Estimating Manketti Nut Yields in the Forests of Western Kavango, Namibia

A Report Submitted to CRIAA SA-DC (Namibia)

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Non Timber Forestry Products (NTFP) Project
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The Approximate Location and Extent of Manketti Groves in northern Namibia

LEGEND:

- Extensive Linear Manketti Groves: These core Manketti areas are situated far from settlements in areas with well-defined, permanent sand dunes. These linear manketti groves can be very large, often more than 500 metres wide and 20 kilometres long, constituting a large, untapped forest resource.

- Smaller Linear Manketti Groves: These Manketti groves occur around core Manketti areas on smaller sand dunes, typically 50-500 m. wide and 1-5 km. long.

- Irregular-shaped Manketti Groves: Situated closest to settlements in and around central Mpungu District and central Kavango, these Manketti groves are currently the most important for local communities.

Permanent Monitoring Points: Established in March 1999 to estimate average fruit yield from Manketti trees.
Manketti Yields in the Forests of Western Kavango

Terms of Reference

Within the broader project of investigating the potential of a local Manketti industry there is a need to assess the size of the Manketti nut resource in terms of the potential volume of supply and in terms of the proximity of the resource to those who traditionally utilise the resource.

One of the aims of this project, therefore, is to develop methods to accurately define and measure the current Manketti yield within commercially and traditionally important forests of Mpungu District, western Kavango. In addition, CRIAA SA-DC wished to collect samples of Manketti fruit from the 1999 season for chemical analysis by the University of Namibia, one of CRIAA SA-DC’s partners in the Manketti project.

Executive Summary

Estimates of Manketti nut yield in the Mpungu District of west Kavango have been derived from three data sources.

The literature survey provides an overview of estimated Manketti production derived from studies carried out in the forests of northern Namibia, north-west Botswana and southern Angola. Based on the findings of previous studies total annual yield¹ in Manketti groves range from around 130 kg to 1000 kg per hectare per year.

Field work and transect surveys carried out in Mpungu District during February-March 1999 identified two types of Manketti forest used by commercial and subsistence harvesters: Extensive linear Manketti groves occurring in areas dominated by a sand dune topography, located in the far south and far north of Mpungu District and secondly; smaller, irregular-shaped Manketti groves in central Mpungu District occurring in areas without (prominent) sand dunes. Manketti yields in both grove types were estimated using two techniques; simple visual estimates by local harvesters and by stripping and counting fruit from a sample of selected trees. The two techniques provided similar results and below are the CRIAA SA-DC estimates of total yield per hectare:

Estimated Manketti kernel yield in linear groves on sand dunes average 30kg/ha/yr.

Estimated Manketti kernel yield in smaller, irregular-shaped groves average 47kg/ha/yr

In linear groves, far from settlements, the actual amount of Manketti available to harvesters will be less than the total biological production of the forest; harvesters cannot collect all the fruit from all the trees every year, as these groves are too far to visit on a regular basis. Much of the fruit in linear groves, therefore, is never harvested, representing a considerable potential Manketti resource.

In small, irregular-shaped groves close to settlements in central Mpungu, on the other hand, harvesters can visit these groves regularly to collect virtually all the total Manketti production. In these groves any increase in demand for kernel could potentially compete with the current off-take by subsistence and commercial harvesters.

¹‘Yield’, measured in kilograms, refers to the amount of nut meat only (the kernel), and does not include the weight of the skin, fruit or shell.
CRIAA SA-DC also established **monitoring points** in two Manketti groves, one in eastern Kavango at a village called Livayi in Mukwe District (about 15 km due north-east of Kaudom Game Park) and one at Kaguni village near Mpungu in west Kavango. At each site local residents have been employed to collect every single fruit falling from a sample of six mature, female (productive) trees in order to accurately quantify the yield per tree for the 1999 season. Figures from each of the monitoring points can then be compared with estimates generated from the literature survey, transect surveys and visual estimates. Tree monitoring will continue from February to September 1999 until all fruit have fallen from the trees and can potentially continue in future years. Results from the monitoring programme will be available at the end of September.

**Literature Survey**

A review of the existing literature revealed two dominant approaches to the study of Manketti: a botanical approach and a anthropological approach. (There are also a few geographers, nutritionists, and others, writing on Manketti but they are relatively few). The bulk of the existing literature referred to in this study, therefore, comes from either botanists or anthropologists.

The botanists concentrate almost exclusively on taxonomy, edaphics and the use of aerial photography to estimate fruit yields within Manketti forests. Anthropologists tend to concentrate on the relationship between people and Manketti, utilising indigenous knowledge to understand forest structure and to estimate fruit yields. Drawing from all sources, the following section provides a brief summary of total production figures and yields per hectare within different Manketti groves in Namibia and neighbouring countries where Manketti occurs.

**Manketti Nut Yields based on Previous Studies**

Charles Peters (1987)\(^2\) provides three estimates of nut production in Manketti groves (he refers to them as Manketti "heartlands"). Peters quotes a survey carried out in the Manketti Block farms; "the forests situated approximately 80 kilometres from [north of] the railhead of Tsumeb. These forests around Tsumeb cover an area of about 60,000 ha. and...the normal annual crop was about 50,000 tons of nuts", equivalent to 830 kg/ha. A second study in southern Angola estimated Manketti groves to cover 68,100 ha. producing about 30,000 tons of fruit, equivalent to around 6,000 tons nuts, or 90 kg/ha\(^3\). Lee (1973, 1979) estimated annual production in 35 groves in the Dobe area of Botswana to be 25.6 million nuts, weighing about 40 tons. This is equivalent to around 130 kg/ha, much less than Tsumeb/Kavango and about the same as south-eastern Angola. "A lower density of trees, not yield per tree, seems to account for most of the difference". (Peters 1987).

Based on the review of existing literature the following table provides estimates of Manketti yield in Namibia, Angola and Botswana:

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\(^2\) His paper, Peters C.R. (1987), refers to three studies: Coelho (1966); Lee (1973) and; Muller(Undated). (See also the bibliography at the end of this paper)

\(^3\) Peters provides a "reasonable calculation" (p.499) that 30,000 tons of Manketti fruit is equivalent to 18,000-21,000 tons nuts. CRIAA SA-DC experiments and Lee (1973) estimate that Manketti kernel is approximately 10% and 20% of the fruit weight. In other words, 30,000 tons of fruit provides a maximum of 6,000 tons of kernel only, and not 18,000-21,000 tons as Peters calculated.
Table 1: Manketti Kernel Yield in Namibia, Botswana and Angola

<table>
<thead>
<tr>
<th>Location</th>
<th>Area (ha.)</th>
<th>Yield/year.</th>
<th>Yield/ha/yr (kg)</th>
<th>Author</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tsumeb/ Kavango/Owambo</td>
<td>60,000</td>
<td>50,000 tons nuts</td>
<td>830</td>
<td>After Muller n/a</td>
</tr>
<tr>
<td>Tsumeb/ Kavango/Owambo</td>
<td>n/a</td>
<td>n/a</td>
<td>1,000</td>
<td>Vahrmeijer 1976</td>
</tr>
<tr>
<td>Cuando-Cubango/ SE Angola</td>
<td>68,000</td>
<td>6,000 tons nuts</td>
<td>90</td>
<td>Coelho 1966</td>
</tr>
<tr>
<td>Angola</td>
<td>n/a</td>
<td>30,000 tons oil plus 50,000 tons seed cake</td>
<td>n/a</td>
<td>Adrian 1955</td>
</tr>
<tr>
<td>Botswana/ Dobe area</td>
<td>300</td>
<td>40 tons</td>
<td>130</td>
<td>Lee 1973</td>
</tr>
</tbody>
</table>

