Baobab Resource Mapping, Monitoring and Management in Binga, Hwange, Mudzi, Rushinga, Bikita, and Chipinge Districts of Zimbabwe

USAID RESILIENCE ANCHORS ACTIVITY

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List of Acronyms

AGRITEX	Agricultural, Technical and Extension Services/ Agricultural Advisory Services within the Ministry of Lands, Agriculture, Fisheries, Water and Rural Resettlement
ANCHORS	Accelerating New Community-based Holistic Outcomes for Resource Sustainability
COVID-19	Coronavirus disease 2019, an infectious respiratory disease caused by the SARS-CoV-2 virus
DBH	Diameter of a tree measured at breast height
EMA	Environmental Management Agency
FC	Forestry Commission
FGDs	Focus group discussion(s)
GIS	Geographic information system
GPS	Global positioning system
KIIs	Key informant interview(s)
NTFPs	Non-timber forest product(s)
RDC	Rural District Council
SCD	Size-class distribution
SEL	Southeast Lowveld
USFS	United States Forest Service

Executive Summary

USAID Zimbabwe Resilience ANCHORS focuses on improving and strengthening the resilience capacities of communities in Zimbabwe, such as in the Southeast Lowveld by supporting community income-generating initiatives that sustainably utilize natural resources. One of the most significant opportunities around natural resources derives from the commercial potential of non-timber forest products. The Southeast Lowveld (SEL) is an especially productive area for these products and is already the center of the country's growing baobab fruit industry. Zimbabwe has one of the highest population densities of baobab trees in Southern Africa, and the area is currently one of the major exporters of baobab fruit products in Africa. Baobabs in the country, however, are potentially under threat from several factors including increasingly erratic and unpredictable rainfall levels, felling, elephant damage especially in protected areas, outbreaks of mold disease, and commercial bark harvesting.

Overall Purpose and Scope
The scope of this exercise aimed to establish an accurate assessment of the baobab resources nationwide. The assessment focused on six districts with high concentrations of baobab in Zimbabwe: Bikita and Chipinge in the SEL, Hwange and Binga in the northwest, and Mudzi and Rushinga in the northeast.

The assessment had five main objectives:

(1) Undertake a detailed resource assessment looking at distribution, density, and dynamics of baobab populations in the six selected districts;
(2) Identify concentrations of baobab trees under threat as a priority for conservation action;
(3) Develop protection and restoration measures aimed at mitigating and preventing any urgent threats to baobabs within the areas;
(4) Design a long-term monitoring program to monitor the health and stability of the baobab resource, enabling the adoption of rapid corrective measures in the event of negative impacts on the baobab population; and
(5) Explore opportunities for income-generating activities for communities based on the conservation and sustainable use of the baobab tree species.

Methodology
For each district, we completed socioeconomic data collection and transect plots, with high densities of baobabs where local people were known to use baobab resources. Six transects per district in rangelands, fields, and at homesteads were executed at random within the selected wards. We recorded vegetation type, soil, and geology for each plot, with a total of 1,022 trees measured, including recording a geographic coordinate and photograph of each tree. We also measured baobabs for girth and height, with fruits and flowers on each tree counted and an evaluation completed covering the extent of elephant damage, bark harvesting, and mold growth on the trunk and branches. The trees that had evidence of elephant damage or bark harvesting were counted and the age (looking at color and texture of the scars), extent and depth of the damage was quantified on each side of the tree (south, west, north, and east). Mold growth was assessed by quantifying the extent of the growth on the entire surface of the trunk and branches separately. Recognizing moisture stress in plants is complex. During our surveys, we took note of leafing, excessive branch die-back, and tree mortality. In each district, we selected 30 trees (40 in Hwange) for future monitoring. These trees are located near roads for easy access.

Socioeconomic Surveys
We interviewed a total of 445 community members. The full report of the KIIs and FGDs is attached as Annex 2.

Key Findings

The assessment had a range of key findings:

- Overall, the baobab population in the districts studied are in a healthy, stable state as reflected by a reasonable ratio of juveniles to adult trees.

- There is a noticeable lack of recruitment in rangelands, which is not surprising given the threats of livestock browsing.

- In those communities where baobab trees are valued, there are clear signs that young trees are nurtured and protected in fields and around homesteads.

- Although there are a few examples of baobab trees being actively planted by community members, the main anthropogenic impact on baobab recruitment comes from the active protection of seedlings that have naturally emerged (usually from seeds discarded by humans after eating).

- In some communities, baobab seedlings are destroyed by people when found growing too close to homesteads and when uprooted to consume the edible tuberous roots.

- In areas where they occur, baobab is ranked as the most important wild fruit by community members. Although many people use baobab in many traditional ways, only a small percentage of community members are currently engaged in commercial fruit harvesting.

- While there is no evidence to suggest that commercialization of baobab has negative effects on the baobab population, there are anecdotal stories of baobab branches being deliberately broken by people while harvesting fruit.

- There is evidence to suggest that baobab commercialization has a positive impact on the baobab population, but this is not adequately documented and requires further study.

- There were no signs found of fresh elephant damage to baobabs in communal areas (consistent with the relatively low elephant numbers in the study areas). However, elephant damage (often very severe) was observed in some neighboring wildlife areas.

- Although bark harvesting takes place within some areas, there is no evidence to suggest that it poses any threat to the baobab population.

- In most of the study areas, nearly 90% of baobab trees have black mold infestation. The degree of infestation is mostly light, but there are notably higher levels in some areas, such as along the main highway in Hwange. It is speculated that this may be a result of pollution, either from road traffic or from industrial emissions.

- No evidence was found to suggest that baobabs in Zimbabwe are under threat from changing climatic conditions.

This last finding is particularly interesting in light of the recent publicity from a Romanian research team working in Southern Africa (Patrut et al, 2018). Their study, which looked at a number of very old and very sizeable baobab trees in the region, reported on the death of a few of the trees being studied and speculated that the cause may have been changing climatic conditions. Given how hardy and resilient baobab trees are, this seems unlikely and, indeed, none of the 1,022 trees examined during this study showed any evidence of moisture stress.

Suggested Protection and Restoration Measures
Given the assessment, we have listed a series of recommended actions.

