities.

5.2.2. Costs and income of operation

The following table shows the economic concept for the chipper train introduced. The stated costs and performance of production have been verified in the field during the visit of the project team.

For the production of 1 metric ton of wood chips with an energy content of ca. 5000 kWh, the on-site experience showed that around 1.47 liters (14.7 kWh) of Diesel are required to run and move the tractor with the chipper. For movements, a distance of 2 x 10 km was estimated. The rate of Diesel used compared with the energy output in the form of wood chips is therefore 1:340 without taking into account grey energy and transport of the wood chips to the buyer.

The onsite experience allows to estimate a business-case for the operation of the chipper. Table 1 shows the respective calculation, which leads unter the given estimates to production costs of ca. 12’500 TSH per metric ton of chips produced. This compares to the 16’000-20’000 presently offered by the paper factory, where the factory provides their own transport.

The calculations have been done based on the on-site experience with the Farmi F260 chipper and a New Holland tractor provided by CB company Ltd. For other types of machinery, the calculations may deliver a different result. However, the introduced Farmi F260 chipper seems appropriate in size for the envisaged operations by our local partners.

The main variables which can not be clearly determined are the price which the seller will be able to get from buyers, the price of diesel, the payback time and maintenance costs. These variables will need to be verified with the mid-term experience gained by operating the chipper.

Table 4: Business case for the operation of a chipper (prices as in April 2012)

Key parameters

Exchange rate		1 USD =	1'600	TSH
Cost of Investment	Chipper		25'000	USD
			40'000'000	TSH
	Tractor		40'000	USD
			64'000'000	TSH
Produced Unit	Truck load		17	t (metric)
	daily production		34	t
			120	m3
Operating time	days per year		250	days
	avg. yearly production		8'500	t
Payback time	tractor		10	years
	chipper		5	years
Payback and interest rate	tractor		9'600'000	TSH
	chipper		10'000'000	TSH
Maintenance	rate of investment		10	percent / yr

Fuel	Diesel	1.47	ltr / t
	Diesel cost	2'200	TSH/ltr
Production site (example)	Kalinga		
Buyer	Mufindi Paper Mill		
	Transport distance	80	km
	Transport costs (per t)	19'000	TSH
		11.90	USD

Revenues		**in TSH**	**in USD**	**in TSH**	**in USD**
Unit		1 metric ton		17 tons	
Sale of wood chips		20'000	12.50	340'000	212.50
Total revenues		**20'000**	**12.50**	**340'000**	**212.50**
Costs					
Labour (4 workers)	7000 TSH per pers./day	824	0.51	14'000	8.75
Diesel		3'235	2.02	55'000	34.38
Raw materials	estimate	3'000	1.88	51'000	31.88
Maintenance tractor & chipper	10% of investment	1'224	0.76	20'800	13.00
Payback & interest tractor	9'600'000 for 10 yrs	1'129	0.71	19'200	12.00
Payback & interest chipper	10'000'000 for 5 yrs	1'176	0.74	20'000	12.50
Capital costs	Annuity for 5% interest	1'660	1.04	28'220	17.64
Total costs		**12'248**	**7.66**	**208'220**	**130.14**
win/loss		**7'752**	**4.84**	**131'780**	**82.36**

5.2.3. Conclusion and outlook

From the working hypotheses the project team draws the following conclusions:

Hypothesis 4:

«It is realistic to assume that small rural entrepreneurs in the forested areas will be able to profitably sell wood chips to the paper factory by renting the chipper trains from CB energy Ltd at rates that are profitable for CB energy Ltd. Each operating chipper train creates 3-5 new rural jobs.»

==> This business model will only work if and when the large steam turbines come online. Furthermore the model will be risky if the paper factory and other large-scale users are the only buyers of chips. The demand would need to be more diversified and more decentralized. In general, this business model must be reviewed given the new insights into the range of potential ventures at the village level that could be based on sustainable use of forest resources, ie. energy self-reliant sawmills, producing electricity at the village level, etc.

Hypothesis 6:

«There are good chances to upscale the venture in a next phase to a level that can show commercial viability, and thereby to build a business plan for both CB energy Ltd as well as the small rural entrepreneurs for submitting to investors for large scale replication, ie. many such chipper trains operating throughout the area.»