Factors Affecting Manketti Yield

When considering the existing agricultural potential of the area, Manketti yields are high - Lee (1973) estimates that a single tree produces around 950 fruit and, based on existing studies, yield per hectare ranges from 90 – 1000 kg a year. Rainfall is the main determinant of fruit yield per tree although, "heavy spring rains coinciding with flowering cause disastrous fruit yields" (Helgren 1982). This happened in the Mpungu area during November and December, 1998, when violent storms battered flowers with high winds and hail stones, "the size of your thumb nail" (Michael, 1999. See photos on the following page). Other factors cited in the literature known, or believed, to affect fruit yields include; human settlement (clear- and selective-felling, grazing/browsing, increased incidence of and untimely forest fires), insects, wild animals and birds, fungi/disease, storms, (sand blasting, high winds, drought and hail damage), etc.

The photos on the following pages show some of the most important human and environmental factors affecting Manketti fruit production around Mpungu.
The bark of this Ulmus tree has been
bruised red by wind, hail and rain "as if
heaven threw a stick."

Storm Damage: Branches and leaves
of Manchest trees have been broken,
and fruit prematurely knocked to the
ground during a hail storm.

Mangkeli groves on crests of dunes have been cleared to make way for fields near the DR3412 road in east Kavango.
The DR 342 road in east Kavango. Dune crest cleared of plants and other vegetation near.
Harvesters from Wiwi, Mpoto and Kaguni villages stated that Manketti productivity is determined by the quantity, frequency and duration of rainfall during the key months October to March; too much as well as too little rain will reduce yield. For example, Mpungu-IKung harvesters estimate, "10-20% of all mature females did not fruit this year (1999), as a result of fire or storms damaging the flowers. The only evidence that these trees are productive is last year's fruit on the floor." (Michael and Johannes).

Thomas Likuwa from Kaguni village went on to explain in more detail that the time and volume of fruit falling on the ground is determined by the weather, particularly the timing and intensity of heavy rains and strong winds. "Manketti fruit is most susceptible to the weather at key times of the year: During September Manketti trees flower, coinciding with the end of the windy season. If strong winds blow as the flower emerges it can potentially damage the delicate flowers. Then, during October and November the fruit is being formed. This is also the time when the clouds and, usually, the first rains come. The type of fruiting season is determined at this time, by the onset of the clouds and rains; affecting the size, shape, quantity and quality of fruit. Good rains early in the season can ripen fruit earlier than usual. And high winds can shake fruit from the tree prematurely."

Harvesters from Livayi village in eastern Kavango stated that good rainfall will produce a good Manketti harvest the following year. (Headman of Livayi, eastern Kavango). Lee 1973, p 312 also noted, "There is little firm evidence on the variation in total fall of nuts from year to year. The IKung say that following a year of high rainfall the next year's fruit crop will be larger than usual".

The following impressions from local harvesters discussing the Manketti situation this 1999 season should give an indication of the uncertainty and variability in yield from place to place and from year to year:

"This is a really bad year. This is the worst year we have ever seen. There are no fruit. Last year was bad, but it was better than this year. Next year should be better because the rain this year was good". (Headman Kandjembe, Livayi village, eastern Kavango, February 23rd 1999).

"It is now the end of February and the first fruit are already beginning to fall, a poor quality fruit, and very small. We leave these ones. You can see with your own eyes they are small, the shape is wrong, and the skin is wrinkled and yellow". (Johannes, Péte Forest, February 28th 1999)

"This is a normal year, an average year. We had good rains early on in the season, at the end November/beginning December. Then there was no rain the whole of January and the first two weeks of February. In the last two weeks (of February) we have experienced heavy wind, rain and even hail. So now the Manketti are already falling. [Manketti 'normally' starts falling in April]. These fruit have no pulp and no nut, just a thick skin and a hard, empty shell – they're worthless. (Thomas Likuwa, Péte Forest, March 1st 1999). He then shows me last years fruit on the floor, cracks one open, revealing a big nut inside. "That is a normal-sized nut". (Compare photos on pages 18 and 19). [Although the outer covering of skin and fruit has been dried and eaten by insects, rodents and micro-fauna, the nut was still fresh even after a year on the ground]. "Now, if you look what's left on the tree there are some green balls. These are normal fruit. They will start falling and will be collected later in the season. So, overall, this year is a normal year in terms of Manketti production: The early fruit was worthless and the later season fruit looks OK".

"In a good year you can't see the leaves of a Manketti tree because of all the fruit in the tree. As a rule of thumb, if the mahangau is good then the Manketti is good. They like the same
kind of weather; not too dry, not too wet, and not too windy." (Thomas Likuwa, Kaguni forest. March 2nd 1999)

Although the literature provides production estimates for large forests in the Zambezi basin area there are no specific estimates for the Kavango as a Region, and there is a complete absence of detailed statistics on yield per tree or yield per hectare at the District level. More importantly, there are no maps defining the size, location or yield within the productive forests and groves most frequently visited by harvesters. Existing vegetation maps, at best, lump Manketti trees together with other tree species as a forest 'type' or 'vegetation 'association'. In other words, Manketti groves are not classified as such, but as a 'mixed' forest. Based on existing information we have a limited concept of the size, location or density of Manketti trees within different forest types in the Kavango Region.

Reasons for Opting for an Anthropological Approach

The lack of information on Manketti production in the Kavango, (and in Namibia in general), has motivated the project to draw on the expertise of local harvesters, producers and traders to better understand the nature and extent of the local (subsistence and commercial) Manketti industry.

Although the project could potentially estimate Manketti yield using other methods (such as aerial photography, satellite imagery, cartography and videography, combined with intensive transect measurements) these procedures are expensive, time consuming and also have their own sets of errors and bias. As well, these "remote" methods can only (potentially) estimate the surface area of Manketti groves within the greater forest. The project would still be left with field survey work ('ground truthing') to quantify nut production within different types of productive Manketti trees and forest types.

There is an added complication that Manketti trees come in many shapes and sizes. Standard forestry measurements such as DBH (diameter at breast height) and height could be misleading because they do not correlate closely with productivity. For example, DBH and tree height are often used in combination to classify a mature (productive), medium (semi-productive) or juvenile (unproductive) tree. In the case of Manketti trees these measurements would produce biased results; for example, some trees have a single stem while others have multiple stems (as many as 10) growing from the same root system. Different size trees may be the same age but have a very different appearance and produce a different quantity of Manketti. What seems to be a better indicator of yield is canopy size and volume rather than tree height or DBH. For example, the Mpungu-Kung reckon trees with a single trunk tend to produce a larger canopy volume and more fruit than trees with multiple stems which tend to form more of a bush with a smaller, lower canopy. (Compare photos on pages 9 and 10).
Il"Xa di !xo: Large, female Manketti tree with a single trunk. This example is a very old tree and according to !Kung harvesters will produce fruit for the next 3-5 years: "It is changing colour, becoming pinker, and the smaller branches are dying and falling off. The fruit for this year and next year will be fine though."
\textit{Xa di ma}: Medium sized female Manketti tree, not yet fully productive and with multiple stems.
Developing a methodology utilising the skills of local harvesters, like the one developed by Richard Lee, appears to be a more appropriate (quicker and more accurate) approach than a purely botanical methodology. The Mpungu-!Kung classify trees according to their own criteria of productivity, such as tree canopy volume, tree health, the location of trees/forests in relation to settlements, their location in relation to soils, local topography, and their distribution compared to other tree species within the larger forest.