- Develop a national baobab conservation and monitoring program, through which all further baobab monitoring, conservation, management, and commercialization activities could be implemented.

- Enrichment planting of baobab seedlings, especially in rangelands. Enrichment planting models with centralized nurseries supplying seedlings and the use of financial incentives to support their growth over several years are strongly endorsed.

- Baobab awareness and education aimed at growing knowledge around the potential values and uses of baobab trees and reinforcing positive behaviors.

- Active local promotion of baobab commercialization, investing in new product development and consumer awareness raising campaigns.

- Study to assess link between baobab commercialization and community actions leading to improved protection and conservation of baobab trees.

- Support for efforts to mitigate elephant damage in areas of high elephant populations. Thus far, experiments have found that wrapping trees in wire mesh is the most effective method of protecting baobabs from elephants.

- Expanding baobab monitoring and conservation efforts through voluntourism, bringing in revenue and volunteer labor, and helping to elevate the profile of baobabs amongst the Zimbabwean communities hosting these voluntourists.

- Pollinator research to assess the link between fruiting and the health of pollinator populations.

- Development and enforcement of laws and regulations around harvesting and sale of baobab fruit and bark in districts.

Long-term Baobab Monitoring Program
We recommend a continuous, long-term baobab resource monitoring program to underpin all baobab conservation and management activities. This assessment has established a number of permanent monitoring plots. It is also recommended that additional monitoring plots be established in areas where specific threats are found or where additional information is required, such as monitoring for elephant damage in national parks, bark harvesting in the Chimanimani area, and mold growth in areas of high pollution. We recommend trees to be monitored every five years, which will be enough to capture changes in girth and height, mold growth, elephant damage, and bark usage. It is important that the measurements are done using the same methods as for the baseline to ensure comparability. These methods are described in detail in the monitoring manual (Annex 3). Given the importance of the fruit to long-term commercialization, monitoring yields should be undertaken annually, with a particular focus (where possible) on links to the health of pollinator populations.

Opportunities for income generation
There are a multitude of commercial opportunities arising from the baobab tree. The main marketable products from the fruit are the powder, the seed oil, and handicrafts and home décor products made from the pods. Non-fruit products from baobab include handicrafts, including the famous "Chipinge rugs" made from the bark, edible leaves, seedlings, carbon sequestration offsetting, and ecotourism offerings.

During the study, each district was assessed against a group of criteria for its suitability for one or more of these enterprise opportunities: fruit production/tree density, current levels of commercial production, transport infrastructure (road network within district and distance to processing plants), proximity to tourism infrastructure, and use of pesticides (commercial agriculture, malaria). A detailed account of this is included in Annex 4.

Each of the selected districts has potential to further develop income opportunities around baobab. There is no doubt that the durability and resilience of baobab in the face of changing climatic conditions will make it an increasingly important component of community livelihood strategies. Much of the work to develop these income opportunities will take place on the ground. There are also several higher-level activities needed to support efforts at the grassroots level. These include the need to develop and adhere to minimum quality standards around baobab products, to continuously innovate with the development of new baobab products for the market, to support research that substantiates the health and other benefits of baobab, to raise consumer awareness around baobab products, and to cultivate closer linkages with the tourism sector.

Outline for a Proposed Second Phase of Activities
A detailed set of activities are proposed and included in Section 8 of this report.

1. Purpose, Objectives, and Scope of the Study

1.1 Overall

USAID Zimbabwe Resilience ANCHORS focuses on improving and strengthening the resilience capacities of communities in Zimbabwe, such as in the Southeast Lowveld by supporting community income-generating initiatives that sustainably utilize natural resources. One of the most significant opportunities around natural resources derives from the commercial potential of non-timber forest products (NTFPs). The Southeast Lowveld (SEL) is an especially productive area for these products, already as the center of the country's burgeoning baobab fruit industry. Baobabs could be an important source of income to local communities through the sale of their fruit to supply the growing global demand for nutrient-dense superfoods.

Zimbabwe has one of the highest population densities of baobab in Southern Africa, and is currently one of the major exporters of baobab fruit products in Africa. Baobabs in Zimbabwe, however, are potentially under threat from several factors including increasingly erratic and unpredictable rainfall levels, felling when natural woodland is converted to arable agriculture, large-scale open cast mining, elephant damage especially in protected areas, outbreaks of sooty mold disease (common but extent and impact on individual trees needs to be assessed), and commercial bark harvesting.

The scope of this exercise aimed to establish an accurate assessment of the baobab resources nationwide. The assessment focused on six districts with high concentrations of baobab in Zimbabwe: Bikita and Chipinge in the SEL, Hwange and Binga in the northwest, and Mudzi and Rushinga in the northeast.

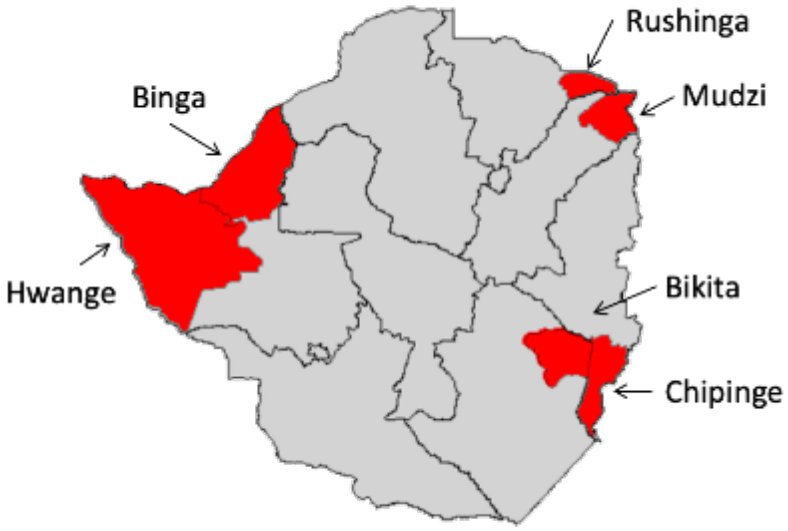

Figure 1: Districts selected for the baobab resource assessment

The assessment had five main objectives:

(1) Undertake a detailed resource assessment looking at distribution, density, and dynamics of baobab populations in the six selected districts;
(2) Identify concentrations of baobab trees under threat as a priority for conservation action;
(3) Develop protection and restoration measures aimed at mitigating and preventing any urgent threats to baobabs within the areas;

(4) Design a long-term monitoring program to monitor the health and stability of the baobab resource, enabling the adoption of rapid corrective measures in the event of negative impacts on the baobab population; and
(5) Explore opportunities for income-generating activities for communities based on the conservation and sustainable use of the baobab tree species.