==> This is not confirmed. The same argumentation applies as above to Hypo 4.

Hypothesis 5:

«It will also be possible to adapt the heating arrangements in tea factories to also burn chips. The tea factories will gladly buy chips».

==> We could not explore this option in detail. However, while talking with the tea factories it became quite obvious that electricity generation from chips and using the heat for the wilting would easily fit into what such factories need. Technically this would be very near to energy-autark sawmills (ie. woodchips to electricity for machines, and waste heat for timber drying). It seems energy is very wastefully used in tea factories. Improving this situation for tea factories with wood-based energy would warrant an own R&D project in its own right.

For the future we identify three independent developments on different scales which will significantly increase the demand for wood chips. The large scale development is well on its way and will be put in place without any further intervention. Designing ventures for that level is not required. Medium and small scale activities on the other hand need a push in order to set up the appropriate solutions which will **develop the demand** and create local employment**:**

- **Large scale:** MPM and Sao Hill Industries both plan the installation of a large steam turbine driven by wood chips. MPM plans to be operational in June or July 2012 with a 35 MW unit (in addition to the existing 10 MW unit), Sao Hill plans the installation of a 15 MW unit for 2013 or 2014. Together, these electricity generation facilities will result in a total electrical performance of 60 MW with an estimated yearly demand of approx. 200'000 t of wood chips per year.

- **Medium scale:** The project group identified the possiblity to introduce electricity generation units in the range of 20-200 kW (electric performance) for the supply of electricity to local communites and small and medium enterprises. These units could operate on the basis of gasfication of wood chips or burning in boilers for small steam turbines. These projects can bring forward the electrification of machinery in remote villages off the main grid. Per 10 kW such small decentralized units will demand 500m3 wood chips per year.

- **Small scale:** In local communites, the project group sees a possibility to replace diesel engines for running stationary generators and for the operation of tractors through gasification of charcoal. This technology was used in Europe in the 1930s and 1940s but has since been given up due to the good availability of fossil fuels. However, efforts to modernize this technology are under way in the Emmental and the African market for this appears to be substantial. In rural Africa the costs for diesel or other fossil fuels is very high compared to the income per capita. Replacing diesel through a locally produced energy source will internalize diesel costs in the village economies plus also open up new opportunities for rural ventures. (Note: All efforts to increase the use of locally grown wood must go hand in hand with efforts to enhance and increase local forestry. Given the already strong push by farmers to grow trees, this should be easily achieved).

Conclusions for the Business case

- **Investing in an expansion of a venture that only produces and sells chips is presently not feasible. The chances increase as soon as the large steamturbines come online, reported to be the case later this year for MPM.**
- Energy generation through wood chips must be linked to efforts to enhance and increase the already existing strong push by farmers to grow trees.
- At the present phase, the chipper operator is planning to create a stock of wood chips. With this stock he can contact potential buyers. This seems like a viable mode of operation to us.
- The continuous functioning of the large facilities at MPM or Sao Hill is not sure, as experience has shown. While many opportunities for using wood chips appear on the horizon, a diversified and decentralized market for chips still needs to be developed before being able to recommend investments into expanding chipper operations.
- The planting activities in local communities and the expected increase of transportation costs create a comparative advantage for decentralised operations.
- **We discover a wide range of interesting opportunities for ventures that would have impact on the village economy. The possible forest-based village ventures must be explored further to make an investable business case for each of them and thereby make the forest potential of the area accessible for enhancing the village economies.**

5.3. Analysis of actors

5.3.1. Project team

The visit of the project group to Mafinga was initiated by Mr. Cyprian Tweve from CB Energy Co. Ltd. and Mr. Ueli Scheuermeier from Rural African Ventures Investments Ltd. (RAVI). Mr. Cyprian Tweve had recognized the availability of energy wood and had contacted Ueli Scheuermeier to consult him on the possibilities how to use this resource.

The project team consisted of Mr. Ueli Scheuermeier, Mr. Thomas Müller, Mr. Christian Hüsler and Mr. Anton Küchler. The team has decided to continue after this project as a consortium and sees its role as facilitators for exploring and launching ventures in the forestry sector for local partners in Mafinga as well as in the Emmental.

