Danida

MEMA, Community Based Natural Woodland Project Iringa, Tanzania

Forest and Vegetation Baseline Survey

January 15 to February 08 - 2000
and
April 26 to May 16 - 2000

COWI **in association with**
Danish Forestry Extension
Regulus Consult

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Prepared	Per Christian Christensen
	Forest Inventory Consultant
	Danish Forestry Extension
Checked	Lars Wollesen
Approved	Morten C. Andersen

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LIST OF ACRONYMS

The following acronyms or abbreviations are used in this report:

CCO	Community Conservation Officer
CF	Cultivated Farmland
CTA	Chief Technical Advisor
DBH	Diameter at Breast Height (1.3 m's)
DF	Divisional Forester
DFE	Danish Forestry Extension
DFO	District Forest Officer
DGO	District Game Officer
DGPS	Differential GPS
DNRO	District Natural Resources Officer
GPS	Global Positioning System
ha	Hectare(s) = 10.000 m²
HW	Highland Woodland
LW	Lowland Woodland
MBOMIPA	Kiswahili abbreviation for "Sustainable Use of Wildlife Resources in Idodi and Pawaga Divisions, Iringa Rural District"
MEMA	Kiswahili abbreviation for "Community Based Natural Woodland Management"
NWMP	Natural Woodland Management Project
PM	Project Manager
PSP	Permanent Sample Plot
TA	Technical Advisor
TAFORI	Tanzanian Forestry Research Institute
TANAPA	Tanzanian Natural Parks
TOR	Terms of Reference
UTM	Universal Transverse Mercator
WF	Wooded Farmland

Discussions on Terms of Reference for the Forest and Vegetation Baseline Study

The Terms of Reference for the present mission can be found in annex 1.

On a meeting on the 17 January at the office of the DNRO, the following amendments to the ToR were agreed upon by the following persons present:

DNRO Mr. Mallango
DFO Mr. Mchomvu
CTA Mr. Henrik Lerdorf
Consultant Per Christian Christensen
Consultant Michael Gehlert

The present consultancy will deal with issues related to an inventory of relevant woody species in the miombo woodlands and will thus not be concerned with the Udzungwa area nor with non-wood products.

The first part of the present mission will develop one or (presumably) more methods to make inventories of major woodland wood-products.

The methodology will relate both to the interpretation of aerial photographs, the stratification of the vegetation types and the ensuing mapping, as well as to the actual measurements of the inventory itself.

The participatory mapping and inventory will concentrate on the common land (more specifically the woodlands) and only to a lesser extent carry out a survey in the farmland. Fallow land will be analysed in order to estimate the importance of the eventual inclusion in the actual inventory.

During the presence of the consultants, the mapping and the inventory will be developed and initiated, and the two foresters from the project/district will complete it in collaboration with the villagers in the concerned villages.

The issue of establishing unambiguous and acceptable ways of demarcating boundaries, will not be a high priority, as the very nature, necessity and timing of these boundaries have not yet been decided upon. The present mission will nevertheless - based among other things on observations in the field - present a “catalogue” of possibilities according to the purpose, nature and timing of the boundary.

Elements for the determination of growth potential will be integrated in the methodology for the inventory, but the analysis and the estimation itself of the growth potential under different conditions will take place on the coming mission.

The identification of suitable indicators will be treated as the growth potential mentioned above.

During the present mission capacity transfer will take place through on-the-job training. During the coming mission, a limited formal training for additional forestry staff can take place, based on the experience gained through the execution of the inventory.

The TORs were equally discussed on the second mission between:
DNRO Mr. Mallango
DFO Mr. Mchomvu
CTA Mr. Henrik Lerdorf
Consultant Per Christian Christensen
Consultant Bengt Kvitzau

but no major alterations were made.

1 Photo Interpretation

1.1 Existing material

1.1.1 Topographic sheets

Topographic sheets in 1:50.000 are available for the whole of Tanzania. They are elaborated in the period from 1977 to 1985 jointly by the Survey and Mappings Division, Ministry of Lands, Housing and Urban Development and the Canadian International Development Agency.

The basis of the topographic sheets is aerial-photography with supplementary ground control surveys. The maps proved quite reliable on the more permanent topographic issues as roads and contour lines. The UTM projections 36 and 37 are used and shown as a grid-net on the maps.

The sheets covering the Kitapilimwa Forest Reserve:

215/1(Mwaya) – UTM 36

The sheets covering the Nyang'oro Forest Range:

197/3 (Chamdindi) – UTM 36
197/4 (Nyang'oro) – UTM 36
198/1 (Luhombero) – UTM 37
198/2 (Mtera) – UTM 36

All recorded 1977/78 and published in 1982/83.

1.1.2 Aerial photos

Photomap International Inc., Nairobi, carried out both the aerial photography and the processing of the pictures in September 1999. The photos are taken in an average scale of 1:50.000 with a 60% overlap between the successive exposures *in* the flightrun and a 30% overlap *between* the flightruns. It is not clear if the photos have been rectified, but they are probably not.

Photographic enlargements in 1:25.000 of every second exposure have been produced. When compared, a discrepancy between the expected scale (1:2) between the contact copies and the corresponding enlargements occur. It is not clear which of the sets is true to scale (if any of them). In any case, variations in flight altitude can be detected on the instrument readings of the contact copies, indicating an error of scale in this material.

It is difficult to measure the quality of the photos because of the lack of ground references. Apparently no reference pointers were laid out in connection with the photo flights and

other references, i.e. other maps or known beacons in the terrain are scarce. Thus, it is virtually impossible to verify the actual scale. But when comparing with the topographic sheets, it is obvious that the photos contain rather large parallel axis errors – caused by the hilly terrain, especially in Nyang'oro. Hence, the photos are only accurate in the centre of each photo.

In this context, it is a disadvantageous feature that the overlap between the flight runs in some cases are less than the expected 30%.