1.2 Population Structure

Baobab populations across Africa typically exhibit bell-shaped distributions with a general lack of recruitment. This has been ascribed to wildfires, livestock browsing, and clearing of land. As baobabs are long-lived, reaching up to 2,000 years in age, they have the ability to sustain population levels with low or episodic recruitment. In recent times, however, the impact of human populations on the environment is increasing, and episodic recruitment events may have become fewer. Thus, the lack of recruitment may be more serious than it was in the past. Population information gathered in this survey will give a snapshot of baobab populations structures in Zimbabwe revealing past and current recruitment.

1.3 Elephant Damage

Elephants are known to feed on baobab bark and wood. Fortunately, baobabs are resistant to debarking as they have a natural and unique ability to regrow bark. Repeated and frequent debarking without a recovery period, however, makes trees vulnerable to dehydration and death. Where elephant numbers are high, such as in national parks, the impact on baobabs can be severe, with trees not only being debarked but often even gouged out to an extent that trees collapse and die. Baobabs recruit very slowly, and trees can take decades to reach adulthood, thus high losses of adult baobab trees are detrimental to maintaining stable populations. Assessing the threat of elephants to baobab populations is an important part of establishing the health of the population.

1.4 Bark Harvesting

Baobab bark has been used for generations by local people across Africa for making rope and to weave household items such as mats and baskets. Baobabs easily tolerate bark harvesting as they are able to regrow their bark. Young baobabs are often the most harvested as their fibers are more pliable and stronger than older baobabs. If the bark is allowed to recover for a few years, as is the custom in most places around Africa, trees are not harmed. In the 1980s and 1990s, however, a tourist demand for baobab fiber products developed. Demand was so high that bark was being harvested continuously from the same trees. This practice resulted in local populations of baobab trees, especially in southeastern Zimbabwe, being under threat.

1.5 Mold Growth

Baobab trees are often found covered with varying degrees of black mold. Although this black mold is often referred to as sooty mold, it is not a true sooty mold as the fungi associated with black mold do not penetrate below the infected tissue and do not cause a host reaction, as with sooty molds. A study (Cruywagen, *et al.* 2015) identified four fungi species referred to as black mold. Although black mold is often associated with declining trees, its occurrence is more likely to be as a consequence of the trees being stressed and unable to resist the growth of the fungi, rather than the actual cause of decline. The growth of black mold on baobab trees may be an indication of other problems such as pollution or tree stress.

1.6 Moisture Stress and Climate Change

In 2018, a paper published in *Nature Plants* suggested that baobab trees may be dying of the effects of climate change. The authors of the paper reported that five trees had died and another

nine trees had collapsed and this raised the alarm about the future of baobab populations in Southern Africa. What the authors did not describe were the health conditions of the trees prior to their deaths or collapse. They neither investigated symptoms of death nor the environment that each tree was living in. In fact, subsequently it was found that two of the trees had died due to overwatering and one of the trees had produced new sprouts in the following growing season. Despite this, climate change is still of great concern, and it was decided that during this survey, the team would examine signs of moisture stress to check if climate change is having an impact on baobab trees in Zimbabwe.

2. Methodology

2.1 Selection of Sample Sites

For each district, we collected socioeconomic data collection and conducted transect plots in wards with high densities of baobabs and where local people were known to use baobab resources (see Annex 5 for wards surveyed). Homesteads were sampled as the team came across them along the edges or within fields that were being surveyed. The data collected represents the wards and not necessarily the districts as a whole. We focused on communal forests and cultivated zones within these wards, factoring in considerations such as accessibility and roads.

The remote sensing aspect ended up not being utilized in the ward selection and mapping. This is because a baobab report from 2014, which had used remote sensing, and which was going to be used as a base for this study, had used verified trees from areas different from the areas in this assessment. This meant that when overlaid with the districts in this study, the results were doubtful. This was verified in Hwange where the 2014 baobab distribution map suggested a high density in certain areas. Local knowledge, however, differed and suggested very different areas.

It was hoped that satellite imagery could be used to determine the density and distribution of baobabs across entire districts and countrywide. Due to limitations of the tree recognition software devised during the 2014 mapping, however, there is need for incredibly high-quality satellite images of large areas, coding, and verified locations of many baobab trees. The software needs to be coded to review satellite images and identify which tree is a baobab tree. To do this it needs satellite images on which baobab trees are identifiable, as well as a code to determine what to identify as a baobab. The code needs to be trained by multiple examples of satellite images with confirmed baobab trees.

The US Forest Service (USFS) used GPS baobab location points from the survey to generate a Maxent species distribution model based on 80% of the points, and then tested that model with the other 20% of baobab field data points. This was based on planet satellite imagery, which has medium resolution of 30m. Yet the resolution of that satellite imagery is not fine enough to distinguish individual trees. USFS plan to repeat the analysis with high-resolution Maxar data, once obtained through a partnership with the Polar Geospatial Center at the University of Minnesota.

A team of nine different ecologists and social scientists spent six weeks in the field collecting data. See Annex 5 for list of team members. Roughly one week was spent in each district intermittently between January 11 and March 19, 2022. On each field trip, three data collecting exercises were conducted. First, we conducted transects through fields, rangelands, and homesteads to collect baobab population data and tree health information. Second, we established monitoring plots and collected baseline data for future monitoring work. Third, the social scientists collected socioeconomic data and cultural and traditional knowledge via interviews with key informants and communities who use baobab resources.

2.2 Transect Plots

The team conducted random transects in rangelands, fields, and at homesteads within the selected wards. Within each of the three land-use types, we conducted six transects per district. Rangelands had six-kilometer-long transects and fields had two-kilometer transects. Transects were straight lines walked in a set direction determined by a compass bearing. All baobabs falling within 25 meters left and right of the line were measured.