This project supported by REPIC is considered to be the start of a pre-commercial phase for a wood energy venture. The consortium plans to continue this pre-commercial phase as proposed in **chapter 6.**

Through interviews with our partners in Mafinga it is possible to gain an overview over the principal actors which need to be involved in the operation of the chipper train, the business case and the further development of the project.

Images 16 & 17: Above from left Anton Küchler, Ueli Scheuermeier and Thomas Müller (25.3.12). Below Christian Hüsler assembling the imported Farmi F260 (19.4.12)

5.3.2. Partners for operating commercial chipper trains

For the different scales of operation and the related business opportunities, the partners can be grouped into key partners, primary partners and secondary partners.

Key partners can significantly take influence on the operation of the chipper train, through either their knowledge, their competence or their resources. They are veto-players in that the operation cannot be run successfully without their consent.

Primary partners are immediately concerned by the operation either through social, economic or ecological profits or losses.

Secondary partners are only indirectly or temporarily concerned with the operation.

Table 5: Partners on different scales for ventures to operate chipper trains in the Mafinga area

	Large scale	Medium scale (up to 10'000 m3 chips per year and unit)	Small scale (up to 1'000 m3 chips per year and unit)
Key partners	Buyers (MPM, Sao Hill, Cement Mbeya) Providers of energy wood (local saw mill operators, forest owners)		
Primary partners	Local workers for the operation of chipper trains, Financing	Local saw mill operators (location of energy generating unit and pro-viders of raw materials), Energy consumers (Tea estates, Mills, Local In-dustry, Local communi-ties), Tanesco (grid pro-vider, energy consumer), Local communities (last mile provider, billing), Financing	Forest owners, charcoal producers (providers of energy wood / charcoal), Local enterprises (consumer of energy), Financing
Secondary partners	Providers of energy unit	Providers of energy unit	Providers of energy unit / tractor

Images 17 & 18: The principal local partners for the envisaged ventures: Cyprian Tweve (CB Company Ltd), discussing with Ueli Scheuermeier (above, 25.3.12) and Bahat Tweve (first from right) and his father Candidus Tweve (second from left) discussing with Thomas Müller and Ueli Scheuermeier (below, 29.3.12)

5.3.3. Green Resources

The Norwegian company Green Resources is a large commercial player producing timber for the world market. The company operates large plantations in the Mufindi district and in other regions of Tanzania and East Africa. Besides harvesting its own plantations, Green resources has a concession to harvest government forests at Sao Hill. Green Resources also runs several tree nurseries in the area and is operating the saw mill at Sao Hill through its sister company Sao Hill Industries.

Currently, Green Resources is developing two CDM (Clean Development Mechanism) projects in the context of the UNFCCC Kyoto protocol. The first project aims at installing a 15 MW CHP at Sao Hill for the production of electricity out of wood chips. The second envisages the development of a sawdust briquette production. Further, Green Resources has installed 12 stationary kilns at Sao Hill used to produce charcoal from offcuts.[5]

Green resources gives away yearly around 120'000 seedlings on request of private planters for free. The company does this as part of its strategy to protect its plantations from the yearly fires. The goal is to motivate the local population to keep fires under control by supporting them to establish their own plantations, which they will be interested to protect from fire.

The project team had the opportunity to interview Mr. Sangito Sumari, Managing Director of Green Resources.

[5] Source: Green Resources (2010): Development of Clean Development Mechanism Projects in Tanzania by Green Resources AS, Lessons Learnt

5.3.4. Opportunities for local communities

Local communities are important players in the management of forests and the use of the resource for timber and energy production. As shown in chapter 2 (potential analysis), it is estimated that local communities account for more than 1/3 of the total surface of forest plantations in the Mufindi district, and there are strong indications that this is probably increasing.

Given the predictions about the possible yield of plantations in the government owned forest, it seems therefore plausible that local communities will be important suppliers of wood both to the buying public and to the industrial processors such as MPM and Sao Hill.

Because of the dissatisfactory supply of electricity, local communities also have the potential to be important purchasers of the produced energy. Especially in the form of electricity, or traction in case technology is available and able to compete with the prices of diesel-run equipment.