The resolution and grey tones on the contact copies are good. On the enlargements, the quality is lower - the picture is in general darker and not so distinct. Still, the enlargements offers a good supplement to the 1:50.000 photos, as many features in the terrain, which could hardly be seen on the smaller photos, could easily be detected on the enlargements.

In spite of the above-mentioned technical problems, the aerial photos combined with the topographic sheet are considered to meet the necessary demands for the elaboration of maps for the inventory.

1.2 Activities undertaken

1.2.1 Interpretation

The main interpretation was carried out directly on the contact copies (1:50.000), but both the 1:25.000 enlargement photos and a stereoscopic examination (mirror stereoscope) of the contact copies were used as supplementary means of interpretation.

1.2.2 Supplementary ground surveys

The ground survey served two major purposes:

- To verify if the interpretation of aerial photographs was correct and sufficient; i.e. were supposed boundaries between different forest types distinguishable in the field, *and* did the field trip reveal any significant boundaries, which were not initially detected on the photos?

- Training of the local personnel (both foresters and farmers) in the skills of interpretation and mapping.

The findings and conclusions of the initial ground surveys are briefly presented in the following.

<u>Kitapilimwa</u>

A route that ensured both the verification of the expected vegetation borders and a browse through the large plain with - according to the photos - rather uniform miombo was taken.

Findings:

The expected changes in vegetation / forest type could quite distinctively be found in the field. The question of the impact on the management - and thus the planning of the inven-

tory - was discussed on the site. The preliminary conclusion was that the distinction was clear and of relevance to the consequent planning. Hence, the following strata were identified in Kitapilimwa:

A Miombo woodland
Covering the largest part of the forest reserve. Heavily disturbed by uncontrolled cuttings, but still trees with potential for both timber, charcoal and commercial fuelwood. Contains in it self a large variation - but the variation is in a continuum and borders almost impossible to establish. Should be regarded as one stratum - perhaps with the exemption of the riverbed forest, which may be separated.

B Depleted woodland
The lower woodland area is separated as a stratum because of the obvious human impact (several fields within the reserve could be detected) and the apparent absence of lager trees with a canopy distinguishable on the photo. Potential production in short and medium term is mainly fuelwood.

C Thicket
Some of these areas are woodlands exploited to an extent, which leaves very little regeneration potential.
Species: No 'true miombo'-species - mainly shrubs and trees with low potential for utilisation.
Height: 3-5 m.
Value: Low.

E Previous clear-cut
The area had been cultivated as farmland. Agriculture has ceased and enrichment planting with both exotic and indigenous species has been carried out. The area was exploited - but with a large number of stems per hectare, it still has the potential for regeneration.
Species: Fuelwood
Height: 3-6 m
Value: Potential for charcoal and commercial fuelwood.
Stems: 4-5000 pr. ha (est.)

The descriptions made in the field were only preliminary – to be used for further discussion on stratification.

Nyang'oro

Because of the size and accessibility of Nyang'oro Forest Range, it was not possible to browse the entire area on the initial survey. Instead a transact penetrating a typical part of the southern range was performed as well as a survey tour in the northern plains.

Findings:

In Nyang'oro the distinction between different forest types was less clear than in Kitapilimwa; to a very high degree variations were continuos with no clear borderlines. However, the following types could be identified:

A Highland woodland / Miombo: Miombo species as Brachystegia and Commiphora sp. could be found, but during the first field trip, almost no Mninga was found – and the few specimens found was small dimensioned. Still, a decent immediate potential for both poles and commercial fuelwood was present. Apparently, present cutting activities were low – only few and scattered stumps were found.

B Lowland woodland: A zone between the farmed or grazed areas and the miombo. Heavily exploited for commercial values and with significant smaller trees (both in height and diameter) than the highland miombo.
Grazed woodland: Mainly on the northern side of the hills. Dominated by Acacia species – with livestock hampering regeneration. Utilisation of the trees is mainly restricted to fodder and domestic fuelwood.
The difference between Lowland Woodland and Grazed Woodland is only distinguishable in the terrain and not on the aerial photos, why a common stratum is used in the photo interpretation, and only later inventory measurements will show if there is evidence for a real difference.

1.3 Recommendations

As the same type of photo has already been procured for the rest of the district, it is not really worthwhile considering other options.

But nevertheless, orthophotos in scale 1:25.000, e.g. with enlargements in 1:10.000 for just the limited management area, might be considered for future applications. Mainly in order to enhance the interpretation and the stratification of the vegetation cover, and thus reduce the actual inventory field work in difficult accessible mountainous terrain.

Analogous to previous experience from e.g. the Tabora-based woodland management project, based on the photo-interpretation, it proved possible only to detect two distinct types of vegetation in the wooded areas.

Ground verification, socio-economic knowledge and topographic features might later on lead to further stratification for management purposes.

2 Vegetation Cover Mapping

2.1 Findings

As described in the preceding section, only very few vegetation strata have been identified, as it is hard to distinguish different vegetation types and difficult to define the limits because of gradual transition between vegetation types

2.2 Procedures undertaken

The necessary photos to cover Kitapilimwa and Nyang'oro were identified and selected from the MEMA archive. The selection is carried out by reading the coordinates (in latitudes and longitudes) of points surrounding the forest on the topographic sheet. Transferred onto the map showing the flight-runs, it is thus possible to identify the numbers of the photos needed.

A transparent film (tracer paper) is placed on the topographic sheets.

First at least four intersections from the UTM grid net are marked. The transference of the UTM grid points both makes it possible to produce a large map based on smaller part-drawings without any error and to transfer the UTM grid net to the forest map.

Secondly, distinctive features like major roads and rivers, some hilltops and ridges are marked in order to create correspondence between the photos and the transparent.

Hereafter the interpretation of the aerial photos is transferred to the map drafts on the transparent film using the 1:50.000 photos.

The mismatch between topographic sheets and the photos makes it necessary to make partial fitting of the photo interpretation, i.e. the photo where the area to be interpreted is located as close as possible to the centre of the photo, is placed to the 'best available' fitting with the nearby features drawn from the topographic sheet.

