Review of existing information and data on the Marula *(sclerocarya birrea)* Resource in Namibia

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1. Background

The marula tree is a drought-resistant tree that is widely distributed in sub-Saharan tropical Africa. The sub-species *S. birrea* ssp. *caffra* is indigenous to southern Africa. In Namibia it is mainly found in the northern parts of the country. The multipurpose marula tree has a long history of traditional use, especially in North-central Namibia. Here, the importance of marula stretches from the social, to the cultural, the economical, and the nutritional aspects of people's lives, and its value makes a significant contribution to local livelihoods.

The North-central regions (NCRs) of Namibia –the Ohangwena, Oshana, Omusati, and Oshikoto Regions- are by far the most important marula producing areas in the country, both with regard to the resource availability and the traditional use. Marula is however not equally distributed in these regions. It tends to be clustered in slightly higher-lying areas where it is not flooded by rising water levels in the oshanas or impeded by hardpans in the soil, but does not do very well in the highest areas or other places where the soil is too saline and dry. The resource is particularly abundant in the Cuvelai drainage system, an inland delta which is dry for most of the year, but is fed by rains falling locally and in Angola during the summer months. The elevated strips of land between the waterways have the best soils and it is here where marula thrives. In addition, because of its better soils, the Cuvelai delta is more densely populated, and from previous work on marula in the NCRs it is known that there is a strong positive correlation between human settlements and the distribution of the marula resource.

Cold-pressed marula oil is marketed locally and internationally as a massage / skincare oil and a cosmetic ingredient by the Eudafano Women Cooperative (EWC). In the past 10 years this has grown into a multi-million dollar community trade business, benefitting a few thousand women in 22 communities in the North-central Regions. Currently, a modern marula food oil is also developed and locally marketed. The commercial usage of the fruit has been limited to the local processing of *omaongo*, a fermented marula juice, both on homestead and EWC factory level, but marula fruit processing has been one of the top priorities of the Namibian Indigenous Natural Product development pipeline[1] for the past ten years. It is mostly in view of potential commercialisation opportunities that marula resource information is becoming increasingly important.

This report intends to pull together and review the different sources of literature on the Marula *(sclerocarya birrea)* resource in Namibia. In chronological order, these include the following documents:

- Hangula, R.J.K (2000) – *Estimating the sex ratio of marula (sclerocarya birrea) in natural stands.* National Forestry Research Centre, Ministry of Environment and Tourism, Namibia
- Hangula-Mungandjela, R.J.K, M Aimanya (2001) – *Report on the field selection of marula (sclerocarya birrea) germplasm from Namibia for vegetative propagation*. Ministry of Environment and Tourism, Namibia

[1] As described by the Indigenous Plant Task Team (IPTT) in several strategic documents

- Leakey, R, S. Shackleton, P. du Plessis, K. Pate, C. Lombard (2002) – *Characterization of phenotypic variation in marula (Sclerocarya birrea) fruits, nuts and kernels in South Africa and Namibia.* DFID/FRP Winners and Losers in Forest Product Commercialisation (ZF0140/R7795)

- Botelle, A, P. du Plessis, K. Pate, R Laamanen (2002) – *A survey of marula fruit yields in North-central Namibia*. CRIAA SA-DC for DFID/FRP Winners and Losers in Forest Product Commercialisation (ZF0140/R7795)

- Den Adel (S) (2010) – *Marula Resource Survey. Report on the Sclerocarya birrea tree population and the availability of its fruits in Northcentral Namibia.* Project report CRIAA SA-DC for the Indigenous Plant Task Team, Namibia

- Lushetile, K (2010) – *Inventory report of marula trees in Namibia* (Draft version). National Forestry Research Centre (NFRC), Ministry of Agriculture, Water and Forestry, Namibia

2. Review 1: Hangula, R.J.K (2000) – *Estimating the sex ratio of marula (sclerocarya birrea) in natural stands.* National Forestry Research Centre, Ministry of Environment and Tourism, Namibia

This short report describes the study undertaken by the National Forestry Research Centre (NFRC) in order to estimate the sex ratio of marula trees in natural habitats and their possible influence on fruit yield and quality. The sex ratio of a population is an important aspect to be understood in any breeding, domestication or vegetative propagation program, and the NFRC has been involved in such programs for marula since 1996.