Figure 2: A transect in a rangeland

Rangeland and field transects were divided into one-kilometer lengths to make up a series of 0.5-hectare plots. We recorded vegetation type, soil, and geology for each plot (see Annex 1 for information collected). In Zimbabwe, homesteads are scattered across the landscape between and among fields rather than clustered into villages. Every homestead that fell within or close to a field transect was measured for its area, and any baobab trees found within the homestead area were measured. If a homestead did not have any baobabs, then only the size of the homestead was recorded to contribute to calculation of baobab density within homesteads.

We measured baobabs for girth and height, counting fruits and flowers on each tree. We also evaluated the extent of elephant damage, bark harvesting, and mold growth on the trunk and branches. Finally, we took a geographic coordinate and photograph of each tree.

Figure 3: Collecting data during transects: recording GPS coordinates, measuring girth, counting fruits and assessing extent of mold growth

We initially recorded data using paper field sheets (Binga and Hwange districts), but for the remaining four districts (Bikita, Chipinge, Mudzi, and Rushinga), the team moved to using tablets for recording data via KoBoToolbox software, which we downloaded onto tablets. The tablets also recorded coordinates and take photos. As a backup, however, the team also used hand-held Garmin GPS devices to record tree positions and a digital camera to take photographs. During the survey, the team measured a total of 1,022 trees and surveyed 172 hectares in the six districts.

2.2.1 Population Structure

The health of a population can be determined by looking at the population structure. This is done by 1) calculating the density of trees; 2) assessing the ratio of juvenile to mature trees; and 3) constructing size-class distribution (SCD) graphs. The density of trees (stems/ha) in a population allows one to compare populations between different landscapes and over time. The ratio of juvenile trees to mature trees indicates the ability of the population to recruit. Lastly, SCDs give an easy visual history of population dynamics, making it easier to establish if the population is growing or declining. Abundance of smaller size-classes is illustrated by an inverse J shaped SCD and is usually interpreted as a healthy and growing population. An absence of juveniles gives a bell-shaped SCD indicating a declining population or, in the case of baobabs, a stable population with a recruitment problem. Transects, made up of a series of 0.5-hectare plots, were surveyed in rangelands and fields. Homesteads were surveyed individually with an estimation of the size of the homestead recorded in order to determine total hectarage. The team also recorded the number of trees per plot and homestead and size (girth and height) of each tree. The data was used to calculate the density of trees per land-use type, to determine the number of juvenile versus adult trees, and to construct SCD charts. Generally, baobabs only start producing fruit above a diameter of 100 cm (DBH). Thus, trees under this size were categorized as juveniles and the rest as adults.

2.2.2 Elephant Damage

Elephant impact was assessed by enumerating the number of damaged trees, specifying age of the damage, extent and type of damage found on each side of the tree (south, west, north, and east). The proportion of trees in a transect that had fresh or recent elephant damage helped establish whether elephants were a current threat to the population or not. Wounds were divided in four age stages: 1) yellow and fibrous, which indicated fresh damage of less than one-year-old; 2) grey and fibrous, which was two or three-year-old damage, 3) uneven and smooth, over which a thin coat of bark had developed, but had not yet got waxy, which indicated a wound of about four to ten-years-old; and 4) smooth and waxy scars which would indicate a wound that is older than ten years, otherwise called ancient bark damage. In this report, elephant damage is described as fresh, recent, and old. Fresh elephant damage would be up to three years old (a combination of categories 1 and 2); recent elephant damage which would be four to ten years old (category 3) and old elephant damage, older than 10 years (category 4).

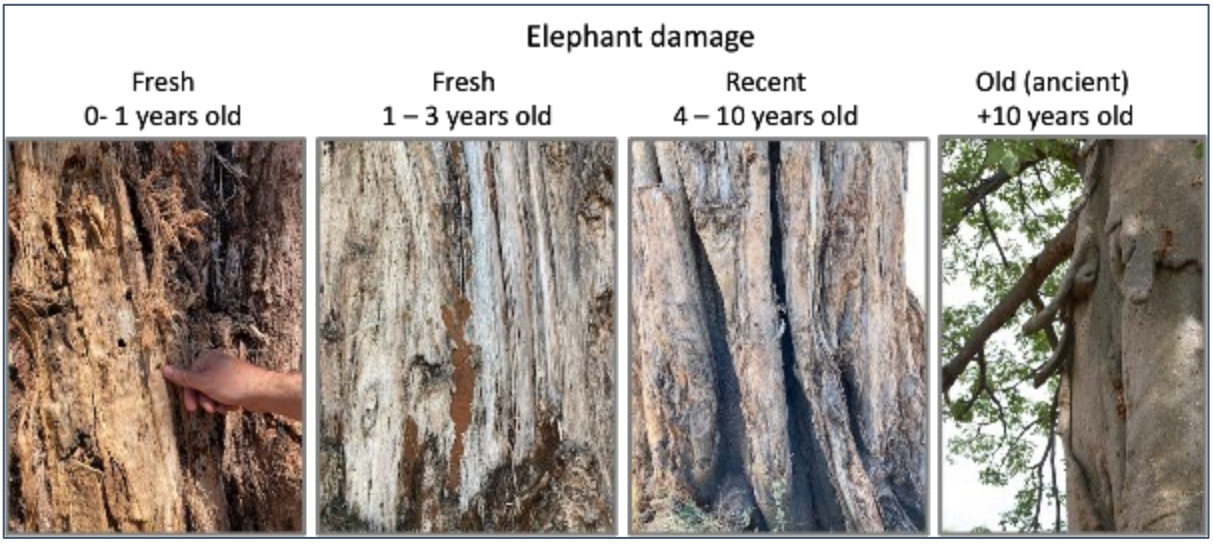

Figure 4: Illustrations of elephant damage age categories

It was also important to quantify the severity of the damage, and this was done by looking at the type or depth and the extent of the damage. Type (or depth) of damage was divided into two categories, damage to the bark only and damage to the wood also. The extent of damage caused

by elephants was assessed by looking at each side of the tree, up to a height of 3 meters, chosen as most elephant damage occurs up to this height. In cases where both bark and wood were damaged, age and extent of the damage were assessed for both tree parts. The data collected was summarized for each district and formed the basis to evaluate elephant threat.