On the basis of among other the socio-economic survey, preliminary boundaries between villages/management units and between farmland and woodland are drafted on the vegetation maps - strictly for inventory purposes.

Finally, by means of a transparent Dot-Grid-Sheet, the area of the different strata per management unit is calculated.

See annex 2 for these data.

For practical reasons, separate draft maps are produced and an aggregated map of the whole area is ultimately merging all the information.

2.3 Recommendations

In order to avoid double work, it would be optimal to locate the position of both the internal and the external boundaries before the vegetation stratification, or at least before the analysis of the inventory results takes place.

See also section 5.3.3.

3 Inventory Methodology

3.1 Basic findings

The inventory method has been thoroughly discussed, and it is agreed that for the present objectives of the management plans, the inventory should be based on existing figures for the relationship between basal area and standing volume. Likewise the determination of the basal area itself must be inexpensive and not too time-consuming.

There is no justification for heavy expenditures on such an inventory, as the most significant product of the miombo woodlands of this region is fuelwood for which specific measures are of low value.

Any extensive experience on woodland inventory is found neither within the region nor amongst the project staff.

The personnel designated for the inventory had mixed experience in "standard" inventory methodology, and thus the use of caliper and tape measure was well known, whereas the use of compass, clinometer (height metre) and relascope was less experienced.

The "Inventory Team" had access to the following inventory equipment:
1 caliper
1 compass
1 tape measure
1 clinometer
2 GPS instruments (Garmin ☺ plus)

This instrument is a simple, easy to use handheld GPS. The quality of the readings varies with satellite position and sky coverage -, e.g. clouds, canopy etc. There is no possibility for differential correction by use of beacon-transmitters. The precision of the ground determination displayed by the GPS is approximately ± 50 m – most likely with the implication, that the actual position is 'probably within a circle with the radius of 50 m. This is within an area of 0.25 ha. Taken into consideration the type and magnitude of other errors – as the demarcation of boundaries and especially the vegetation borders within the forest – this must be considered acceptable. It should be mentioned that the "rocker keypad" on this model is much too small for the "hands of a forester", which causes some difficulties in the manipulation of the instrument.

Add.: As per 1/05/2000 the jamming of the GPS system has been lifted, which results in a much higher precision without any alterations to the GPS instrument, which in

fact corresponds to the previous DGPS.
The present precision is approximately ± 15 m.

3.2 Actions

Based on the findings during the photo-interpretation and mapping procedure and previous experiences -, e.g. the Tabora-based Woodland Management Project - it was decided to apply a simple stratification combined with volume estimation based on direct measurement of the basal area (relascope) combined with species and diameter counts.

The participatory aspect was taken into consideration by including the findings from the socio-economic report concerning, e.g. the list of preferred species, and the on-the-job-training of the two assigned forest division officers and a large number of villagers from the concerned villages.

3.2.1 Stratification

The first stratification layer is the villages or management units (preliminary delimitation on the basis of the maps of the socio-economic survey). See also section 5.

The second stratification layer is the vegetation type.

Kitapilimwa:

Due to the small size and the legal status of the forest, no stratification between villages has been made.

It should be noted that the village of Kiwere, which has been included in the socio-economic survey, has no traditional sphere of interest in the Kitapilimwa forest.

The village of Ikengeza seems to have a sphere of interest both in the Kitapilimwa forest and in the Nyang'oro forest range.

6 different vegetation strata have been identified:

Thicket
Depleted Woodland
Miombo Woodland
Previous clear-cut
Cultivated Farmland
Wooded Farmland

Nyang'oro:

Of the nine villages included in the socio-economic survey, it has at the present stage not been possible to identify a sphere of interest within the Nyang'oro forest range for the village of Makuka. See also section 4.3.

4 different vegetation strata have been identified:

Lowland Woodland

Highland Woodland
Cultivated Farmland
Wooded Farmland

For both Kitapilimwa and Nyang'oro the Riverine Forest, within the proposed management area, does not seem to have any significant distribution, as the surrounding vegetation type in most cases apparently just continues to the very border of the riverbed.

However, further analysis is needed in order to determine the exact magnitude of this possible management stratum, and thus it was decided to include a stratum for Riverine Forest in both management areas.

3.2.2 Measurements and Data Registration Sheets

Initial test-plots carried out during the presence of the first inventory mission, indicate that approximately 4 plots per 500 hectares woodland stratum will present a satisfactory accuracy for the determination of the standing volume.

For the wooded farmland, only 4 plots per approximately 1000 hectares will be examined.

Based on the area data in annex 2, the required number of plots is calculated.

In addition, a number of plots was laid in the most important riverine forests, in order to assess the management perspectives in this type of vegetation.

In order to facilitate the fieldwork, the layout consists of a number of transects, which will each include one to five clusters, which again will include each 4 plots.

The Data Registration Sheets (Inventory Forms) as found in annex 3 are practically self-explanatory, and they equally indicate the measurements taken:

- Explicit identification of the plot. (4 plots per cluster)

- Verification of the stratum as registered in the terrain. This is not necessarily the same as judged from the aerial photo.

- Indication of the slope of the terrain.

- Measurement of the basal area for commercially merchantable timber (DBH > 10 cm) for each plot.

- Measurement of DBH of all trees with DBH >= 5 cm. within a part of the plot consisting of a circle with radius 8m.

- Counting of regeneration/saplings per species. Specimens smaller than 5 cm DBH and 1,3 metres height were registered.

- Measurement of average height of the tree-layer of the plot.

- Indication of evidence of different kinds of activities in the area (not quantitative).

- Comments on any other observation of interest.

The volume per hectare will be determined per plot on the basis of basal area and average diameter (DBH) by the aid of the volume table generated by the Tabora-based woodland management project based on Schultz (1973).

3.2.3 Relascope

The inventory team has produced its own relascopes for several reasons:

- Simple "standard" relascopes are appropriate for forest types with a basal area between 10 and 30 m^2/ha as opposed to the expected 3 to 6 m^2/ha in the miombo woodlands of this region.