Especially in the medium and small scale operations, local communities can profit from the increased availability of electricity, heat or traction. In the discussion with our project partners, the following effects of the new availability were identified:

- Longer working hours in the evenings after nightfall (around 6.30 – 7 pm) because of lighting)
- New opportunities for local processors (milling grains, feed or wood, oil press, carpenters, welding...) leads to an increased added valiue of the local raw materials
- New opportunities for local agriculture (breeding system for chicken)
- New opportunities for processing of timber or non timber products through the availability of heat (e.g. drying of timber, chipboard production, brikette production)

5.3.5. Conclusions

Conclusions of analysis of actors

- The long-term development of business opportunities around the operation of a chipper train should be focussed on medium and small scale, because the entrepreneurial risks seem easier to manage.
- Cooperation with large scale buyers of chips can be envisaged in a first phase to operate the introduced chipper and process the stocks of offcuts which have been set aside in the past months.
- Medium and small scale operations can create interesting opportunities for local communities. Local communities and farmers are important actors with operations and potentials that are still poorly understood.

5.4. Ecologic considerations

Forests are the principal resource which is affected by the operation of a chipper and the further development of the use of energy wood in Mufindi district. During the visit of the project team to the area the possible ecological impact was assessed in order to define criteria for a monitoring strategy when follow up ventures will be started.

As has been explained in chapter 2, the area of the Mufindi district has an annual potential of ca. 1’000'000 m3 of energy wood. If the chipper is run at maximum capacity, it can process 10’000 m3 of wood per year, producing 30'000 m3 of chips. This amount makes up around 1% of the total potential and can therefore be regarded as not significant.

Further it can be stated that chipping wood is not a new operation to the area. Given the fact that the use of wood chips does not entail any dangerous substances or operations, the monitoring of environmental impact can be concentrated on making sure that the resource is not over exploited. This can also be extended to any follow-up of the present project.

Our observation of the planting activities especially by local farmers seems to support a hypothesis that the economic viability of the use of wood for energy will actually increase planting activities and expand the forest areas. However, the presently poor database on private plantations by farmers does not allow to grasp the dynamics here well enough to already assess this hypothesis. This should be explored in more detail.

The follow-up ventures that now appear plausible will result in less diesel or other fossil fuels used in the further development of the local economy. Besides, the controlled combustion of wood residues will reduce methane emitted when unused heaps of off-cuts and saw dust are left to rot. All this will have a positive impact on the globally desired reduction of greenhouse gas emissions in Tanzania and may be a further source of revenues. For this, the emission reduction units must be certified and may be integrated in a project under the Clean Development Mechanism of the UNFCCC Kyoto Protocol.

5.4.1. Monitoring

In order to make sure that the natural limits to the use of the forest resource are respected we suggest that a monitoring system is set up which shall keep track of the following criteria:

- **Soil fertility:** A first assessment on site has shown that the content of organic matter and the porosity of Pinus plantation lots after harvesting is good. The visual examination of samples and the discussions with our local partners has led us to this conclusion. The soil quality after planting Eucalyptus seems less good.

  For the future, a monitoring process should be set up in the frame of a follow-up project. It should track the changes in soil fertility on the surfaces affected by the planned operations. This monitoring should help to identify a degradation of soils in an early stage and subsequently to develop an appropriate strategy for improving the situation.

  Fertility of tropical soils is so far not well understood so that it should be subject to further research, as stated in paragraph 2. Also the effects of fires on the soil – a feature of the landscape since millenia – warrant a closer look (eg. effects of terra preta due to carbon in the soil?).

- **Survey of forested area:** Observing the development of the past years, the project team sees its initial hypothesis confirmed, that the increased demand for wood leads to increased planting activities in the area. This effect is especially remarkable among local communities who seem to have increased the surface of their plantations significantly over the past 10 years.

  In order to introduce a systematic survey of forest areas, the project team proposes to establish a regular monitoring. This may happen through evaluation of satellite images. A first contact has been established with the Center for Development and Environment (CDE) of the University of Berne, which is a competence center for GIS-surveys in East Africa.

  This should also help to survey environmental effects of operations of future ventures e.g. the introduction of decentralised saw mills.

  The survey should also help to protect natural growth forest from exploitation. This may occur because of illegal replacement of natural growth through plantation or

through the equally illegal use of local species for charcoal production.