There is also the fact that absolute levels of production – the total amount of Manketti produced in a given area each year – is huge, and currently much greater than the actual amount used by harvesters. There are vast tracts of Manketti forest effectively out-of-bounds because they are too far away to walk to in a day or they lack potable water for most of the year (April to October). These Manketti forests are left untouched.

Adopting their own law-of-diminishing returns harvesters’ collect from the nearest and most productive Manketti forests first. At the end of every season there remains large Manketti producing forests – estimated at tens of thousands of hectares – which are under- or un-utilised throughout the entire Kavango Region. This is particularly the case in the sparsely populated and heavily forested lands south of the Kavango River, areas from Tsintsabis to Mpungu and from Kaudom to the main B8 road where past studies have been conducted. (See also Table 1 map y).

Although previous studies do provide a range of production estimates, local harvesters are in the best position to select and prioritise the most important Manketti forests around Mpungu for surveying. And at the end of 1998, local harvesters supplied the project with more than 600 kg of Manketti kernel in a trial purchase exercise. All project field work to date points to a wealth of knowledge among Mpungu residents. More importantly, there are strong indications that the Mpungu-!Kung in particular are real experts on Manketti, possessing an extensive (and as yet untapped) indigenous knowledge of forest structure and Manketti production.

With the added constraint of time and money the project opted for a methodology utilising the existing knowledge of local harvesters. It should be noted that much of the methodology used in this study has been adapted from the work done by American anthropologist, Richard Lee, working in the late 1960’s and early 1970’s. He spent many years recording the indigenous knowledge of !Kung Bushmen in the Dobe district of NW Botswana (across the Namibian border from Tsumkwe/Bushmanland): “The Manketti nut is the major food source of the !Kung San, and Lee noted that this abundant, nutritious and reliable staple is the key to understanding...” Manketti production (after Peters 1987). The methodology developed for this study to estimate Manketti production, therefore, draws extensively from the same pool of !Kung knowledge Richard Lee utilised so effectively working in NW Botswana in the 1970’s.

Based on their previous experience working with CRIAA SA-DC two !Kung harvesters from Wiwi village in the Mpungu District, xa kau Nagga, alias Johannes and Kame xo ka, alias Michael, and one Kwangali harvester from Kaguni village, Thomas Likuwe, were employed for one week to assist in developing a methodology to assess the amount of Manketti kernel produced in the forests around Mpungu. John Tshilefu from Rundu Town was also employed as a

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All CRIAA SA-DC-related research to date indicates that it is the poorest families (such as !Kung farm labourers and to a lesser extent Kwangali rural farmers) who are most involved in the actual harvesting and preparation of Manketti nuts. The !Kung in particular spend considerably more time working in the Manketti forests than other population groups. For examples, refer to: Cole et al. CRIAA SA-DC. Oct. 1998; Cole. Dec. 1998; Buschel. CRIAA SA-DC/KFSRE. Nov. 1998; Prié. CRIAA SA-DC. Dec. 1998; and; CRIAA SA-DC. Nov. 1998 (Follow-up findings of the Manketti nut trial purchase).
translator during field work. Based on their experience harvesting Manketti in these forests local !Kung harvesters, Johannes and Michael, adapted their own knowledge of productivity to define different classes of Manketti forests, Manketti groves, Manketti trees, and Manketti fruit (kernel). In addition they were employed as 'spotters' during field transects, defining the different Manketti forest-, grove-, tree- and fruit- classes by sight. This information was then be used to determine the Manketti yield of different areas.

!Kung Manketti harvesters, Michael (left) and Johannes from Wiwi village, western Mpungu District, were employed by CRIAA SA-DC to help develop a methodology to assess the yield of Manketti kernel within different forests and groves.
Developing a Classification for Manketti Forests and Groves

In terms of Manketti production the !Kung harvesters classified three broad forest types. The first type are forests where Manketti occurs as isolated trees in very low densities or not at all. The second type is a forest with a greater mix of trees where Manketti is found in greater densities but in too small concentrations to attract local harvesters. (In these forests individual Manketti trees close to homesteads will be heavily utilised by those family members, but commercial harvesters require forests where high concentrations of Manketti can be found). These Manketti "groves", what Peters (1987) called Manketti "heartlands" constitute the third forest type. Within groves Manketti is the dominant or co-dominant species, producing very high yields, potentially as much as 1,000 kilograms per hectare per year (After Vahmeijer, 1976 working in the Manketti Block, northern Namibia).

In terms of the existing industry and future supply, Manketti harvesters collect almost exclusively from Manketti groves. This study therefore, will aim to assess the amount of Manketti fruit produced within the most important groves in the Mpungu District, western Kavango. (See also Map on page i).

Developing a Classification of Important Manketti Groves

In order to provide an initial assessment of the extent of Manketti in the Mpungu District, CRIAA SA-DC conducted a Natural Resource and Livelihood Study during July-September 1998 (CRIAA SA-DC, Oct. 1998). The report showed that around Mpungu there are core areas within forests where Manketti forms almost pure stands. In the past and today these are the most important areas for subsistence and commercial harvesters. Harvesters explained that the largest groves closest to settlements are the most important of all. PRA maps drawn by local residents revealed that Manketti groves form in two kinds of habitat; in irregular-shaped groves on areas without (prominent) sand dunes and; in linear groves along the crest of fixed sand dunes. The PRA map allowed us to classify these two types of "important" Manketti resources. (Cole et al, Oct. 1998 and Buschel Nov. 1998).

1. **Linear groves** occur in the far south and far north of Mpungu District in areas where sand dunes are prominent. These groves tend to be very extensive producing large quantities of fruit most of which are un- or under-utilised. Situated far from permanent settlements these groves are visited almost exclusively by !Kung subsistence harvesters when sufficient rainfall allows temporary settlement or when Manketti resources closer to permanent settlements are exhausted (i.e. not all year round and not every year). Mpungu-!Kung harvesters identified these groves as important potential resources, the limiting factor being the absence of surface water.

2. **Irregular-shaped groves** occur in areas where sand dunes are absent or eroded, particularly in central Mpungu District. These groves tend to be typically a few tens to several hundred hectares in size. Situated relatively close to settlements these groves are heavily utilised throughout the year by commercial and subsistence harvesters alike. In terms of a future supply from these groves, there could be instances of competition between subsistence and commercial harvesters although more research is necessary to quantify seasonal variations in yield and to compare this with the current level of off-take. Research could focus on the most heavily used groves, those closest to settlements.
Developing Manketti Tree and Nut Classes

Based on their own experience collecting Manketti in different forests, Mpungu-!Kung Manketti harvesters accurately described the basic structure and classes of Manketti forests. They then classified Manketti trees and fruit into classes according to their estimated yield.