2.2.3 Bark Harvesting

Trees in the transects were assessed for evidence of bark harvesting using similar methods to those used to assess elephant damage. The trees that had evidence of bark harvesting were counted and the age, extent, and depth of bark harvesting was quantified. Similar to the method used to assess the age of elephant damage, the color and texture of the harvesting scars helped estimate their age.

Figure 5: Illustrations of bark harvesting age categories

The proportion of trees in a transect that had fresh or recent versus older bark harvesting scars indicated if the practice is growing or dwindling in the area and how important it was to the local economy or household use. This was further verified in focus group discussions conducted by the social scientists. The extent and depth of bark harvesting was used to determine if the population might be under threat of unsustainable use. Scars were divided into two categories, shallow harvesting (<5 centimeters depth) and deep harvesting (>5 centimeters depth). Deep harvesting is an indication of repeated harvesting from the same place. The extent of each of these categories (age and type) of harvest was assessed to a height of 2 meters on each side of the tree, chosen because people generally harvest bark up to this height.

2.2.4 Mold Growth

Mold growth was assessed by quantifying the extent of the growth on the entire surface of the trunk and branches separately. This was done by standing on each side of the tree, looking at the trunk and branches, and estimating the percentage surface area of the trunk and branches that was covered by mold. The percentage coverage of each side was then combined and an average coverage of the whole trunk and all branches was calculated. Data was summarized by number of trees infected and the extent of mold found on infected trees as light (1-24%), moderate (25-49%), heavy (50-74%), and very heavy (75-100%).

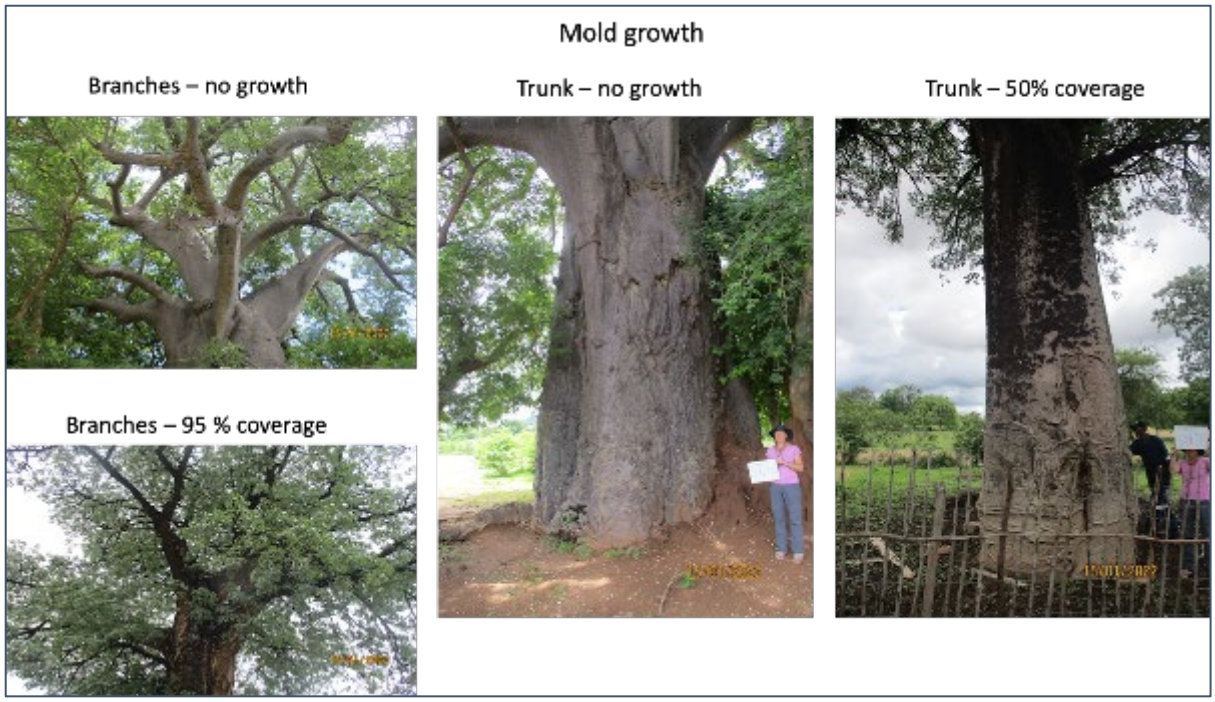

Figure 6: Illustrations of extent of mold growth on trunk and branches

2.2.5 Moisture Stress

Recognizing moisture stress in plants is complex and cannot easily be assessed. During our surveys, however, we took note of leafing, excessive branch die-back, and tree mortality.

2.3 Monitoring Plots

In each district, we selected 30 trees (40 in Hwange) for future monitoring. These trees are located near roads for ease of accessibility. Baobabs were measured for girth and height, fruit and flowers were counted, and an evaluation was done of the extent of elephant damage, bark harvesting, and mold growth following methods used for the transect trees. The team took photos of the whole tree and of the trunk and branches from all four sides of the tree. They also recorded coordinates of each tree and a brief description of the location of the tree.

2.3.1 Future monitoring

The frequency of repeated measurements will depend on the type and level of threat. For example, if there is an increase in elephant populations in an area or if a market for baobab bark products develops or increases, one might want to measure trees every year. If no concerns are raised, it is recommended that the trees are monitored every five years, which will be enough to capture changes in girth and height, mold growth, elephant damage, and bark usage. It is important that the measurements are done using the same methods as for the baseline to ensure comparability. These methods are described in detail in the monitoring manual (Annex 3).

2.4 Data Curation

Field sheets were captured in Excel and data downloaded from KoBoToolbox to Excel and combined into a single Excel workbook. All final raw transect data, monitoring trees data, tree co-ordinates, and photographs have been uploaded to a Google Drive folder. Future data collected should be added to the same database and folders.