- Locally produced instruments have a higher degree of "participation".

- The comprehension of the methodology is enhanced when you know the tool thoroughly.

- The production price of this relascope is extremely low.

See annex 4 for a short description of the theory behind this relascope.

3.3 Recommendations

Inventory intensity and precision.

On the basis of the analysis of the present inventory, it will be possible to assess to accuracy of the results, and thus evaluate if the intensity of the inventory measurements was sufficient or exaggerated.

The preliminary figures seem to indicate that a similar precision could have been achieved with fewer measurements.

Inventory stratification and layout.

As it turned out to be very difficult to distinguish between the different strata - even on the spot in the field - it should be considered instead to carry out a systematic layout of the inventory.

A decision whether to go for a vegetation mapping with an ensuing stratified layout, or to go directly to a systematic layout of the inventory, could be based upon an aerial survey (perhaps supported or backed with handheld photos) which could indicate if at all there is a possibility to stratify the vegetation cover.

An analysis of the variance of the inventory data can perhaps clarify if there are any significant distinctions between the different strata.

Future use of the methodology and the database.

The data processing software, produced in Access database, can be used to process similar inventories for other forest areas.

The file called nwmp2000.mdb is the file holding the data for the Nyang'oro and the Kitapilimwa forests.

The file called Inventory.mdb has got the same structure but contains no data. A copy of this file can be renamed and used for any other similar inventory with only minor preliminary new data definitions.

Coordination with other aspects of the management project.

On the basis of a brief meeting with the MBOMIPA project, who is conducting the wildlife survey in the MEMA area, it seems possible to create close coordination between the forest and vegetation survey and the wildlife survey with mutual benefits.

The wildlife survey can refer to the same stratification as used in the forest and vegetation survey, and the results from this forest and vegetation survey can be used to assist the wildlife survey. Especially information on species distribution and evidence on game, hunting, grazing and farming activities.

Coordination with e.g. the non-wood and the biodiversity aspects of the project is discussed in section 5.2.2.

Please also refer also to sections 2.3 and 3.3.

4 Inventory

The fieldwork of the inventory has been planned and prepared in detail during the first mission, and two teams carried it out in the months of February to April.

The teams consisted of villagers from the concerned villages, and the teams were headed by the two division forest officers Mr. P.Njau and Mr. F. Nikata assisted by inventory consultants Mr. E. Haule and Mr. M. Kisima as well as personnel from Iringa District Natural Resource Office.

A total of 84 clusters were measured.

4.1 Inventory results

In the present report a selection of figures is presented. Additional figures and analyses can be obtained from the database itself. Mr. P.Njau and Mr. H. Lerdorf have received "rudimentary" training in this facility.

4.1.1 Volumes

Calculations

Schultz (1973) registers commercially merchantable timber > 10 cm. (measured under bark). Basal area and volume are based on registration of trees of DBH > 15 cm. The volume curves from the Tabora Project and the resulting regression models are shown in copy in annex 5. Volume curves depict the standing volume as a function of basal area and DBH. In the current project, the limitations of the available material become evident, when evaluating average DBH, which is substantially smaller than in the figures from Schultz (1973). For practical purposes, we have on the basis of the 20 and 30 cm. DBH curves estimated the 10 cm. DBH curve as having the same relative distance to the 20 cm. curve as the 20 cm. curve has to the 30 cm. curve.

According to Lowore et. al. (1994) the total volume (> 2 cm. on bark) of timber removed from Miombo Woodlands corresponding the forests found in the Iringa region can be expressed as a linear regression based on basal area of removed volumes. Lowore's findings are based on removed material with a DBH > 5 cm. The volume regressions are shown depicted in annex 5.

Malimbwi et. al (1994) found in a another study of the Miombo Woodlands of the Morogoro Region of Tanzania a conversion factor of 0,51, when calculating volume > 15 cm. on the basis of total volume.

When trying to approximate the figures derived by Lowore et. al. (1994) to merchantable timber > 10 cm. using an approximated conversion factor of 0,60, we find a regression corresponding to the prior estimated 10 cm. DBH curve mentioned above. As the material of Lowore et. al. (1994) is based on material with an average DBH > 10 cm., it would be reasonable to assume, that our 10 cm. DBH curve has too steep a regression. Further information from permanent sample plots could yield valuable information for future predictions.

The regressions used to derive merchantable volumes in the data analysis on the basis of basal area and DBH are:

DBH 10 [Volume > 10 cm.] = 4,43*[Basal Area]
DBH 20 [Volume > 10 cm.] = 5,43*[Basal Area]
DBH 30 [Volume > 10 cm.] = 6,43*[Basal Area]

When evaluating harvesting levels it should be noted, that when the estimated basal area to be removed and the corresponding average DBH are found, the Volume Table can be used to estimate menchantable volume > 10 cm (10, 20 and 30 cm DBH curves) and potentially available firewood (for local consumption) volume from 2 to 10 cm (difference from the Total curve).

Results

When examining volume figures from the two distinctly different forest areas, the developed database allows the evaluation of data per forest, per stratum and per village.

From a management point of view, the Volumes gained per Stratum, given the present uncertainty concerning boundary identification and demarcation between the villages within the Project area, may be the most appropriate approach in assessment of standing volume.

However, this method does not take into account the possible variation over the total Project Area within a given stratum. The implications of this will be further commented in the following.

Figures for Volume per Stratum are presented both as simple averages based on the sample plots, and weighted averages based on plot average weighted according to total Stratum area. The volume figures are presented in Annex 6

The Volumes per Village (average and total) have been calculated in two different ways. The figures are presented in Annex 6.

- Using the calculated volumes per strata, the “per Village” predictions of standing volume have been calculated using the stratified areas generated as the basis for the inventory.

- Volumes are predicted directly on the basis of the measurements taken within the area designated as belonging to the particular village. Volumes are presented both as simple averages based on the samples and weighted averages based on plot average weighted according to total forest area belonging to the village.