- **Invasive species:** The team suggests to introduce Black Wattle as a secondary crop between rows of Pinus plantations. Black Wattle is ubiquitous and has been spread throughout the area after the establishment of large Wattle plantations in the southern part of the Mufindi district.

  Wattle must be considered as an invasive species, which is proliferous through high seed production. Wattle is usally weeded in plantations. Weeding is not difficult, since Wattle seedlings can easily be uprooted in the first 1-2 years.

  Wattle might be problematic when it spreads out widely, pushing back natural growth trees. However, a spread by Wattle into natural growth forests has not been observed by the project team. A monitoring of the further development seems desireable.

- **Harvest / plantation ratio:** In the past years harvesting activities have increased significantly because the large consumers of wood (MPM and SHI) took up their operations again after shutdown for several years.

  In order to uphold the ability for regular harvesting, the replanting of the plantation lots must be ensured. Observations in the area have shown that replanting works quite well. This supports our hypothesis that the use of the resource also ensures that replanting after harvest is taken care of.

  The government has already established a mandatory replanting requirement for concessionaries.

  The project team therefore proposes that the replanting remains in the responsibility and self control of forest owners and local communities.

- **Reduction of Greenhouse gas emissions:** The proposed ventures will contribute to the reduction of greenhouse gasses through the substitution of diesel generators and the prevention of methane emission through the rotting of unused stock piles of offcuts and saw dust.

  These effects should be closely monitored and quantified to identify economic opportunities within in the UNFCCC Kyoto protocol mechanisms and possible succeeding schemes.

5.4.2. Further research activities: Fire ecology, soil fertility, Black Wattle

The visit on-site of the project team made several aspects apparent which are not yet fully understood by both experts and farmers. In these areas it seems desirable to undertake further research to understand the processes and develop adequate strategies. The areas in question are:

- **Fire ecology:** Understanding the role of fire in the ecologic and agricultural system. Develop strategies to work with fires and to optimize the desired effects (increase in soil fertility, reduction of fire hazard, protection of cultivated areas).

  The use of fire offers a possibility to enhance the accumulation of organic material in the ground, if the biomass is charred and then mixed into the topsoil. Traditional practices of the Kinga tribe work exactly with this method. The accumulation of charcoal in topsoils might support efforts to reduce greenhouse gas emissions. However, the mechanisms must be understood and adequate techniques must be developed.
- **Soil fertility:** As stated in the previous paragraph, soil fertility of tropical soils must be further investigated in order to understand mechanisms and develop techniques for improvement.

- **Species used:** The use of Black Wattle seems like a good option for the production of energy wood. Nitrogen fixation will also help to increase soil fertility in the plantation lot.

  However, since Black Wattle must be considered as an invasive species, further research should be undertaken to see if Wattle is the proper pick or if there are alternatives which yield similar positive effects, but reduce the negative aspects.

5.4.3. Ensuring the sustainability of the operations

In Tanzania, as in all other parts of the world, the demand for energy is large and increasing. If the renewable but also degradable forest resource is used for providing supply with energy, it is necessary to establish a resource management in order to ensure the sustainability of the operations in the plantation areas.

Villagers have suggested to us that the resource can be managed through a kind of collateral management whereby growing trees would be regarded as assets that can work as collateral for credits. This would then require collateral management that would have the following responsibilites:

- Training of forest stewards, who will support the plantation owners (especially local farmers) in preventing destruction through fires and in sustainably and profitably managing their small scale forests.
- Ensuring the sustainability and predictability of the growth should make plantations useable as security for bank loans and therefore allow forest owners to make necessary investments.
- Whoever wants to operate energy generation units based on wood chips must own plantations for energy wood. This could happen through the system of forest stewards who also ensure the use of forest as assets for bank loans. If for example a village community desires to run a energy generation unit with a yearly consumption of 1000 m3 of roundwood, they must first present a proof of the existance of plantations able to generate the respective amount of wood and their sustained good management through contracted forest stewards, etc. This must be a condition for obtaining the necessary license from the government to operate a wood-burning energy unit. A forest stewardship venture could manage all the regulatory work designed to safeguard sustainability.