2.5 Socioeconomic Surveys

During the pre-field desktop review, the team interviewed key informants to help identify most appropriate areas for transect walks and community interviews and find out about any past work related to baobab. Each district in Zimbabwe is governed by a local Rural District Council with officials who are responsible for natural resource management. Other entities that play a role in natural resource management are the Forestry Commission (FC), Environmental Management Agency (EMA), the Agricultural Advisory Services (AGRITEX) and local chiefs, village heads, and headmen. For each district, ward, and village where data was gathered, contact was made with the above officials and ward councilors. (See Annex 2B for a list of officials interviewed during the field work.) A minimum of four key informants per day were interviewed and relevant policies, rules, and laws that govern management, access, and use of baobab trees by the communities discussed. The interviews also assisted in understanding health of the baobab resource as well as identify potential threats to the resource, current use, and harvesting and any opportunities for income generating activities.

The focus group discussions (FGDs) helped to understand farmers' activities at different times of the year, including their current income-generating activities, the occurrence, distribution, and fruiting of baobab, community's access, traditional knowledge, and current uses of the species. Use value and income value of baobab was compared with other wild fruits and other sources of income respectively. The discussions also informed the team on threats faced by baobab trees in each area. Potential spots for ecotourism were also noted during the discussions. The FGDs expected to interview ten participants at each center, with seven centers per district. The groups comprised of mostly females older than 35 (preferably with responsibilities within their community, such as lead farmers) as they are the ones usually involved in NTFP work. The team also included younger women and a few males who could be village heads and headmen, herbalists, or any traditional leaders familiar with the baobab resource. The seven FGDs carried out in each district assisted the team to identify any behavioral/socioeconomic differences within a district.

The team interviewed a total of 445 community members, comprised of 73% females, 27% males, and 17% youths between the ages of 18 and 35. The average attendance in the districts was fair. Copies of KII and FGD questionnaires are attached as annexes (2B).

Figure 7: Team of sociologists conducting FGDs

3. Limitations of the Mapping Study and Challenges

The study was limited by poor baobab distribution data available. As mentioned above, the density distribution maps produced in a 2014 study were too inaccurate to be used for selection of sites and assumptions made then could also not be used to extrapolate data across districts and the country as a whole. It was hoped that baobab recognition software and the use of satellite imagery would supplement the distribution maps, but this too proved complex to implement. Another limiting factor was access to some sites, in Hwange district due to flooded rivers and in Rushinga district due to landmines. These limitations however did not detract from the overall objective of assessing the health of baobab populations in the selected districts.

4. Key findings – Identification of Threatened Baobabs

4.1 Population Structure

The density and SCD and the percentage of juvenile and adult trees was assessed in three land-use types namely rangelands, fields, and homesteads. It was found that the density of trees in all wards monitored was high, ranging from 2.24 stems/ha in Hwange wards to 10.67 stems/ha in Mudzi wards.

It is very important to note that baobab density data in this report <u>does not</u> represent the density of baobabs for the whole of each district. Wards where baobabs were known to occur and where communities had a high use of baobab were selected for this study. Wards where there were no baobabs were not included.

Table 1: Summary of population structure findings in the 6 districts surveyed

	Bikita	**Binga**	**Chipinge**	**Hwange**	**Rushinga**	**Mudzi**
Density in rangelands	3.67 stems/ha	5.77 stems/ha	7.92 stems/ha	4.5 stems/ha	6.9 stems/ha	15.2 stems/ha
Density in fields	3.5 stems/ha	8.77 stems/ha	1.5 stems/ha	12.57 stems/ha	4.8 stems/ha	8.3 stems/ha
Density in homesteads	No trees in homesteads	0.23 stems/ha	1.63 stems/ha	0.25 stems/ha	1.65 stems/ha	1.46 stems/ha

SCD	Bell-shape More small trees in fields.	Bell shape in rangelands	Bell shape in rangelands. No juveniles at homesteads at all.	Poor recruitment in fields and homesteads	Fields and homesteads show no recruitment at all	Recruitment in fields and homesteads is good, but poor in rangelands. Homesteads do not have large trees.
Conclusion	Good recruitment of small trees in fields where protected by farmers	Rangelands will benefit from enrichment planting.	Locals should be encouraged to protect young trees.	Community recognizes commercial value of baobab: nurture and protect young trees	Locals should be encouraged to protect baobab seedlings, esp. when clearing out fields	Very high density of baobabs, excellent area for commercial fruit harvesting

The SCD data showed that baobabs in rangelands generally had a bell-shaped distribution with a lack of young trees, indicating poor recruitment. SCD curves in fields and homesteads varied, with some districts having excellent recruitment and others none at all (see Annex 1). This is influenced by the local attitude towards baobab and the importance of baobab trees/products/uses to communities. In Hwange, for instance, baobab is highly regarded and thus seedlings are protected, whereas, in other areas, baobabs are not wanted in fields and homesteads so are cleared out. The ratio of juveniles to adult trees was reasonable everywhere showing that the tree population in all districts was healthy and not in decline.

4.2 Fruit Production

Table 2: Fruits found on trees in the 3 land-use types

	Bikita	**Binga**	**Chipinge**	**Hwange**	**Rushinga**	**Mudzi**
Rangeland						
Avg # fruit/tree	61	53	38	8	11	17
Avg # fruit/ha	170	477	697	143	607	3,698
Fields						
Avg # fruit/tree	52	31	13	26	12	9
Avg # fruit/ha	165	617	120	267	386	1,932
Homesteads						
Avg # fruit/tree	No trees	3	6	4	1	1
Avg # fruit/ha	No trees	8	168	2	152	287

The quantity of baobab fruit varies from year to year and from area to area. The above table shows the differences in fruit production between districts and land-use types that were sampled. The total productivity of a landscape is a combination of both the density of trees and the productivity of the population. Fruit production in the Mudzi rangelands and fields is exceptionally high and thus an excellent area for commercial fruit harvesting. Changes from year to year will be monitored as part of the suggested long-term monitoring program and can maybe be linked to rainfall patterns over the next few decades.

4.3 Elephant damage

It was found that in all districts, elephant damage was not a threat to the baobab populations. In all districts, historic elephant damage was recorded, but recent and fresh elephant damage was rarely seen (See Annex 1). This is because in communal land, where the resource mapping took place, elephant numbers are low.