The study was carried out in 4 regions where marula naturally occurs. Both areas that could have been subjected to major (human) disturbances and those with minimum disturbances were selected. Areas where a number of male marula trees were likely to be removed, but still had female trees successfully reproducing were also selected, in an attempt to determine the minimum number of males needed for successful fertilisation. The sample sites were approximately 10 ha in size each, and were selected were in the following regions:

- Oshana region (3 sample plots)

- Ohangwena region (3 sample plots)

- Omusati region (4 sample plots)

- Caprivi region (Katima Mulilo) (2 sample plots)

Although the average ratio of female to male marula trees was 5:1, a distinct difference was found between the plots in Katima Mulilo, where marula fruits are not or seldomly used, and the plots in the Northcentral regions, where marula fruits are an important part of peoples' lives. In both plots in Katima Mulilo, there were more male than female marula trees, in one of the plots the female :

male ratio was as low as 1:3[2]. In the Northcentral regions on the other hand there were much more female than male marula trees. The average female : male ratio in these plots was 7:1[3], varying from 3:1 in Iipandayamiti (Oshana region) to 15:1 in Onhuno (Ohangwena region). The largest populations of marula trees were recorded at Eembidi area (Ohangwena region) and at Okafitu Kakahala (Omusati region), while the smallest populations were recorded at the 2 sites in Katima Mulilo.

The overall conclusion of the author was that the observed average ratio of 5:1 was higher than expected, but could be used as a guideline when establishing or managing marula stands.

3. Review 2: Hangula-Mungandjela, R.J.K, M Aimanya (2001) – *Report on the field selection of marula (sclerocarya birrea) germplasm from Namibia for vegetative propagation*. Ministry of Environment and Tourism, Namibia

This report describes the selection of mother trees for the vegetative propagation (grafting) of marula. Grafting of marula can shorten the period before a tree starts fruiting, and facilitates the production of either already improved trees or of trees with natural desired traits.

A total of 70 trees from 7 sites in 3 regions (Oshana, Ohangwena and Omusati regions) were selected, based on one or more of the following selection criteria:

- Fruit size (larger)
- Fruit taste (sweeter)
- Nut yield (more)
- Fruit production (more)
- Juice production (more)

Farmers were asked to identify marula trees possessing the best traits in one or more of the above mentioned criteria. Trees which satisfied more than one criteria and those with outstanding traits were given priority.

GPS coordinates of the selected trees were selected and both a collective map as site maps were produced. A list of 60 trees, their GPS coordinates, the name of the owner of the tree, and the score with regard to the selection criteria, was given as an annex to the report.

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[2] It is stated that the ratios observed in Katima Mulilo are difficult to explain. Many species can be observed to have more females than males in natural habitats. It is possible that some of the female trees did not fruit that season and as a result were wrongly recorded as male.

[3] It should be noted that there are some calculation errors in the tables presented in the report. In table 1 the total number of male trees should be 143, not 168. In table 2 the same calculation error is present; the total number of male trees is 92, not 117. The total of the ratios in table 2 should be 71:10, resulting in an average of 7.1:1, not 7:4

The report furthermore gives some detailed information on the different stages and aspects of vegetative propagation: rootstock preparation, collection, storage and transportation of scions, cleft grafting, and nursery and field establishment. The report was written in preparation of two trial clonal orchards at Ogongo Agricultural College and Onhuno Forestry plantation sites. Results of the vegetative propagation trials are therefore not included in the report.

4. Review 3: Leakey, R, S. Shackleton, P. du Plessis, K. Pate, C. Lombard (2002) – *Characterization of phenotypic variation in marula (Sclerocarya birrea) fruits, nuts and kernels in South Africa and Namibia.* DFID/FRP Winners and Losers in Forest Product Commercialisation (ZF0140/R7795)

In this comparative study of South African and Namibian marula fruits, ripe fruits were collected from 63 trees in the Northcentral regions of Namibia, and systematically analysed on the mass of their relative components (skin, flesh/juice, nut, shell, and kernel).

The study found that there was a considerable tree-to-tree variation in fruit and kernels characteristics, which is consistent with results from other indigenous tree species. It was however found that the Namibian fruits were consistently larger than those from South Africa, and in South African fruits, those from the farmers' field were significantly larger than the fruits from the wild varieties.

The kernel mass, which is important for oil production, is not only dependent on the size of the kernels, but also on the number of kernels, which varies between 0 and 4 per nut. The variation in number of kernels per nut has a genetic component, but also suggests variation in pollination success.