Nyang’oro Forest:

- Riverine forest: Although plots have been allocated to the stratum, basal area has only been measured in very few plots due to the nature of the areas. So far, no Stratum area has been allo-

cated due to the uncertainty of which criteria should define the width and the length of an *important* Riverine forest. The findings show no significant deviation in DBH and height from the surrounding Miombo and Lowland Woodland. From an inventory point of view, it will thus have no major importance whether this stratum is included in the woodland strata or not for harvesting purposes. From a management point of view however, this stratum may be of significant importance as an independent unit, e.g. in relation to catchment area considerations.

- Lowland Woodland: This stratum constitutes by far the largest area of the inventory, totalling nearly 60% of the area designated as future forestry lands. Average basal area and volume is, as expected, fairly low, but with great variation. Standing volume >=10 cm. is app. 21 m^3 / ha.

- Highland Woodland: As expected the highest harvestable volumes are found in this Stratum. The average standing volume is 50% larger than in the Lowland Woodland totalling 32,5 m^3/ha. This bigger standing volume probably indicates not only a better potential, but also the inaccessibility of the area. It should nevertheless be recognised that the area to a large extent has been depleted of high value timber of large dimensions. In only a very few cases we find sample plots with average DBH > 20 cm.

Nevertheless, the Highland and Lowland Woodlands holds, as expected, the greatest potential for future harvesting of commercial timber.

- Farmland Woodland has in connection with the inventory only been registered in the buffer zone around the forest. It is a heavily utilised vegetation type, which to a large extent especially on the southern side of the range is threatened by more permanent cultivation. Surprisingly it was found, that this stratum closely resembles the Lowland Woodland constituting app. 25% of the total volume available. In total almost 250.000 m^3. Standing volume per ha. is close to 16 m^3 per ha.

When examining volumes at village level calculated on the basis of stratum averages, the variation between villages is mainly dependent on the variation in vegetation cover in the area allocated to the villages. As mentioned earlier, this is from a management point of view a convenient approach.

Examining the volumes based on the plot averages within the village areas, the figures show a distinct difference. Variation from the mean is approximately 50% with volumes ranging from 8 to 33 m^3 per ha.

Two villages dominated by Lowland Woodland and close to the Iringa-Dodoma Road - Ikengeza and Chamdindi - have levels of standing volumes clearly lower than average. This could support the general impression of heavy exploitation and grazing pressure in this area.

A third village, Usolanga, has an even lower level of standing volume. This is probably mainly due to a low number of plots given the limited size of the area, and possibly a pour representation in especially Lowland Forest (remarks in the registration sheets indicate presence of farmed areas) and a proportionally large number of Riverine plots. In the terrain, there is little indication that the stand composition of Highland Woodland should vary considerably between the neighbouring villages of Mkulula, Usolanga and Mangawe. This consideration is also supported by the simple averages from the highland plots as found in the report Vol.>=10/Villages/Plot.

Kitapilimwa Forest:

The overall results for this forest were as expected quite pour. The utilisation of the forest has depleted most of the strata. The level of standing volume of app. 16 m^3 is 25 – 30 % lower than the average for Nyang'oro Forest.

General recommendations:

As the most reliable data exist at stratum level, it is recommended to base further assessments of overall regional commercial options for the forestry areas on these data. When the overall management plan is to be made operational at village level, it is important to verify any uncertainties.

It would be recommendable to supplement especially the measurements for Usolanga before a management plan for this area is made operational.

The Lowland / Farmland Woodlands holds a large future potential for commercial utilisation. If the management area is extended, it would be recommended to assess the need for supplementary inventory in the area North of the Nyang'oro Range.

As soon as reliable data can be extracted from the permanent sample plots mentioned in chapter 7, the volume tables and the conversion factors from total to merchantable volumes should be altered respectively as explained in Annex 9.

4.1.2 Increment.

Methodology

The calculation of increment for Miombo Woodlands has been investigated by amongst others by Malimbwi, R.E.; J. Kielland-Lund; Nduwamungo, J.; (1998).

There are large variations in observed increment depending on the site and stand composition. Increments measured varied from 1,0 to 6,3 m^3 /ha/year total volume. The latter increment was achieved in mature undisturbed Miombo. This type of stand will normally achieve a total basal area of 10 – 12 m^2 / ha. The lower increments were typically registered in heavily disturbed stands and stands on poor soils.

For the Iringa region, sufficient local data have not been available to elaborate a local increment table. Through consultation with TAFORI and on the basis of the available material, an approximate increment on the basis of a maximum increment of 5 m^3/ha/year in mature stands with a basal area of 12 m^2 /ha has been chosen.

As the relation between actual basal area and increment is not known, the following linear relations have been used:

$Increment_{Total}$ = ([$Basal\ Area_{Actual}$]/12) x 5, where:

$Increment_{Total}$ is total increment >= 2 cm.

[$Basal\ Area_{Actual}$] is the actual measured basal area/ha. / Stratum or Plot.

Conversion of volumes from Total Volumes to Volumes >=10 cm. has been achieved using the same approximation as mentioned in the previous section concerning Standing Volume.

Results

Given the very low levels of registered Basal Area, the corresponding levels of increment are equally low. Using the method of calculation mentioned above, all the relationships concerning Total Volume are also applicable to increment.

The average increment calculated for Nyang'oro Forest is 1,2 m^3/ha/year and the corresponding figure for Kitapilimwa forest is 0,9 m^3/ha/year.

More detailed results can be found in annex 6.

Recommendations:

The future permanent sample plots will also provide the MEMA project with valuable information on local levels concerning increment in the different vegetation strata. As soon as preliminary data is available from the sample plots, the existing assessment of increment should be re-evaluated. Hopefully this will be possible by the end of 2001.

Until the data can be evaluated, it is advisable to predict potential harvesting levels on the low side of the figures mentioned above. As an average, it will not be advisable to recommend harvest levels of more than 1 m^3/ ha. / year.