!Kung Classification of Manketti Trees (related to fruit production)

The !Kung in Dobe, Botswana, estimate that 50% of all Manketti trees in a forest are infertile and male ("\"xa !go\") and 50% are female ("\"xa di\") with the potential to produce nuts (Lee 1973). From their own experience collecting in the forests of Mpungu, local !Kung harvesters also estimate there to be (near-)equal proportions of male:female trees. Their experienced eye can differentiate male from female simply by looking at "the shape of the leaves. Male trees have smaller leaves and do not produce any fruit." (Johannes).

The following Table 2 lists some of the Mpungu-!Kung names for the different fruit-producing trees (female trees). (Please note my lack of knowledge concerning !Kung spelling). In addition, harvesters provided an estimate of the available yield from each of these tree classes based on their observations of the Manketti forests this year - for the 1999 season. Harvesters usually collect from linear groves once a year, at the most twice a year, as they are so far from settlements. (For example, the nearest part of Pêtê forest is 35 km or one and a half days walk from Wiwi village). It is to be expected, therefore, that the amount of fruit available to harvesters in most years will be considerably less than the estimated total yield from given tree, as a large proportion of the fruit not collected by harvesters will gradually be buried in the sand, eaten by wild animals and micro-fauna or will eventually rot away.

Estimates of available yield are based on simple observation (with the qualifier that these trees were in fruit at the time the estimate was made (end February) and that these harvesters have collected from these very same groves before). Estimates are based on a comparison of this year’s fruit on trees with previous years’ collections (visual quantification):

Table 2: Mpungu-!Kung Classification of tree types and Visual Estimates of Available Tree Yield

<table>
<thead>
<tr>
<th>Name (!Kung)</th>
<th>Tree Size and description</th>
<th>Estimated Fruit (kg fruit/tree/yr)</th>
<th>Estimated Nut (kg nut/tree/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;&quot;Xa ma&quot;</td>
<td>A small tree too young to produce</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td></td>
<td>Any tree from seedling-juvenile (photo 1/4 from this wet season)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;&quot;Xa di-ma&quot;</td>
<td>A medium sized tree: 4.5-9.5 m high Producing fruit, not to full potential</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>&quot;&quot;Xa di-ixo&quot;</td>
<td>Large and fat, max. yield: 7.5-15m high ≥15-50 kg</td>
<td>≥1.35-4.5kg</td>
<td></td>
</tr>
<tr>
<td>&quot;&quot;Xa ung&quot;</td>
<td>Tall and slim maximum yield)</td>
<td>n/a</td>
<td>&quot;</td>
</tr>
<tr>
<td>&quot;&quot;Xo lxo&quot;</td>
<td>Short and fat maximum yield)</td>
<td>n/a</td>
<td>&quot;</td>
</tr>
</tbody>
</table>
Other Useful !Kung and Rukwangali Names

//"Xa" Manketti fruit and tree
//"Xa ne xo" Good Manketti season
//"Xa ne me" Bad Manketti season
//"Xa !go" Male tree
//"Xa di-" Female tree

Kutapeka A Manketti tree growing from a branch cut from a living Manketti tree
Pale A fence pole made from a branch cut from a living Manketti tree

Manketti trees and Marula trees both have the ability to produce Kutapeka; where branches cut from a mature tree and planted in the ground, with sufficient water, will take root and grow again. This photo of a avenue of Marula trees shades the road leading to the Shambiyu Roman Catholic Mission on the banks of the Kavango River, north-east Kavango.

This idea of planting Kutapeka groves close to settlements could be a good idea for the Owambo marula project as well as the Manketti project in the Kavango. "There was a day when I had nothing to do so I came here with a bunch of kids from the mission school. We cut large branches from a few local marula trees and planted them inside the fences either side of the road. 50 years later we now see this, made in just one afternoon: a long term benefit to all. It's probably the most successful development I have ever done!" (Father Bernard Van Roosmalen. Now 79, he has spent nearly half a century working in the Kavango, first arriving in Shambiyu in 1950).
Examples of *Kuapeka*: Manketti branches cut and re-planted outside the Ministry of Agriculture offices in Rundu at the beginning of the rainy season. Nov. 1998. This method could be employed to plant dense groves of Manketti nearby settlements.
A very large female Manketti tree.

A Manketti seedling germinated Nov./Dec. 1998
Developing a Classification for Manketti nuts

Lee (1973) asked !Kung harvesters to describe and explain the different types of nuts produced by Manketti trees. One of the most important types of nut he described were 'Tcoro nuts'; those fruit which have fallen early on in the season (usually February to April) and which are "useless" to the !Kung because they are empty shells without a fruit or a nut. Some experienced !Kung harvesters can identify Tcoro nuts by sight and will simply ignore them on the ground and move on to the fruit with nuts.

The following classification is based on the names used by !Kung around Mpungu. (The names and phrases given below describe "the fruit as an entity" and implicitly also describe the fruit and nut as separate parts:

<table>
<thead>
<tr>
<th>!Kung Name</th>
<th>Fruit and nut description (affecting potential Yield)</th>
</tr>
</thead>
<tbody>
<tr>
<td>//&quot;Xa xe&quot;</td>
<td>What Lee called 'Tcoro nuts'; fruit with small nuts or empty shells. They fall very early on in the season. Not really usable but available.</td>
</tr>
<tr>
<td>//&quot;Xa !ai&quot;</td>
<td>When the fruit has fallen very early but the nut is normal.</td>
</tr>
<tr>
<td>//&quot;Xa !Goi&quot;</td>
<td>Fall later in the season and usually the best nuts of the year.</td>
</tr>
<tr>
<td>//&quot;Xa shoro&quot;</td>
<td>Without a nut (but with fruit)</td>
</tr>
<tr>
<td>//&quot;Xa xam&quot;</td>
<td>A normal, but very fresh fruit and nut</td>
</tr>
</tbody>
</table>

Another important type of tree are those female trees producing a fruit with two nuts inside, instead of the usual one. The photos below and over the page show good examples of these twins. Lee estimated that 1 in every 20 female trees produces fruit with two nuts. As Michael and Johannes explained, "about 1 in every 10 female trees produces fruit with two nuts inside. They are not very common but they are the most important; they are the trees we collect from first. Usually from a tree producing twins, about half the fruit will be normal with a single nut, and one half will be fruit with two nuts inside. We like these because they are half the work so we keep an eye out for these trees."

Lee (1973) working in Botswana estimated that 1 in 20 trees produce extra large fruit with two nuts inside. Mpungu !Kung estimate that 1 in 10 trees produce fruit with twin nuts:
A comparison of normal fruit (one nut) and large fruit (two nuts). Harvesters prefer collecting "twins" both for Kashipembe production (liquor) and for eating; in terms of effort it is, "Two for the price of one."
Important Manketti Groves in Mpungu District

Important Linear Groves

Kung and Kwangali harvesters stated that the most important linear groves are Pété and Kruku forests. Pété, in the far south of Mpungu District is a Manketti forest area described by Cole et al (CRIAA SA-DC, Oct. 1998) and Buschel (CRIAA SA-DC/KFSRE, Nov. 1998) as one of the largest and most important Manketti resource areas. According to Mpungu-Kung harvesters from Wiwi village, "Pété is so large it never runs out of fruit, extending far to the east and south of Kavango".