Larger fruits did not necessarily contain more flesh or larger kernels. Therefore if one wants to develop cultivars for either juice or kernel oil production, it is necessary to do multi-trait selection. To assist in this process, “ideotypes” were identified that would optimise the combination of traits for different products, and the best trees were compared to these ideotypes. None of the sampled trees came very close to the ideotypes, but significant improvements could be achieved by selecting the trees that are “best-fit” with the ideotypes.

The report ends with a discussion of the results in the context of the potential for developing participatory domestication programs in South Africa and Namibia, aimed at poverty alleviation in the rural communities, the restoration of the natural resource and the maintenance of traditional and social values of marula. Such programs would involve the use of commercially prudent selection and improvement strategies.

5. Review 4: Botelle, A, P. du Plessis, K. Pate, R Laamanen (2002) – *A survey of marula fruit yields in North-central Namibia*. CRIAA SA-DC for DFID/FRP Winners and Losers in Forest Product Commercialisation (ZF0140/R7795)

The aim of this study was to quantify marula fruit yields in North-central Namibia, and to find correlations between tree size (trunk, canopy and height) and fruit yields. Apart from the fruit yield

survey methods and results, the report also provides a rich source of information on the agro-forestry systems in North-central Namibia and ecological, biological and socio-cultural factors affecting the marula resource and its fruit yields.

The results of the study showed a wide variety in fruit production per tree, ranging from a few kilograms to 2860 kg. The average amount of fruit production per tree was 596 kg (standard deviation 465kg). The fruits of 104 marula trees were weighed by community members, but in the final analysis only 56 of the data sets seemed reliable, and the rest of the data was discarded. It was furthermore said that the results of the study were not statistically valid because of the small size of the sample, the not random selection of the trees, and the late start of the survey, which excluded many of the trees that had already started to drop their fruits earlier in the season. Moreover, of the data that was used in the final analysis it was said that reliability of the yield measurements was affected by a number of factors:

- The quantity of usable and unusable fruits was unknown, bad or damaged fruits were included in some measurements and excluded in others
- It is likely that unmeasured fruit fell onto piles of measured fruits, meaning the actual number of fruits was higher than recorded
- Fruit flies added strongly to the quantity of fruits which perished. Especially towards the end of the season these unusable fruits were most likely ignored by harvesters

In addition to the problems with the reliability and validity of the data of this survey, it is known that there are strong annual variations in fruit production, and it was mentioned that in 2002, when the measurements were done, the trees generally had fewer and drier fruits than the year before.

Apart from weighing the fruits produced per tree, the researchers also measured tree age, height, trunk circumference and canopy size, and looked for correlations between fruit yield and these characteristics, in an effort to develop models predicting fruit yield. The results of these measurements were more reliable, and the sample size was therefore generally bigger. The averages for marula tree characteristics can be found in table 1 of the report:

Tree characteristic	**Sample size**	**average**	**Variations**
Canopy size	56	45 m2[4]	3 sqm – 231 sqm
Trunk diameter	90	67 cm	
Tree height	100	10.2 m	3.99 m-21.43 m
Tree age	65	53 years	5 year - > 100 years

[4] Canopy size was expressed in sqm, since only the width and height were measured

It was found that tree trunk and canopy size had stronger correlations with fruit yield than tree age and tree height. The correlations found between these variables and fruit yield are shown in the following table:

variable	**Population (n)**	**Simple Correlation Coefficient (R)**	**Statistical significance (p-value)**
Yield: canopy size	56	0.67	<0.05
Yield: circumference	67	0.59	<0.05

These correlations were also analysed per region, and prediction models for different regions are presented in the report.

In the conclusions and recommendations the authors stress the problems with the validity and reliability of the data, and suggest that more research needs to be done, collecting data on the number and characteristics of marula trees and fruit yields, creating better prediction models using multiple regression analysis. It is also recommended to conduct a deeper analysis to test the relationship between rainfall and various soil/land characteristics, as these are believed to be primary factors affecting fruit yield.

6. Review 5: Den Adel (S) (2010) – *Marula Resource Survey. Report on the Sclerocarya birrea tree population and the availability of its fruits in Northcentral Namibia.* Project report CRIAA SA-DC for the Indigenous Plant Task Team

This report summarizes the results of a marula fruit resource survey that was recently conducted by CRIAA SA-DC in cooperation with the Eudafano Women Cooperative (EWC) in a number of selected areas in the Oshana, Ohangwena, Oshikoto, and Omusati regions. The main aim of the survey was to establish whether sufficient amounts of marula fruits were available to justify the development of further commercial opportunities around this resource.