4.1.3 Regeneration

The regeneration potential can be expressed on the basis of two of the inventory measurements.

The "Regeneration Count" includes all specimens of woody plants with DBH < 5cm. From the diameter measurements, we can extract the number of trees with DBH >= 5 cm. This number can be sub-divided into diameter intervals. In this report the number of specimens is calculated for DBH >= 5 cm and < 10 cm and for DBH >= 10 cm.

The three categories; Regeneration, 5 <= DBH <10 and DBH >= 10 can thus give us an idea of the regeneration potential over time, as the "Regeneration" expresses the number of small seedlings and saplings, the "5 <= DBH <10" expresses the number of seedlings and saplings that has survived to a later stage as "middle layer", and the "DBH >= 10" expresses the number of maturing trees.

All of the above-mentioned figures can be expressed per species, per group of species according to utilisation, per stratum or per village.

Nyang'oro forest.

Stratum Name	Regeneration	DBH<10	DBH>=10
1 Riverine forest	2470	476	212
2 Lowland woodland	4026	693	340
3 Highland woodland (miombo)	6187	467	401
5 Wooded farmland	3321	387	351
Village Name			
Chamdindi	3203	621	392
Ikingeza	4579	783	423
Izazi	15290	466	334
Mangawe	9965	569	421
Migoli	4296	572	363
Mkulula	2619	493	369
Nyang'oro	2031	393	340
Usolanga	1627	468	140

Nyang'oro forest	4709	543	359

The database reports "Regeneration - uses per stratum" and "Regeneration - uses per village" detail the regeneration per use, stratum and village. See annex 7.

An average number of regeneration per hectare of 4709 for Nyang'oro seems encouraging, and the survival rate for the intermediate layer of 543 stems per hectare, until the stems reach DBH >= 10 cm, where the number per hectare is down to 359 looks normal in comparison with other similar studies, and it can thus be considered satisfactory. This overall evaluation is especially true for fuelwood species, whereas regeneration for timber species is poor, which can be observed in the annex 7. The situation for species suitable for poles seem to be intermediate, but closer to the situation for fuelwood species than to timber species. A discussion of these facts should take the observations of different activities in the area (see section 5.1.4) into consideration.

It should be considered that the registration of different uses per species is still very scarce, and a completion of the species list on this subject might reveal a different result on these matters.

On the basis of the very limited registration of uses per species (see section 5.2.1), it is nevertheless interesting to observe that the highest number of regeneration species suitable for timber purposes is found in the "Wooded Farmland" stratum, which *could* indicate that a clear-cut "management" gives more equal opportunities for the more valuable species to regenerate, than in an area where selective cutting has taken place.

Kitapilimwa forest.

For Kitapilimwa forest, the same tendencies are observed, although generally lover survival rates for the middle and the maturing layer are noticed. This corresponds well with the expectations for this over-exploited and misused forest.

Stratum Name	Regeneration	DBH<10	DBH>=10
6 Riverine forest	1470	490	150
7 Thicket	5716	0	306
8 Depleted woodland	7731	527	318
9 Miombo	7875	533	216
11 Cultivated farmland	1750	0	50

Kitapilimwa forest	6685	422	234

4.1.4 Evidence of different activities.

The database report "Activities" details the registered evidence of different activities per forest, village and stratum. See annex 8.

Nyang'oro forest.

For the Nyang'oro forest, one can observe that grazing is apparent in more than 60% of the plots, but this does not seem to have a pronounced negative effect on the presence of wildlife, as an equal number of plots (64%) shows evidence of game. This is most evident in the Migoli area (northern part of the mountain range) where more than 90% of the plots shows evidence of game.

Tree harvesting and pitsawing are only evident in approximately 20% of the plots, but this might be due to the fact that especially the southern part of the range has already been drained of valuable timber, and the main cutting activity is now on the northern side of the range, which shows figures around 30%.

Kitapilimwa forest.

For the Kitapilimwa forest, one can observe that tree harvesting is apparent in 80% of the plots, charcoal burning in 45% and pitsawing in 8%, which is an evidence of the very high pressure on the forest resources.

From a management point of view, it is also interesting to observe that in more than 50% of the plots, there is clear indication of grazing activities.

4.2 Recommendations

4.2.1 Species and their utilisation

In order to achieve a more complete analysis of the inventory data, the project should make an effort to complete the species list with more botanical names.

If it turns out that more botanical species names each are covered by more local names, it might be necessary to run the analyses by botanical name instead of by local name, in order to get meaningful results.

Likewise the project should make an effort to indicate the main use(es) of more species (*Timber, Poles, Fuelwood, Other*). Such an indication could facilitate a better overview by presenting results by 4 groups instead of by 250 species. It would also be most interesting to produce estimations of the standing volume only for the commercially interesting species (Timber, Poles and Fuelwood).

4.2.2 Further analyses on the existing data.

The Riverine Forest stratum will need a further analysis before any decisions on eventual future use and management of this forest type are taken.

Inventory data have been registered in a fairly detailed manner in order to make further analyses possible.

Both regeneration counts for specimens below 5 cm DBH, and diameter measurements for specimens above 5 cm DBH have been performed on species level, which permit a deeper investigation of e.g. the bio-diversity aspect.

If possible, a fifth - or more - group(s) (like *Timber, Poles, etc.*) could be added to the species list, in order to analyse e.g. the potential for production or harvest of honey, traditional medicine, fruits, fodder etc.

Other possible analyses could include the effect of *slope* and human presence (*farming, grazing, beekeeping, game, hunting, tree harvesting, pitsawing, charcoal burning,* and *mining*) on the species composition, average stand height, volume level, regeneration capacity and diameter distribution.

Given the fact that all data exists in a database, such analyses could be carried out anywhere and simply verified in the management area and presented locally.

4.2.3 Extent of management area.

An eventual enlargement / extension of the management area towards the north in the western part of the Nyang'oro range should be considered. This zone seems equally stocked as the principal part of the presently inventoried woodland area, and such an extension would probably facilitate the "distribution" of management spheres between the concerned villages.