Both the 1:250,000 topographic maps and existing literature show that the sand dune topography and associated Manketti forests cover thousands of hectares through present day central and southern Kavango and northern Oshikoto Region; from Tsintsabis in the south to Kasima village in the north.

The last time Johannes and Michael were in Pété was winter 1997. "We collected a lot but brought back just one 20 litre bucket [15 kg], the same one used in the [Manketti] trial purchase.

"Kruku is the other big resource area utilised by Mpungu harvesters although they estimate it to be "even bigger and more densely forested than Pété; the distribution of Manketti trees in Pété forest is comparatively thin, dispersed throughout the forest in relatively small pockets of Manketti grove. Kruku, on then other hand, is a series of big, dense, linear groves stretching 30km east-west and about 10 km north-south". (Michael)

Following a discussion with local harvesters collecting from both forests it was agreed to survey Pété Forest rather than Kruku Forest. Results derived from a survey of Pété could then be extrapolated directly to the Kruku forest without fear of overestimating the Manketti resource there; following the premise that it is better to underestimate than to overestimate a Manketti resource.

Important Irregular-shaped Groves

The most important irregular-shaped groves are located in central Mpungu District where omurambas are the dominant drainage feature. In most instances these are the most important groves in the District as they are relatively close to settlements, and therefore visited most frequently by harvesters.

CRIAA SA-DC/KFSRE research to date has identified the most important groves closest to settlements around Mpungu. (See Cole et al. Oct. 1998; Buschel Nov. 1998). According to Mpungu-Kung harvesters living in Wiwi the most important (largest and closest) Manketti groves occur in Mpoto South forest, utilised by neighbouring villages including: Wiwi, Mukekete, Mpoto (north and south), Nkodi, Nalisova, Njere, Nangera, Sirondera. As Johannes from Wiwi village explained: "This forest is heavily utilised by people from all neighbouring settlements and because of that often runs out; not literally, but it becomes too much effort to walk that far. That's when we decide to go and collect in the big forests at Pété or Kruku".

Mpoto South forest is about 2,125 hectares and was surveyed during field work in February-March 1999.
A Description of Linear Groves and their Proximity to Settlements

If viewed from the air, the sandy plains of northern and southern of Mpungu District resemble a gently corrugated surface of wavy, coloured lines. This banded pattern stretches more than 100 kilometres east-west. In places these bands are dissected by other lines running roughly north-south. What lies below is a series of parallel sand dunes 1 – 3 kilometres apart with lower-lying areas and pans in-between; all that remains of an inland sea, now dry. The undulating, sandy seabed and shore have been rooted down with vegetation; forests emerging on the sand dunes while grasses and shrubs have appeared in the inter-dunal valleys. In cross-section the sand dunes protrude just 10 – 20 metres above the shallow valleys, but it provides enough of a change in micro-environment to give Manketti a comparative advantage over other tree species (especially on sand dunes where deep, free-draining soils predominate). On the crest of dunes Manketti flourished and in some cases is now the (co-)dominant tree species.

Between sand dunes Manketti does not occur at all or in very low concentrations. According to the Mpungu-I-Kung Manketti trees lucky enough to propagate in these shallow valleys tend to take longer to mature, are smaller and produce less fruit (if any). Similarly, where dunes have been dissected and lowered (usually by old watercourses running north-south) then Manketti is scarce, even absent, particularly in the wider, deeper Omumumbas.

These ancient dunes are the most dominant feature in the Mpungu District. (In fact this same dune-inter-dunal valley topography occurs over the entire Kavango Region except along the Kavango River or at more localised sites where fossil rivers have eroded the sand dune surface or dissected the dune profile). Along the crest of sand dunes linear Manketti groves vary from approximately 100–500 metres wide and 2–20 kilometres (or more) in length. According to Mpungu-I-Kung harvesters some of these sand dunes extend intermittently from, "the Ovamboland-Kavango border in the west to Nepara (35 km) and Kaparara (90 km) in the east". As Johannes explained (from his experience patrolling the western Kavango with the SADF), "these forests go on and on. They are too big to map. You can't walk around them and you can't drive through them (unless you have a Casspir). I don't know where they end but these Manketti forests run intermittently from inside Ovamboland to Nepara and Kaparara, and as far east as the Rundu road. And there are sand dunes all the way south for about 100 kilometres, from south of Mpungu to Tsintsabis. There is a lot of Manketti here."

With just one week it was not possible to visit the entire dune area. Based on discussions with local harvesters and by studying the 1:250,000 topographic maps the estimated location and size of the linear groves extend over most of southern Kavango.

According to Cole et al (CRIA SA-DC Oct. 1998) and Buschel (CRIA SA-DC/KFSRE Nov. 1998) and by referring to topographic maps, linear groves are situated very far from settlements. These extensive forests have developed on deep sandy soils and therefore lack surface water, prohibiting permanent settlement. Virtually no boreholes have been drilled in these areas. (The only boreholes we found were abandoned and without pumps: ex-SADF bases). For this reason linear groves on sand dunes are utilised predominantly by !Kung harvesters for the Kashipenbe industry and for their own consumption. The two most important linear Manketti groves in western Mpungu District are Kruku forest in the north and Peter forest in the south. Peter forest starts about 35km south of Wiwi village and continues south and east. Kruku forest lies about 20 kilometres north of Mpotto extending to the east and west for tens of kilometres. The exact size and extent of both forests are not
known, "but they are very big. You can never walk across them and they never run out of Manketti." (Michael and Johannes).

Linear groves are used by !Kung harvesters when Manketti resources close to settlements have been exhausted and when heavy rains signal a high chance that water is available in these (typically sandy, waterless) forests. Usually it is the men who make a reconnaissance trip to the closest dune groves to evaluate the availability of water and Manketti fruit. If there is sufficient of both then they may decide to move "with the whole family and, sometimes with other harvesting families, and set up camp in the forests for a few weeks or even months" (Michael). The Manketti trees themselves provide water for the group which may return to the same sites near these water-bearing trees year after year. Manketti is the focus for moving to distant groves but in good years of rain especially, there are a wide range of other resources available to harvesters.

A hollow in a large Manketti trunk provides an important source of water for harvesters, particularly for the !Kung collecting from linear groves in southern Kavango.
Michael collecting berries during a transect survey and eating a Sunday dinner of roast lizard in the Pété Forest, southern Mpungu District.
A Description of Irregular-shaped Groves and their Proximity to Settlements

In central Mpungu District (for example around Mpungu village) deeper, wider valleys, or omurambas have formed in place of ezanas. (Ezana is the Rukwangali name for inter-dunal valleys comprising low lying pans of grassland and shrubland vegetation with isolated trees). Omurambas are fossil rivers in-filled with aeolian sands. Where omurambas occur they comprise broad features dominating the landscape; incising through and eroding the dune-ezana landscape leaving an uneven topography (compared to the uniform, corrugated dune/inter-dune landscape). Within this uneven and irregular topography, extensive linear groves cannot form. Omurambas prohibit extensive Manketti tree growth as soils in these larger valleys have a higher silt/clay content and water is too close to the surface. In these areas smaller, irregular-shaped groves have developed on pockets of higher ground and areas with deep, sandy soils while settlements have been established in omurambas. Hand-dug wells and boreholes tap the shallow water table and water-retaining soils enable dryland arable agriculture.