With EWC constituting the largest and most organised marula supply chain currently in existence in Namibia, the survey was conducted in the areas where EWC has its associations for a number of reasons:

a) EWC associations are organized around the supply of marula, and are therefore found in areas where marula trees are abundant

b) EWC factory will most likely be used for actual processing

c) EWC members possess traditional knowledge about marula trees in their areas, which implied that the survey could be conducted outside the fruiting season

The study consisted of a literature search, key informant interviews, a focus group discussion mostly with EWC leaders, and a questionnaire collecting information from 2494 farms. A strong

representative sample of the EWC membership was included in the survey; about 50% of the surveys was conducted among EWC members. Furthermore, surveys were conducted in 13 of the 21 associations, and 21 of the 25 constituencies where EWC has its members. The data collected by the enumerators was entered by 6 data capturers in a simple excel spreadsheet database. From the database the following results were extracted:

Amongst the 2494 respondents of the survey, the number of female fruiting marula trees on their farm ranged from 0 to 50 with a total of 13 278 fruiting trees, which is an average of 5.33 per farm/household. The mode was 3, and the median 4. The large majority of the respondents (84%) had between 1 and 10 fruiting trees on their farm, 6% of the respondents did not have any fruiting marula trees, and 10% of the respondents had more than 10 fruiting marula trees on their farm.

The average population of the non-fruiting male marula trees on the surveyed farms was 1.41, making the male : female ratio 1 : 3.8, slightly higher than the 1 : 4.9 ratio found by DoF in 2001, but that survey constituted a much smaller sample. The number of young and old trees was consistent over all areas and regardless of EWC membership, with an average of 1.30 young trees per farm, and 0.14 trees that were too old to fruit. Young trees were defined as trees that were close to maturity, but not (yet) fruiting, so it was unknown whether they were male or female trees. With almost 10 times more young trees than old and dying trees, the marula population seems at least sustainable, although it was said that a more thorough age structure surveys would be needed to establish whether the marula tree population is increasing, decreasing, or stable.

No fruit yield survey was done as part of this marula resource survey, but yield figures from the 2002 survey reviewed in 5. were used instead. Using these figures in the calculations, a total estimated yield of 8’334’000 kg of fruits amongst the 2494 respondents was estimated, which is an average 3’342 kg of fruits per farm per year. This average includes the households that do not have any fruiting trees on their farm. Using a conservative estimate of 80’000 households in the marula producing areas in North-central Namibia, that would lead to a total average annual yield of over 267’000 T (+ or – 25%).

One of the tasks of the Marula resource survey was to assess the socio-economic availability of marula fruits for commercial processing, not just the biological resource. Having established the estimated yield of marula fruits among the EWC membership and the general population in the North-central regions of Namibia, does not say much about the availability of these fruits for commercial processing:

a) The area surveyed has a high level of competition from traditional users of the fruit, it should therefore be established how much they are using, if they would be willing to sell a portion of the available fruits and if so how much.

b) Logistical challenges would include transport of the fruits to the processing facility. The area surveyed is large, and transport and accessible roads are not available everywhere.

c) Fruits may in principle be available, but the majority of the fruits will ripen within a relatively short period of time, and a large part of the fruit will inevitably rot or be affected by fruit flies if not picked at exactly the right time, which is virtually impossible,

especially since not all fruits from a particular tree ripen and fall off the tree at the same time.

d) In addition to the fact that the portion of usable and unusable fruit is unknown, not all fruits in the right stage of ripening may be suitable for processing purposes, there are strong variations in the taste of fruits as there may also be in the chemical or other qualities.

e) Peoples' willingness to sell would largely depend on the price offered for the fruits.

Because it was outside the scope of this survey to extensively investigate all of these issues, the research mainly touched upon the traditional usage of the fruits, peoples' willingness to sell, and a quantification of the amounts of fruit available for commercial purposes in principle. During the focus group discussion, it was confirmed by all 14 association leaders present that on average more than 50% of the marula fruits is currently unused and a large majority of the communities in their areas would therefore show a keen interest and willingness to sell marula fruits. They agreed the problem would be the organisation and costs of transport rather than willingness to sell or availability of the resource. In the survey, a bit more than a fifth of the respondents (18% of EWC members and 23% of non-EWC members) said they were not interested to sell their fruits, either because they did not have enough or because of other reasons. Less than 5% was not sure if they would want to sell the fruits, and a three-quarter majority of the respondents either said yes, and/or yes depending on transport /price / harvest / timing. The focus group also drew attention to the fact that only during peak marula season, usually somewhere during February-March, you find the fruits are too much for the people to process, and they are left to rot. In the survey, almost 70% of the trees in the overall sample fruited in the period February-March, 18% of the trees were indicated as early fruiters, and 12% of all trees were said to fruit after March.