An area of approximately 1000 hectares situated in grids 0816 - 0820 and 9184 - 9186 (north-east of Mangawe Village) could likewise be included.

5 Boundaries

5.1 Basis material

The socio-economic survey has not established a valid reference for boundaries between villages within the woodlands.

(*The mapping exercise of the socio-economic survey has focussed on the village and not on the woodlands, which would perhaps have been more logic / appropriate for the MEMA project)*

The future limits between woodland and farmland cannot be established until negotiations on a management scheme have taken place amongst all stakeholders.

5.2 Actions

As mentioned under mapping and stratification, preliminary boundaries between villages and between farmland and woodland have been drafted on the vegetation maps - strictly for inventory purposes.

The basis for this sketch was the local knowledge of the division foresters and the village-drawn maps from the socio-economic survey - even though quite a few of these maps contained very little or no information on the subject.

On the second mission a field trip was undertaken in order to gather information on the experience of different models of boundary demarcation. The findings from this mission has been included in the table in the following section

5.3 Recommendations

5.3.1 Localisation of boundaries. See also section 4.3.

Localisation of internal boundaries should be initiated as soon as possible through a joint effort between villagers and foresters.

External boundaries (i.e. limits between forest- and farm-land) are of less immediate importance, except for the areas mentioned in section 5.3.

5.3.2 Demarcation of boundaries.

The demarcation of boundaries should take into account the difference between internal borders (between management units) and external borders (between woodland and "farmland").

The internal borders only need recognition by villagers from adjacent villages involved in the management of the forest area, whereas the external borders need to be recognised by all who could enter the management area - irrespective of entrance point.

Internal boundaries do thus not necessarily need actual physical demarcation in the field, as they are very often identified by natural physical features like hilltops, rocks, rivers, solitary trees etc.

External boundaries could have the same features as the internal boundaries, but as they also need recognition by "outsiders", an actual physical demarcation is necessary. Regardless of entry point into the management area, such an external boundary must be recognisable, and it is thus necessary that any plantation, signposts or similar appear as a line.

The actual demarcation can be in the form of clear-cut lines, eventually followed by ensuing plantation of easy recognisable tree species (exotic to the area), or other vegetation by choice of villagers according to utility and local demand. It must be kept in mind, that the actual installation and maintenance of the boundaries should be a part of the management scheme, and thus be a part of the obligations of the beneficiaries in the villages. It could jeopardise the long term sustainability of the management, if too many of these tasks are carried out or paid for by the authorities or the project.

It is important that the significant effort, which will be put into the demarcation of boundaries, should be turned to good account whenever possible.

If plantation of exotic species is adopted, the choice of species should assure utilisation for e.g. timber, poles, fuelwood, honey-production, ulanzi, edible fruits, vegetable oil etc. without destroying the demarcation effect.

Species for consideration could be:

Neem (Azadirachta indica), Coffee, Tea, Sisal, Pine, Ficus, Grewelia, Senna siamea, Mellea azedirach, Parkinsonia aculeata, Eucalyptus citriodura, Eucalyptus teriticornig, Eucalyptus saligra, Pear, Cypress, Eucalypt, Bamboo or similar according to soil, climate and local preferences.

Without forcing any decisions, it can be indicated that evidently not all species are appropriate everywhere. An indication of some suitable species is:

South-eastern part of Nyang'oro (Mkulula, Usolanga, Mangawe, Ikengeza):
Sennea simea
Mellea azedirach
Azadirachta indica
Parkinsonia aculeata

South-western part of Nyang'oro (Nyang'oro, Chamdindi):
Eucalyptus citriodura
Eucalyptus teriticornig

Eucalyptus saligra
Sennea simea

Northern part of Nyang'oro (Izazi, Migoli, Makatapora):
Azadirachta indica
Sennea simea
Mellea azedirach
Parkinsonia aculeata

Once recognised and agreed upon by all concerned parties, the location of the boundaries should be established and registered by the use of GPS.

Boundary type	**Advantages**	**Disadvantages**	**Remarks**
Wooden signposts	Inexpensive	- Perishable - Not very visible in the terrain	Some strategic placed signposts can contain more comprehensive information
Metallic signposts		Not very visible in the terrain	Some strategic placed signposts can contain more comprehensive information
Concrete signposts	Not as vulnerable as wooden or metallic signposts	Arduous installation	Some strategic placed signposts can contain more comprehensive information
Concrete or metallic beacons	Not as vulnerable as signposts	Not very visible in the terrain	
Paint on trees or rocks	Not vulnerable	Needs regularly maintenance	
Cut line	Stands out clearly in the terrain	- Arduous installation - Needs yearly maintenance	The initial clearing could in certain areas be done by machinery
Cut line with naked soil	- Stands out clearly in the terrain - Can serve as fire-break	- Arduous installation - Needs yearly maintenance with heavy machinery	
Cut line with plantation	- Stands out clearly in the terrain. - Can be a production element as well as a demarcation	Arduous installation	- The initial clearing could in certain areas be done by machinery - Should be exotic (to the area) species in order to show a clear distinction from the surroundings. - Any choice from e.g. the species list on the previous page can be made, according to soil, climate and local preferences. Any mixture of these species must still appear as a line.
Cut line with cultivation	- Can be a production element as well as a demarcation	Resembles “ordinary” farmland with risk of confusion	- After a number of years, the separation between farmland and forest might become so distinct that boundary demarcation is no longer necessary.

Naturally, a combination of the above-mentioned types would probably serve a given purpose well.

For example, a few signposts on strategic points on the boundary would probably be useful, even if the boundary consists of planted exotic trees.

Likewise, a few signposts or beacons could be useful even on internal boundaries.

5.3.3 Stratification of vegetation

If the final internal boundaries turn out to be distinctively different from the ones used for stratification of the inventory results, the necessary re-allocation of clusters between management units should be made, and - if necessary - additional clusters should be established and measured.