5.4.4. Conclusions

Conclusions of ecologic considerations

- The project team proposes the introduction of a monitoring system, scientific studies and a professional collateral management of forest plantations in order to protect the forest resource from overexploitation.
- The availability of energy wood can be increased by intercropping Pinus plantations with Black Wattle or other fast growing leguminous tree.
- The establishment of energy generation units based on wood chips should only be permitted if the operation is linked to a sufficient surface of plantation area.

6. Future Prospects

The main currently existing framework conditions for the use of wood energy in the Mufindi district are:

1. The obvious potential of wood production in the area
2. The successful introduction of mobile chipping technology
3. The widespread planting activities in local communities
4. The unreliable or largely missing supply with electric energy
5. The government policy that demands improved local saw mills
6. The increasing costs for transportation

Taking these framework conditions into account, it seems appropriate to develop a decentralised approach for any follow-up efforts.

The proof of technical concept has been achieved. The operational concept has not been achieved due to a lack of buyers of wood chips. Given the decentralised approach of the introduced wood chipper technology, the demand for chips is currently not sufficient and must be further developed.

The strategic aim should be to electrify wood chips in small-medium decentralized units and primarily use that electricity for local operations.

To move ahead on this strategy the best immediate leverage is the establishment of a modernized stationary sawmill that will – through modular addition of technologies – end up using its own waste wood for its energy needs. It is therefore proposed that:

- A modern stationary small sawmill is established that produces high quality timber according to the government policy
- This sawmill shall be small enough to need logs from maximum 20km perimeter to run at capacity
- Once operating the sawmill will become the testbed to modularly attach further technologies, ie:
- Generate electricity from its waste wood for its own operations (and potentially feed surplus into the grid)
- Use the generated heat to dry timber for the high-quality market and for reducing transport costs and transport energy
- Produce wood briquettes out of sawdust (as applied at Mena Wood Co. Ltd. in Mafinga, see picture 20), using the generated heat to dry the sawdust
- The ecological effects and limits must be carefully assessed and monitored. In order to develop a sustainable management of the forest resource, a appropriate forest managment should be an integral part of any energy project based on the use of energy wood.

Images 19 & 20: Current mode of operation of local saw mills. This technology level should be phased out according to plans of the national government and replaced by modernised saw mills (above). The saw mill of Mena Wood Co. Ltd in Mafinga established a pioneering venture into the production of wood briquettes out of residual saw dust (below).

7. Conclusions and Outcomes

7.1 Wood for energy is available in the area

Waste wood from forestry operations is available in the southern highlands in large quantities. Presently it is mostly unused. The potential is still poorly understood. It is safe to work on ventures for wood energy in the area, provided that the potential is being explored at the same time, particularly also with farms and local communities

7.2 Chipping technology successfully introduced

The technical and operational proof of concept has been achieved for mobile chipper trains (chipper, tractor, trucks) that process waste wood into chips and transport them to where they can be converted into energy.

7.3 Need for understanding small scale forestry

There is a recent upsurge of private plantings of trees by farmers that has been insufficiently monitored so far. Efforts must be made to work with communities and farmers on their level of forestry with often unique features that are not typical of large scale clear-cutting industrial plantation forestry, ie. through action research, "participatory technology development (PTD)", etc.

7.4 Demand for chips not yet developed for investing in only chipping ventures

Wood chips are presently processed into energy in one large 10 MW steam turbine in the paper factory. This is at present the only source of demand and it is unreliable and erratic. Within the next 6 months the capacity is said to increase to 45 MW and by end 2013 to 60 MW through installation of two further large steam turbines in the area. Should this happen, demand can be expected to rapidly increase. However, this can not be assured. At present, an investment in expanding the chipping operations must wait to see whether and how the demand develops from these two large buyers. Also, it appears too risky to depend on just a few large industrial buyers.