The survey calculated a total local use of 5'689'185 kg of fruits in a good year, or 2'281 kg on average (including the respondents that do not have any fruiting trees), which constitutes 68% of the total fruit yield. Asked what portion of their fruits they would in principle be willing to sell in a good marula year, it added up to a total commercial availability of 4'398'790 kg amongst the respondents, or an average of 1'764 kg per household, including the households that do not have any trees. 1'764 kg constitutes 53% of the yield, so while an estimated 68% of the yield is currently used in good marula years, people are in principle willing to sell 53% of their total fruits in those years, suggesting that the commercialisation of fruits might affect the tradition of sharing to some extent, and probably especially so if the price for the fruit becomes more attractive. With less fruits available in bad marula fruiting years, the percentage of respondents not interested in selling their fruits increased from 21% to 26%. Generally smaller portions of the available fruit in bad marula fruiting years was said to be made available in principle for selling, with a total adding up to 2'662'945 kg amongst the respondents, or 1'068 kg on average per household per year.

In conclusion, it was estimated that in principle, people would be willing and able to sell:

- ✓ between 570T and 940T in the EWC associations directly surrounding the factory
- ✓ between 8'000T and 13'500T in the 10'000 households surrounding the factory

- ✓ between 6'000T and 10'000T amongst the whole EWC membership, and
- ✓ between 85'000T and 141'000T in the marula producing areas in North-central Namibia

Part of the survey was used to get some more information on the fruit characteristics, even though it was not known what qualities and characteristics would be commercially interesting. 61% of the trees in the survey were said to have sweet fruits, 31% of the trees were indicated as having average fruits, not sweet, and not sour, and only 7.5% of the trees were said to have sour fruits. The quality of the omaongo made from the fruits, and the quality of the kernels inside the nuts indicated similar percentages; 60% was said to make very good omaongo, 32% made omaongo of average quality, and 7% of the trees had fruits that were not really used to make omaongo. With regard to the kernels 60% of the trees had fruits with very good kernels, both in size and quality, 32% of the trees produced fruits with kernels of average size and quality, and only 7% of the trees produced fruits of which the kernels were not extracted.

Despite a large number of uncertainties, including the lack of reliable data on fruit yields per tree, the annual variations in yield, the borders of the marula producing areas, knowledge about what quality of fruits would be suitable for commercial processing, and the level of efficiency in logistics that could be deployed in a commercial purchase effort, it was concluded that the survey showed that without a doubt the resource base and the socio-economic availability of the fruits were more than sufficient to warrant a commercial[5] investment around the resource. It was also concluded that although it is highly unlikely that any commercial enterprise would be able to collect all of this available fruit in the right state of ripeness, during the short period of time that the fruit is available, the figures are so many multiples of the indicated commercially interesting amount, that the question of logistics, price and fruit quality become much more important issues than the resource availability.

7. Review 6: Lushetile, K (2010) – *Inventory report of marula trees in Namibia* (Draft). National Forestry Research Centre (NFRC), Ministry of Agriculture, Water and Forestry

Of the most recent marula survey conducted by the National Forestry Research Centre only a draft version of the report is available, expected to be finalised by March 2011.

The study was conducted in the Caprivi, Kavango, Kunene, Otjozondjupa, Omusati, Oshana, Ohangwena and Oshikoto Regions, as these are the Regions in Namibia where marula more commonly is found due to rainfall patterns and the occurrence of woodland vegetation types. Belt transects of 1km by 200m were used to collect the data. The transects were selected by stratified sampling of habitats to ensure that the major tree clumps in the different regions were covered. Within the transect the Diameter at Breast Height (DBH), tree height, stem status, and crown size of female trees were recorded for all mature trees. Immature marula trees were counted but not measured.

The results describe variable patterns of spatial distribution of marula in the different regions;

[5] It has been indicated that 300T of fruits would constitute a commercially attractive resource base.

- *North-central Regions:* Marula is fairly equally covered in these regions, but less common in the Southern parts of Omusati and Oshana regions because of more saline soils. More dense populations were observed in the Northern and extreme Southern parts of the Oshikoto Region. Trees were observed mainly around the homesteads and in crop fields and fallows, showing they are highly associated with human settlement in these Regions. These domesticated trees are well protected.