In central Mpungu Manketti groves can be both large and small, from a few hectares to several thousand hectares. Some settlements such as Liha village have been established in one large Manketti grove, while other settlements can be as far as ten kilometres from a small grove.

Conducting a transect survey in Mpoto South Forest. This forest is heavily used by a number of settlements and in the distance is a homestead within the Manketti grove.
Honey is another important resource collected by !Kung Manketti harvesters while out collecting Manketti. Péte Forest, southern Mpungu.

Devil's Claw occurs throughout the Kavango and is used as a medicine by both the !Kung and Kwangali in the Mpungu District. (*Harpagophytum Zeyheri*).
Distribution of Manketti Trees in Linear Groves

On a harvesting trip the !Kung tend to travel in a circular route mainly for the simple reason that they end up with a full bag of Manketti as they enter the camp at the end the day. But there is another reason: After a day spent walking across dune after dune a distinct pattern in the forest emerges. When asked, 'where are the Manketti groves?', !Kung harvesters would reply, "follow the line of the forest. Can you see the lines in the forest? Over there, see the line of the Ezana (Rukwangali for inter-dunal valleys comprising low lying pans of grassland and shrubland vegetation with isolated trees) then, behind the ezana, can you see the line of big trees on the horizon? [As we started the walk up the dune face into the forest...] Here is where the largest Manketti trees are found, see them in a big group all together. [As we continue up the dune...] See here the line of the Kiat and Ehaka trees; they form a different forest, sometimes with small and more localised ezanas within this forest. There are very few Manketti trees here. [Further on, at the top of the dune...] Now the Manketti trees begin again in a different kind of forest, sometimes in big groups and sometimes interspersed with a mix of different trees".

What the Mpungu-!Kung were describing are the different bands of vegetation so clearly visible from the air. With their trained eye a circular route allows harvesters to maximise time spent in the best groves (where they will 'follow the line' of dense Manketti groves) and minimise time spent in the ezanas and forests where Manketti is dispersed (where they walk directly 'across the line' to reach the next grove).

One initial 10 km hike across the dune profile and two transect surveys were carried out in the dune/ezana forests of Pêté resource, 35 kilometres south of Wiwi. The photos below show the structure of this dune-forest complex the Mpungu-!Kung described when "following the line" of the forest:

A mix of Manketti and other tree species in Pêté Forest
Starting point of Transect 1, Pété Forest - In the foreground is an "Ezana" or inter-dunal valley and in the distance is a ‘line’ of Manketti trees demarcating the upper slope of the sand dune.

At the edge of some Ezanas isolated Manketti grow, but do not produce much fruit, if any.
A map drawn in the sand by !Kung harvesters Michael and Johannes clearly shows the alternating sequence of sand dunes and inter-dunal valleys, aligned east-west. The rows of Manketti nuts in these pictures represent linear Manketti groves, found on the crests of sand dunes.
These photos also show how the direction of these transects were oriented north-south to cut across the sand dune profile, to ensure that the most important forest types were incorporated within each transect. A map drawn by harvesters in the sand enabled CRIAA to quickly identify a representative sample (cross-section) of the dune vegetation structure:

The following diagram is a stylised cross-section of a 'typical dune' showing the banded vegetation and associated forest types identified by the !Mpunugu-Kung in Pètè forest in southern Mpungu District:

**Profile view (cross-section) of the sand dune vegetation:**

**NOT TO SCALE:**

<< NORTH  

[Diagram of a sand dune with labels: *Manketti*, *inter-dunal valley* or *erano*, *Manketti* is absent, *Manketti* forms dense stands on the top of sand dunes, particularly on south-facing dune-slopes; according to Mpungu-!Kung harvesters.]

SOUTH >>

← 0.5-1 km ← 1 - 2 km →

↑ 10-20 metres
Plan View (birds eye view) of the dune vegetation:

**NOT TO SCALE:**

<< WEST          EAST >>

Owambo - Kavango border

---

**inter-dunal valley**

*Ezana: Averaging 550 metres across*

Manketti absent

---

**Mixed forest: Averaging 250 metres across**

Manketti varies in abundance with small, dense groves.
Usually not the dominant species

---

**Sand Dune**

**Mixed forest: Averaging 280 metres across**

Manketti in low concentrations
Typically Kiat/Ehaka are dominant, sometimes with a
small ezana with dwarf trees/grassland vegetation

**Mixed forest: Averaging 870 metres across**

Manketti relatively abundant in dense groves. Usually
not the dominant species

---

**Inter-dunal valley**

*Ezana: Averaging 550 metres across*

Manketti absent

---

Although this dune topography produces a fairly predictable relief and a relatively even
distribution of forest types, the width of each forest type will vary from place to place
as dunes meander east-west across southern Kavango. Survey transects across two
sand dunes in Péte forest provide an average figure of the size of each of these different
forest types. These average figures are used to estimate the total surface area of
Manketti groves which in turn are used to calculate total Manketti yield: In the dune
areas north and south of Mpungu mixed forests with linear Manketti groves cover
approximately 55% of the total land area; mixed forests where Manketti is in low
concentration comprise approximately 15%, and ezanas where Manketti is absent
comprise approximately 30%.
Counting Fruit on Trees to Estimate Average Tree Yield

Four large and three medium female fruiting trees were sampled to see how much fruit was growing on the trees this season (1999). The technique involved selecting one of the main branches (where the trunk divides into numerous main branches), and counting all the fruit on that branch. The idea being that by knowing the number of fruit on a branch and by knowing the size of the branch in relation to the other main branches, it is possible to calculate the total number of fruit on a tree.

Estimating average fruit yield for each tree class: Thomas and Michael measuring branch and stem basal areas and counting fruit.

---

3 Of the seven productive trees counted, there is a close correlation between the basal area of the trunk and the total basal area of the main branches; they are almost exactly the same. In other words, even though the sample is not statistically valid, we can assume with some faith that there is a direct relationship between the number of fruit on a given sized branch, the total basal area of all the branches and the total number of fruit on the tree.
Counting fruit to estimate average fruit yield for each tree class - Samples of fruit were geo-referenced and tagged for chemical analysis at UNAM, one of CRIAA SA-DC’s research partners in the Manketti project (Non-Timber Forestry Products 1).
Of the four large female trees sampled, yield per tree varied from 671 fruit to 1,276 with a mean value of 920 fruit per tree per year, equivalent to 6.44 kg nuts/tree/yr. Medium sized trees produce an average of 471 fruit per tree or, 3.30 kg/tree/yr. These estimates correlate closely with the figure of 950 fruit per tree (6.65 kg/tree/yr) in the Dobe district of NW Botswana (Lee 1973), and are slightly lower than the Mpungu!Kung visual estimates of 1.35 to 4.5 kg/tree/yr for a large female tree in Pété forest (refer to Table 2).

Comparing this year’s fruit with previous years Michael and Johannes explained: "This year we probably won’t be coming to Pété forest to collect Manketti. There is not enough water and the Manketti is not really enough to warrant the effort. We’ll probably go to Kruku forest in the north." (Michael and Johannes at the end of the Pété forest survey).