Table 3: Summary of elephant damage findings

	Bikita	**Binga**	**Chipinge**	**Hwange**	**Rushinga**	**Mudzi**
% damaged trees	34% old	1% fresh; 5% recent. Old damage not evaluated.	16% old	No fresh/ recent damage. Old damage not evaluated.	28% old	3% recent and 15% old
Conclusion	Elephants are not currently posing a threat	No immediate threat from elephants	Elephants not a threat	Elephants not a threat	No immediate threat from elephants	Low % (recent) elephant damage indicates low current numbers of elephants

Bark harvesting

Table 4: Summary of bark harvesting findings

	Bikita	**Binga**	**Chipinge**	**Hwange**	**Rushinga**	**Mudzi**
Tree type affected trees	10% juvenile; 11% adult	54% juvenile; 52% adult	29% juvenile; 41% adult	30% juvenile; 21% adult	50% juvenile; 12% adult	24% juvenile; 10% adult
Dominant Scar type	shallow and deep	shallow	shallow	shallow	Small % deep	deep at homesteads
Dominant Scar age	4-10 years	ranges from fresh to old	ranges from fresh to old, but mostly 4-10 years	ranges from fresh to old, but mostly 2-3 years old	ranges from fresh to old, but mostly 4-10 years	ranges from fresh to old, but mostly 2-3 years old
Conclusion	No longer prevalent and not a threat	Currently no threat as harvesting occurs in small numbers	No longer prevalent and not a threat	Occurring at a slow rate; no threat	No longer prevalent and not a threat	Monitoring to check incidence and degree

Our results showed that bark harvesting is ongoing in all areas of Zimbabwe, but that the levels are very low. Trees are able to recover and the practice is of little concern to the health of the population. In all areas, it appears that bark harvesting is getting less frequent. The percentage of trees with fresh or recent bark harvesting was much less than trees found with old bark harvesting scars. In most areas, fresh bark harvesting was found on less than 5% of trees. In all cases, the harvesting was shallow thus allowing the tree to recover easily. The low use of bark may be because ropes can be easily bought in shops and that there are fewer tourists in Zimbabwe. Socioeconomic results indicated that bark is mostly used for household purposes.

Figure 8: Baobab bark stripping to make the famous 'Chipinge rugs'

4.4 Mold growth

Mold growth on baobab trees was found in all areas of Zimbabwe with very high numbers of trees found to be infected. In most districts, more than 90% of trees were infected with both adult and juvenile trees having mold. Yet the degree of infection on over 95% of infected trees was light or moderate and very few trees (less than 5%) had heavy or very heavy infestations. The only area of concern is the along A8 Highway (Bulawayo-Victoria Falls) in Hwange District where it appears that pollution from heavy traffic and possibly coal mining has aggravated the disease. In general, however, there is little suggestion that baobabs are under threat of mold disease in Zimbabwe.

Table 5: Summary of the extent of mold growth on baobabs in the surveyed districts

	Bikita	**Binga**	**Chipinge**	**Hwange**	**Rushinga**	**Mudzi**
Juveniles	60%	43%	59%	13%	17%	52%
Adults	100%	97%	94%	63%	86%	79%
Light Mold	87% branches; 93% trunk	91% branches; 95% trunk	79% branches; 83% trunk	83% branches; 83% trunk	79% branches; 85% trunk	74% branches; 81% trunk
Moderate Mold	14% branches; 5% trunk	8% branches; 4% trunk	18% branches; 16% trunk	8% branches; 10% trunk	19% branches; 12% trunk	22% branches; 15% trunk
Heavy mold	0% branches; 2% trunk	1% branches; 1% trunk	4% branches; 1% trunk	8% branches; 3% trunk	3% branches; 4% trunk	3% branches; 3% trunk
Very heavy mold	0% branches and trunk	0% branches and trunk	0% branches and trunk	3% branches and trunk	0% branches and trunk	3% branches and trunk
Conclusion	No threat (No signs of distress)	No threat (No signs of distress)	No threat (No signs of distress)	Lowest number in all districts. Trees close to roadside need observation.	No threat (No signs of distress)	No threat (No signs of distress)

During our surveys we did not come across any other diseases or pests that were of concern.

4.5 Moisture Stress and Climate Change

During our surveys, we did not find unseasonal leaf-fall, and we did not come across any trees that were losing excessive numbers of branches. No dead and collapsed trees were found on any of the transects. Thus, at a superficial glance, there is no indication that trees in Zimbabwe are currently suffering from moisture stress. This last finding is particularly interesting in light of the recent publicity from a Romanian research team working in Southern Africa (Patrut et al, 2018[1]). Their study, which looked at a number of very old and very sizeable baobab trees in the region, reported on the death of a few of the trees being studied and speculated that the cause may have been changing climatic conditions. Given how hardy and resilient baobab trees are, this seems unlikely and indeed none of the 1,022 trees examined during this study showed any signs of moisture stress.

4.6 Socioeconomic and Cultural Information

4.6.1 Key Informant Interview General Findings

Information obtained from institutional key informants revealed that a few studies on NTFPs have been conducted in the past in the target areas. These studies were not species specific. In March 2021, Zimbabwe's Forestry Commission (FC) carried out a study to quantify carbon stock (no. of trees/ha) in and around the Savé Valley Conservancy. The FC have not done any surveys on baobab specifically but are aware of a survey which was done in 2014[2]. EMA pointed out that they do not carry out species inventories but coordinate biodiversity conservation. This outlined in their 'State of the Environment' and 'State of Forests' reports.

Key informants referred to various laws that exist in governing the harvesting and trade of NTFPs. Regulations that apply to all districts are outlined in the Forest Act, the EMA Act, and the RDC Act (Annex 2B). Laws and regulations known to communities are those governed by traditional leaders. Fruit trees should not be cut. If someone cuts down a baobab tree, they pay a fine to the headman or chief. Trees in fields do not necessarily belong to the field owner but the owner has a say over the tree therefore people ask for permission to harvest.