- *Otjozondjupa and Kunene Regions:* Marula in these regions is dominant on mountain slopes and peaks where dense clusters can be observed. Apart from the mountainous areas, marula is not really found in these regions except for clusters of large trees that are found growing on the sandy soils around Tsumkwe in the Otjozondjupa Region. Fruits in these regions are not used for human consumption.

- *Kavango and Caprivi Regions:* The distribution of marula in these regions are highly associated with riveline vegetation, growing mostly along rivers and on flood plains. No trees were recorded in the Kalahari sands which covers large areas of both regions. In the Kavango region the most dense population of marula was found around the Roman Catholic Missions, where they were planted by the missionaries in the 1950's. In the Caprivi Region the species are thought to be disturbed by elephants. Marula is not or only to a limited extent used as a food source in the Kavango and Caprivi Regions.

The transects produced the following results for stem density:

Region	Sample area (ha)	Sampled trees	Trees per ha	Standard error
Oshana	40	41	1.0	0.7
Omusati	80	73	0.9	10.2
Oshikoto	60	63	1.1	2.5
Ohangwena	120	155	1.3	7.9
Caprivi	67	89	1.3	1.2
Kavango	65	46	0.7	12.9
Otjozondjupa[6]	8	577	72.1	30.5

Since unlike in the North-central Regions, marula does not commonly occur in the Caprivi, Kavango, Kunene, and Otjozondjupa Regions, transects were only done in the vegetation units were marula was found or is abundant. This gives very misleading results when the transect data are

[6] Result for plot data rather than transect data

extrapolated to the whole regions. Especially for the Otjozondjupa region, the vegetation unit where marula occurs covers only 23% of the region. In addition, the region is very large[7] compared to the NCRs. If one multiplies the total area of the region with the trees counted per hectare in the very densely populated plots, one comes to close to 760'000'000 marula trees in the Otjozondjupa region. The researchers are currently working on getting more representative results from the transect data, which will be presented in the final report.

Observed sex ratios were different for the various regions as shown in the following table:

Region	Female:male ratio
Omusati	6:1
Oshikoto	4:1
Oshana	3:1
Ohangwena	3:1
Caprivi	1:1
Kavango	1:1

Although these do not show the exact same results as in previous studies, they are not dissimilar, showing a distinct preference for female trees in the North-central regions, and a relatively equal distribution of male and female trees in areas where marula is not commonly used.

Analysis of tree characteristics results show different results for the different regions as well. It was found that in regions which receive higher amounts of rainfall, like Caprivi and Kavango, trees are generally taller with smaller crowns, while in other regions where the annual rainfall tends to be less, trees tend to have larger crowns but are relatively shorter. The correlation between crown size and tree height was therefore found to be weak overall, with a correlation coefficient of 0.38. The strongest correlation (R=0.62) was found between crown size and Diameter at Breast Height (DBH), while DBH and tree height showed a correlation coefficient of 0.51. The mean DBH overall was 72 cm, the mean crown diameter 15 m, and the average height 12.4 m. From the correlation between tree characteristics a prediction model for crown diameter was attempted based on DBH.

8. Other sources of information

[7] The Otjozondjupa region covers an area of 10'533'400 ha as compared to 868'200 ha for Oshana region.

There are a few more generic sources of literature available describing or visualising aspects of the marula resource in Namibia. Other literature may provide useful sources of background information on the use of marula, and land use in North-central Namibia. This section provides a list of literature that was referenced in the reports reviewed above:

- Botelle, A, P. du Plessis, K. Pate, R Laamanen (2002) – *A survey of marula fruit yields in North-central Namibia*. CRIAA SA-DC for DFID/FRP Winners and Losers in Forest Product Commercialisation (ZF0140/R7795

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9. Conclusion

As the review shows, a substantial amount of information is available on the distribution and characteristics of the marula resource in Namibia. Moreover, the main information gaps are currently being addressed by the "marula resource survey" project, funded through the National Forest Programme Facility (NFPF), of which this literature review forms part. These include:

- An additional fruit yield survey to be conducted by the Department of Forestry in different regions. Apart from generating needed additional data on fruit yields per tree, the survey will be conducted over a period of 5 years, which will give an insight in the annual yield variations.

- Mapping of all existing data that is GIS referenced. The mapping and database will form an open source interactive tool that can be updated and used for future research and reference. With sufficient data available, the tool can also be used to develop predictive models

- A review of existing data and literature which is presented here

The NFPF project will furthermore work on the development of training material for grafting, which will be an important technique to further expand and improve the marula resource base in Namibia.