**Conducting transect Surveys in Pété Forest (linear Manketti groves)**

As well as sampling the surface area of different forest types and classifying trees according to estimated yield (as above), transect surveys also provided estimates of Manketti tree density within each forest type.

The methodology developed was simple and quick. The five-person survey team stood 7.5 metres apart (a total of 30 metres across) at the base of a dune on the ezana/forest border (there is a distinct border easily visible on the ground). Facing due south, the survey team walked slowly through the forest cutting directly across the dune profile. Every Manketti tree within the 30 metre transect was recorded: male/female trees; the size/class of tree; the class of fruit including trees producing twins. The spotters Michael, Johannes and Thomas calling out every tree from the smallest seedling to the oldest tree. Although this method is not exact (perhaps some non-fruiting, female trees were classified as male or a small number of juvenile trees were missed and excluded from the transect survey), transects do provide an initial estimate of the spatial distribution of Manketti trees within a forest. And particular care was taken to identify and record all productive trees (female fruiting trees). See photos on the next page.

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*If one kernel weighs 0.7g then; 920 fruit/tree x 0.7g/kernel = 6.44 kg nut meat per large female tree.*
*(After Lee, 1969.)*
Conducting a transect survey in Pété Forest.

A typical Kiat-Ehaka forest on the north slope of a sand dune. These forests have almost no Manketti.
The following aggregated results were obtained from two transects.

Table 4: Pété Forest Transect Summary (Trees per hectare)

<table>
<thead>
<tr>
<th>Forest Type</th>
<th>Tree Size, Sex and Density (trees/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Manketti density)</td>
<td>Male Female</td>
</tr>
<tr>
<td>Mixed Manketti (medium density)</td>
<td>4.1666 2.1667</td>
</tr>
<tr>
<td>7,800 m square (250 m x 30m)</td>
<td></td>
</tr>
<tr>
<td>Mixed Kiat/Ehaka (very low)</td>
<td>2.4233 1.115</td>
</tr>
<tr>
<td>8,400 m square (280 m x 30m)</td>
<td>0.1852 0.5555</td>
</tr>
<tr>
<td>Mixed Manketti (medium density)</td>
<td>14.3294 2.2605</td>
</tr>
<tr>
<td>26,100 m square (870 m x 30m)</td>
<td>2.98857.8544</td>
</tr>
</tbody>
</table>

Estimated Manketti Yield in Pété Forest (linear Manketti groves)

According to Mpungu–!Kung harvesters from Wiwi there are six dunes in the northern part of Pété forest which are visited most often, especially in years of average-good rainfall. Similarly, both the 1:250,000 and 1:50,000 topographic maps show these six linear dune features and associated Manketti forests, estimated to be a total of 185 kilometres in length, and an average of 1.4 km wide.

The following aggregated results of trees per hectare and yield per hectare were obtained from two transects:
Table 5: Yield per hectare in Linear Manketti Groves

<table>
<thead>
<tr>
<th>Forest Type</th>
<th>Tree Size and Yield (kg/tree size/ha)</th>
<th>Total Yield /Ha. (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Medium Female (3.30 kg/tree)</td>
<td>Large Female (6.44 kg/tree)</td>
</tr>
<tr>
<td></td>
<td>2.195</td>
<td>17.173</td>
</tr>
<tr>
<td>Mixed Manketti</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(medium density)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>250 metres</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mixed Kiat/Ehaka</td>
<td>1.833</td>
<td>4.770</td>
</tr>
<tr>
<td>(very low density)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>280 metres</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mixed Manketti</td>
<td>25.920</td>
<td>14.558</td>
</tr>
<tr>
<td>(medium density)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>870 metres</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total yield (kg/ha.) on linear dunes 25,900 775,274 29.93

The yield of Manketti kernel in the Pété Manketti forest (dune area) is estimated to be 29.93 kg per hectare per year, about one third the yield of the next lowest estimate of other studies. (These figures can be compared with other estimates given in Table 1, page 3) As these estimates are based on the lowest expected yield in the most heavily utilised groves closest to settlements, this is almost certainly an underestimate of the total biological fruit production within linear Manketti groves.

Conducting Transect Surveys in Mpoto South Forest (irregular-shaped Manketti groves)

Using the same techniques we conducted two transect surveys in irregular-shaped Manketti groves in the central Mpungu area, in the Mpoto South forest, south of the main Owambo-Kavango road. The transect survey was conducted in the south-east part of Mpoto South Grove near Nalisova settlement. A semi-circular route was taken through the forest as if mimicking a harvesting outing.

The following results are averages of the two transects. They provide estimates of the number of medium and large trees per hectare and the average yield per hectare:
Table 6: Trees per Hectare in Mpoto South (irregular-shaped groves)

<table>
<thead>
<tr>
<th>Forest Type</th>
<th>Tree Size and Density (trees/ha)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Small Male</td>
<td>Female</td>
<td>Medium Male</td>
<td>Female</td>
</tr>
<tr>
<td>Mixed Manketti</td>
<td>23,700 m square</td>
<td>(810 m x 30 m)</td>
<td>30.8016</td>
<td>13.924</td>
</tr>
</tbody>
</table>

These figures show how irregular-shaped groves in central Mpungu are more densely populated with Manketti trees. Of particular interest is the larger proportion of smaller Manketti trees compared to linear groves, including a higher number of seedlings and saplings. Based on observations and the results of the transect walks, these groves are much smaller and more densely vegetated than Pété forest and influenced to a much greater degree by settlements. There is evidence of veld fires, grazing animals and tree-felling to make way for arable fields and homes. Within cleared fields, only the very large Manketti trees (as well as other fruit trees) are left standing (See photos below). Unfortunately, it is not known how people and domestic stock affect yield or whether they have a negative or positive impact on Manketti yield.

A field cleared of all but the largest Manketti trees in Mpoto South Forest
Mopo South Forest: At the end of Transcat 2 the thick forest emerges onto an open field (left).
Table 7: Yield per hectare in Mpoto South (irregular-shaped groves)

<table>
<thead>
<tr>
<th>Forest Type</th>
<th>Tree Size and Yield (kg/tree class/ha)</th>
<th>Total Yield Ha.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Medium Female</td>
<td>Large Female</td>
</tr>
<tr>
<td>Estimated yield</td>
<td>(3.30 kg/tree) (6.44 kg/tree)</td>
<td></td>
</tr>
<tr>
<td>for each class female tree</td>
<td>(medium density)</td>
<td></td>
</tr>
<tr>
<td>Mixed Manketti</td>
<td>13.9240</td>
<td>29.7103</td>
</tr>
</tbody>
</table>

Total yield (kg/ha) in Irregular-shaped Manketti groves 43.63

Manketti nut yield within irregular-shaped groves is estimated to be 43.63 kilograms per hectare per year. The Mpoto grove where these results were derived is considered by local harvesters as a reliable resource area but heavily utilised by neighbouring villages. These estimates are higher than the estimate for Pété linear grove, and visual observations support these estimates.

Conclusions and Recommendations (with a few comments on Accuracy and Reliability)

It must be noted that these estimates are exactly that – estimates – and should be used only as a rough guide for monitoring, planning and decision-making and not as a definitive estimate of Manketti production for the Mpungu District.