6 Indicators and monitoring

According to the TOR presented in connection with the initiation of the Forrest and Vegetation Baseline Study, it was outlined that the survey was to identify indicators for monitoring status of vegetation and establish benchmark indicators for monitoring in year 3.

On the basis of the inventories carried out, it was decided that establishment of a number of permanent sample plots distributed evenly the different strata and management units could supply the project with the necessary data to monitor the effects of the management procedures introduced

6.1 Initial findings

The project has recently been approached by TAFORI (Tanzanian Forestry Research Institute) in connection with the establishment of Permanent Sample Plots (PSP) within the project area. The establishment of three PSPs in the Nyang'oro Mountain Range is part of a larger study of the Miombo Woodlands of the Iringa Region. The immediate objectives of the study are:

a) To establish PSPs to monitor site variation, regeneration, growth yield and species change with time.

b) To inventorize Miombo Woodland forests nearby villages, village woodlots, agroforestry systems and abandoned fields

c) To carry out wood consumption surveys.

d) To study stand species composition, structure and resilience of species on clears-felled / cultivated abandoned fields.

e) To assess the site productivity of Miombo Woodlands.

f) To estimate the sustainable yield (allowable harvest) from Miombo Woodlands, when supplemented by village woodlots and agroforestry system.

g) To develop an efficient method of managing Miombo Woodlands after studying the above objectives.

From a project point of view, it is obvious, that there are areas of common interest:

- Initial monitoring of stand (total and merchantable) volumes is of interest as an indicator of the validity of information gained in the initial inventory carried out in the spring of 2000.

- Monitoring of stand composition in respect to primary commercial species.

- Evaluation of the yield potential in Miombo Woodlands and yield predictions based on forest stratification and basal area.

- Verification of conversion factors between total and merchantable volumes > 10 cm. with emphasis on diameters < 20 cm. DBH.

- Monitoring of regeneration and possible implications of different management decisions.

- Participation in project development of sustainable management systems for Miombo Woodlands.

Initially the MEMA project has already covered the local inventory aspects of the TAFORI survey. Estimation of local consumption of wood-based products has not been included in the baseline survey, where emphasis is on potential commercial utilisation and harvest.

The number of plots to be established within the project area is not considered sufficient to supply the information needed by the MEMA project staff. The established PSPs are located in areas suited for evaluating potential yield, but not representing the average strata present in the project environment.

In order to fulfil this purpose, the existing plots should be supplemented with a number of plots covering the range of Miombo Woodland and adjoining Acacia Woodlands.

The plots located outside the project area will render valuable reference material for the MEMA project.

6.2 Actions

TA Mr. Henrik Lerdorf, DFE Consultants Mr. Per Christensen and Mr. Bengt Kvitzau met with Mr. J.A. Isango, TAFORI, on the 4. May 2000 to discuss the possible cooperation between MEMA and TAFORI. Mr. J.A. Isango explained the major objectives of the TAFORI project as presented above.

The spheres of common interest were discussed, and Mr. Isango stated that it was possible for TAFORI to adjust project design to facilitate the needs of MEMA without losing the overall goal of the TAFORI project. The time available would allow for additional PSPs to be identified and measured. It was also stated, that the information gathered by the MEMA project was of great interest to TAFORI.

A field-trip was conducted to visit two plots - one at Mr David Moyer's Farm near Wangama south of Iringa, and one in Nyang'oro forest range, close to the aerial transmission tower. The object of the field trip was to evaluate the initial sites partly within the project area and to discuss project layout etc.

6.3 Recommendations

Future cooperation between TAFORI and MEMA should be based on a participatory approach in respect to villagers and foresters within the MEMA project area. All monitoring within the MEMA project area must involve local assistance to the TAFORI experts. It is required that all basic data will be available quarterly to the MEMA project shortly after monitoring of plots is completed. All plots should be identified, plotted, tagged and ready for initial inventory by the end of year 2000.

In the case of future participation by MEMA in the TAFORI Project, financial support should be limited to:

- Identification and establishment of PSPs as described.

- Establishment of additional PSPs within the Project area.

- Initial inventory of PSPs.

- Monitoring of PSPs. for a five-year period. The intensity and form of data accumulation will be as described in the TAFORI project document.

On the basis of the discussion with the representative of TAFORI and the requirements of a management scheme for the natural woodlands, it is recommended to establish further PSPs within the actual management area, in order to be able to

a) Get a more solid foundation for calculation of standing volume based on the inventory data.

b) Monitor the effects of different management methodologies.

The plots should be located in the Nyang'oro Forest representing Highland Woodland and Lowland Woodland. North of the Nyang'oro range it is also recommended to establish two plots in the Acacia dominated Lowland Woodland, which so far has not been included in the initial inventory.

If resources are available, plots in the Wooded Farmland could equally be considered. Commercially, these areas are of little value, but they are important for local consumption and rural sale of firewood.

Each of the chosen locations will have two parallel plots. One plot will be representing the chosen management strategy and he other will act as a reference. The reference should be excluded from treatment. It will most likely not be possible to exclude fire in the reference plots, but it should always be noted, when external factors have had an influence. The positioning of the PSPs is suggested within a 2 X 2 km. plot on the basis of the initial stratification and mapping. The more precise location is left to MEMA and TAFORI to agree upon.

The recommended positioning of the additional plots is proposed to areas:

Highland Woodland:	(0811-13; 9187-89)	Sheet no.	197/4 (Nyang'oro)
	(0818-20; 9191-93)	-	197/4 (Nyang'oro)

Lowland Woodland	(0798-00; 9181-83)	-	197/3 (Chamdindi)
	(0170-72; 9208-10)	-	198/1 (Luhombero)
Lowland Woodland (Acacia)	(0820-22; 9204-06)	-	197/2 (Mtera)
Lowland Woodland (Acacia)	(0796-98; 9193-95)	-	197/3 (Chamdindi)

In order to create comparable data between the MEMA forest inventory and the TAFORI data, it is recommended also to carry out plot measurements similar to the inventory measurements in all the PSPs within the management area.