7.5 Strategy to develop decentralized electrification of wood chips

The strategic aim must be to electrify wood chips in small-medium decentralized units (ie. around 20-200kW) and primarily use that electricity for local operations. A wide range of forest based village-level ventures are beginning to present themselves. They must be explored to make an investable business case for each of them and thereby make the forest potential of the area accessible for enhancing the village economies. Chipping wood and making electricity out of the chips must be seen as an element in such a greater strategic venture

7.6 Need for non-commercial supporting activities

Available information and data does not allow to sufficiently assess the forestry dynamics on the ground. Particularly private plantings by farmers and communities are poorly understood. A range of supporting non-commercial activities should include:

- Monitoring forest surfaces according to management types (govt, private, industrial plantation, line, plenter, natural, etc). This could be done through satellite imagery supported through ground work, eg. with CDE in Berne.
- Understanding soil-fertility dynamics with various soils and under various management types, with special focus on the ecology of bush fires

- R&D with farmers and communities on their innovative forest practices for small scale plenter-type forestry
- R&D on various operational ideas that have emerged for increasing output from forest lands and for technical experiments and test-runs in the villages

7.7 An energy-integrated small sawmill (as immediate technical-energy leverage):

The immediate technical leverage into the system that presents itself at this moment will be an "integrated" sawmill that:

- is stationary and produces high quality timber
- is small enough to only need a perimeter of 20km of logging to run at capacity
- may first operate with electricity (if near the grid) or on diesel...
- ...and at the same time it will produce the offcuts and sawdust for testing an electric generation unit to power the sawmill and with the generated heat dry the timber to high quality (and savings on transport)
- the mill also becomes a test bed for further technologies that can be modularly plugged into the system, eg. feeding electricity into the main grid, production of briquettes, production of charcoal for operating tractors, possibly even production of chip boards at a later stage, and of course using the generated electricity to process timber into higher-value semiproducts.
- if successful such small decentralized sawmills will be replicated throughout the area and become hubs for new energy utilization in the rural locations where they operate, ie. electricity for mills, pumps, crop drying, etc.
- also the modularly developed technologies can and will be adapted to fit other situations, ie. providing electricity and heat for tea factories, charcoal chains for operating tractors, insular electricity generation units in villages, etc.

7.8 Growing trees as collaterals for credit (as immediate operational-forestry/financial leverage):

The above mentioned sawmill can be at least partly financed through loans that take growing trees as collateral. This will require training of forest stewards to provide the collateral management, along with the required monitoring and contractual arrangements. This is a separate venture in its own right that should be seen as a separate program. However, it is highly recommended to always combine the technical energy utilization of wood with efforts at improving forestry sustainability and its profitable outputs.

7.9 Consortium of Emmental actors established

The involved people from the Emmental together with RAVI have together already contributed more than 46’000 CHF to this effort. They have now decided to continue exploring and developing the potential of cooperation with entrepreneurs in Tanzania and have requested RAVI to join in a consortium with them to push this further. Presently the following people are part of the consortium:

- Thomas Müller, farmer and forest owner in Heimisbach, also president of the Emmental Association for Wood Energy
- Christian Hüsler, also Heimisbach, owner of company that sells and services agriculture and forestry equipment
- Anton Küchler, of Trub, environmental engineer ETH specializing on operation of renewable energy systems
- Ueli Scheuermeier, in Berne, of Rural African Ventures Investments Ltd

Further people are expected to join the consortium as and when further ventures evolve. The consortium is a temporary arrangement that will evolve into a more formal company if and when the need arrises.

The consortium gives itself the task to identify, explore and develop ventures with Tanzanians in order to build renewable energy solutions for rural Tanzania.

Immediate opportunities that the consortium has already started to look into are:

- Install and operate a small stationary high-quality sawmill
- Improve the chain from forest to sawmill; a forestry tractor with winch and frontloader that will be able to pull trees to the roadside, debranch them there (for later chipping, also allowing to immediately plant on the cleared land instead of waiting to burn) and load logs onto trucks for transport to sawmills
- Install small electrification units, either boilers with small steam turbines, or wood-gas through explosion motors (new tar-free technology by Markus Arm, Langnau)
- Use heat from electrification units to dry sawn timber
- Explore plenter-management of forests with small farmers, also with focus on charcoal production for early returns when combining planting Wattle with planting Pines for timber
- Train forest stewards to do reliable collateral management
- Make charcoal production more efficient, also using the waste-heat for drying, and combine this with the efforts to run tractors on charcoal (tar-free operations)

8. References

All referred publications are mentioned in the footnotes of those pages where the referral takes place.