Based on the literature and on discussions with Mpungu-Kung harvesters, these results most likely underestimate the actual yield within groves around Mpungu. There is also strong evidence to suggest that yield will vary from year to year and from place to place. Some harvesters say 1999 is a "normal year" and some say it is a "very bad year". (No one says it is a good year.) These estimates of a low-to-average year throughout northern Kavango is almost certainly a result of the absence of rainfall in January and early February followed by intense storms in late February causing early fruiting and the premature falling of 'Tcoro' fruit, recorded in both Pété and Mpoto South forests, for example.

Weather conditions vary considerably from place to place and it is not suprising that Livayi residents, on the other hand, state that the excellent early rain in November and December has since ceased all-together causing the poor Manketti yield envisaged this year.

In particular, this study has shown that the key determinant of Manketti yield is not the number of fruit per tree but the density of productive trees per hectare. In other words, a "big" Manketti forest is not necessarily the best forest for harvesters. A dense grove of large females trees (preferably twin-producers) is preferred as it enables quick and easy collection of Manketti over a small area.

These estimates therefore provide preliminary, "ball-park" figures of Manketti yield in the two most important Manketti groves found in the Mpungu District – in linear groves and in irregular-shaped groves. The methodology developed during this study can be refined in future years and combined with more rigorous scientific methods such as aerial surveys of specific groves. This study shows that harvesters possess considerable first-hand knowledge of Manketti trees and forests which will become
even more relevant if increased commercialisation of Manketti is to occur. Future studies can include other harvesters with specialist skills. For example, it appears !Kung men are involved in the commercial collection of Manketti. Women may know different resource areas, for example those closest to villages in areas where their is more competition for Manketti.

One of the most immediate tasks is to define and map more accurately the most important groves in the area. These could be ranked in terms of their proximity to settlements (how often they are used) and their reliability (how often they run out of Manketti). Of particular interest are groves currently experiencing competition over Manketti resources. Although there have been no reports of competition between different users in groves around Mpungu any increase in commercial trade will most likely affect those harvesters dependent on small groves, particularly those situated close to settlements using the same resource areas, such as the Mpoto South forest. Any scarcity of Manketti will most likely be experienced at the end of the harvesting season, from October to March. In addition, research should focus on identifying households and population groups dependent on Manketti for their subsistence, for barter, or as an important source of income.

For example, the Kashipembe industry in the Kavango is an important source of income for rural and urban households alike. (See Prié Dec. 1998, CRIAA SA-DC). According to Vincent Prié there are three major Kashipembe distilleries in the 'townships' of Rundu (personal comment): "Each distillery is open, literally, every day of the year. Every time I visited one of them they were fully booked, for weeks in advance, usually by local entrepreneurs who produce liquor for sale on the local market. Each distillery processes about 30 kilograms of fruit at a time, If we take a conservative (minimum) estimate, that's at least five days a week, for 40 weeks of the year; that's more than 500 kilograms of kernel a year, from just one distillery. There are hundreds of distilleries in Rundu and the Kavango, many of them producing small amounts a few times a year, others producing large amounts every day. That's a lot of Manketti kernel circulating in the local economy".

At the moment this large supply of 'left over' kernel from the production of Kashipembe is either left to rot, given to those involved in decorticating the nuts as (part) payment for their work, exchanged for mahangu or other local produce, or sold at very low prices in the local markets. If there is a demand for kernel as a result of the development of a commercial market, this resource could become a valuable one and no longer a give-away commodity. It will be interesting to note the impact of increased commercialisation on households benefiting from this cheap and reliable nut resource. In addition, an increase in nut production will give rise to a larger quantity of un-used fruit, the key ingredient of the Kashipembe. A greater supply of fruit may enable locals to distil and drink more Kashipembe, already consumed by some in excessive quantities.

In terms of developing a local Manketti industry the largest resource areas are linear groves in the south and north of Mpungu District. On our last night camping in Pété forest I asked them how they would like to use the forest in the future. They described a future with water, to be supplied at a site in Pété where they could stay for months at a time or even live permanently. Pété is a resource area they identify as having huge potential for them; opening up all the resources held in these vast tracts of under utilised Manketti groves. Obviously this would require outside aid and could just as easily result in an influx of other groups, such as Kwangai farmers, also looking for land to make a living.

In terms of developing more reliable estimates of yield, a number of questions remain unanswered: Are some groves more productive than others? Which groves are most heavily utilised? Are there local names for groves? Are there other types/classes of productive groves? What is the proportion of dead or unproductive trees in the forest?
What are the current and proposed methods of increasing available yield (e.g., Kutapeka; cutting branches and planting dense groves close to settlements)? What is the current level of germination and recruitment in groves? How much Manketti is left under trees at the end of a season?

It must be noted that the two transects conducted in each of the two different grove types are not representative of all Manketti groves in the Mpungu District. More detailed survey work - longer transects in both types of grove - is necessary to quantify yield per hectare with greater reliability. The results of this study shows that it is important to measure tree density per hectare and two transects in two groves cannot be considered an accurate representation of different forest types. Similarly, the estimates of fruit yield per tree derived from visual observations and tree counting should be used with caution. A more reliable source of tree yield estimates in the future will be generated from a longer term monitoring programme, designed to measure the amount of Manketti produced in different trees and groves over the entire season.

Establishing Tree Monitoring Points (to Accurately quantify tree yield in the 1999 Manketti season)

CRIAA SA-DC began a programme of monitoring points (MPs) to accurately quantify tree yield in the 1999 season. Two sites have been established in the Kavango Region, one in the west at Kaguni, Mpungu District and the other in the east at Livai, Mukwee District, about 15 kilometres north-east of Kaudom Game Reserve. (See Map i). Six productive trees – three large and three medium - were selected at each site.

The MPs evolved from the initial findings of transect surveys with the realisation that estimates of tree yield for large and medium trees are very difficult to assess by simple observation and by counting the number of fruit on trees. It was decided that a cheaper, easier and more reliable means of estimating tree yield in the Mpungu District (and the rest of the Kavango) is a longer term monitoring of a select few female trees.

The criteria for tree selection are as follows:

- Manketti trees selected must be productive/female (either have fruit on the tree or on the floor beneath the canopy)
- Manketti trees selected must be from groves currently utilised by harvesters (providing a good indication of available yield in local forests)
- Three large and three medium trees must be monitored
- Manketti trees must be close enough to settlement to be regularly monitored but far enough away to prevent outside disturbance from livestock/raiding by other harvesters etc.
- Selected trees must be checked regularly to ensure all fruit are collected (not buried in the sand, eaten, etc.)
- The ground beneath each tree must be cleared of vegetation to allow easy collection and counting of all fruit beneath the canopy
- The trees selected must be isolated from other Manketti trees to prevent fruit from other trees mixing with sample trees
- Monitoring staff are provided with two bags per tree. Early season fruit (T'coro nuts/empty shells) are placed in one bag and late season fruit (normal nuts) are placed in the second bag

It is important that all these conditions be fulfilled if monitoring estimates are to be used with any reliability.
Livayi Monitoring Programme in Western Kavango has been initiated in order to measure accurately the number of fruit produced on medium and large female trees during the 1999 season. Here, two local farmers employed to gather and count fruit stand next to medium sized trees "5" and "6", chosen to be monitored.
Kaguni Monitoring Project: Thomas and John gather measurements (height, DBH, number and size - basal area - of all main branches) on the first of the six trees to be sampled in western Kavango.
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