4.6.2 Focus Group Discussion General Findings

Population structure and Propagation

In all six districts, community members pointed out that baobab trees were present. Yet the density of saplings, juveniles, adults, and old trees varied from place to place. A few individuals in Binga and Hwange plant baobab trees. They transplant seedlings from areas where people disperse seeds, mostly homestead rubbish pits. In other districts, people just throw seeds near homesteads and in fields after consumption. The saplings are then uprooted and their roots consumed, often by children. Baobab is not commonly planted at homesteads. As the trees grow, their roots may damage buildings and it takes time for the tree to fruit.

Baobab uses, use value and income value

Uses of baobab are similar across Zimbabwe. Baobab fruit is most commonly eaten directly from the pod. This is done by cracking the shell, removing the pulp (powder and seed), and sucking the dry powder off the seeds. The pulp can also be made into a porridge. To do this, the pulp is soaked in water and when the powder has dissolved, the seed is discarded, and the "water" is added to mealie meal porridge to make a sour-tasting porridge. This mixture can also be thickened into a sour-tasting pap (*sadza*), which is eaten without relish. This type of porridge and *sadza* has different names in the different districts. Another use of the powder is to make ice lollies which

[1] Patrut A. et al 2018. *The Demise of the Largest and Oldest African Baobabs.* Nature Plants 2018.

[2] Douie. C and Whitaker. J., 2014. Resource Survey of Baobab (Adansonia spp.) in Resettled and Communal lands of Zimbabwe: Towards the assessment of sustainable harvesting of fruit pulp and seeds. Bio-Innovation Zimbabwe

are sweetened with sugar and colored with instant drink-powders like Jolie Juice. Ice lollies are generally made by people who own fridges, such as schoolteachers, nurses, and shop owners. A further use of the powder is to make it into a drink by soaking the pulp in water until the powder has dissolved. If the pulp is soaked in milk, the mixture is eaten as baobab-flavored "yogurt."

Although not common, young baobab leaves are eaten in many of the districts. The leaves are cooked like a spinach. They form a mucilaginous stew, similar to okra. The leaf "stew" is served as a relish with *sadza*. Baobab leaves are also mixed with other wild vegetables and eaten as a relish. The leaves are harvested when they are tender which is normally as the rains start between October and December.

Baobab seeds have several uses. They can be ground into a powder and added to vegetables. They can also be roasted and ground and brewed into a "coffee". In times of drought, baobab seeds are boiled and consumed like bambara nuts. Baobab fruit shells are burned to ash and the ash is used as an alternative to bicarbonate of soda in cooking. Bark is harvested in many districts to varying degrees. Participants in the FGDs mentioned making mats, hats, baskets, and ropes for construction. Young baobabs have a succulent tuber which is edible. Children and sometimes adults eat them as a crunchy snack.

Baobab was ranked first compared to other wild fruits in all areas visited (see the rankings per district in Annex 2B) because it has many applications. Baobab is a main source of food especially during drought; it is consumed directly as a snack and incorporated in meals. It has a long shelf life; fruits can be stored and consumed all year round. The fruiting season is also longer compared to other fruits, harvesting commences in March till August in most areas. It is usually abundant compared to other fruits.

Currently baobab is sold by a small percentage of community members. The amount of income made from baobab, as compared to other NTFPs and other income-generating activities, varied significantly between districts (see Annex 2B for detailed information). Fruit is sold either as whole fruit or as powder and seed. Most sales are informal, often involving bartering, with very few formal sales to companies like B'Ayoba. Bark products are sold, but not many people are involved in selling bark products so this does not generate much income.

On the other hand, commercialization can lead to overharvesting and increased competition between humans and animals. This could cause human-wildlife conflict (HWC) as wild animals will eat more field crops. Tree damage and accidents may occur. Currently, in Chipinge and Rushinga, people climb baobab trees to harvest fruits. Men in Rushinga even break branches to harvest fruits. If commercialized on a larger scale, community members might end up selling all the baobab fruit they harvest and not keep much for consumption.

4.7 Resource Assessment Conclusions

The resource assessment was undertaken in six districts of Zimbabwe. This equates to almost a fifth of the significant baobab-hosting districts (32) in the country, which are districts containing 10,000 or more baobab trees in communal areas.

The assessment's main findings included the following.

- Overall, the baobab population in the districts studied are in a healthy, stable state as reflected by a reasonable ratio of juveniles to adult trees.

- There is a conspicuous lack of recruitment in rangelands, which is not surprising given the threats of livestock browsing. It would appear that young seedlings are eaten by livestock before they have time to reach maturity.

- In those communities where baobab trees are valued, there are clear signs that young trees are nurtured and protected in fields and around homesteads. This results in positive recruitment, leading ultimately to a growing baobab population. In other communities where baobabs are not held as much in high regard, there is less evidence of seedling protection and recruitment.

- Although there are a few examples of baobab trees being actively planted by community members, the main anthropogenic impact on baobab recruitment comes through the active protection of seedlings that have naturally emerged (usually from seeds discarded by humans after eating).

- In some communities, baobab seedlings are destroyed by people when found growing too close to homesteads and when uprooted to consume the edible tuberous roots.

- In areas where they occur, baobab is ranked as the most important wild fruit by community members. Although many people use baobab in one or more traditional ways, only a small percentage of community members are currently engaged in commercial fruit harvesting.

- While there is no evidence to suggest that commercialization of baobab has negative effects on the baobab population, there are anecdotal stories of baobab branches being deliberately broken by people while harvesting fruit.

- There is evidence to suggest that baobab commercialization has a positive impact on the baobab population, but this is not adequately documented and correlated and requires further study.

- There were no signs found of fresh elephant damage to baobabs in communal areas (consistent with the relatively low elephant numbers in the study areas). Yet elephant damage (often very severe) was observed in some neighboring wildlife areas.

- Although bark harvesting takes place within some areas, there is no evidence to suggest that it poses any threat to the baobab population.

- In most of the study areas, nearly 90% of baobab trees have some infestation of black mold. The degree of infestation is mostly light, but there are notably higher levels in some areas (e.g., along the main highway in Hwange). It is speculated that this may be a result of pollution, either from road traffic or from industrial emissions.

- No evidence was found to suggest that baobabs in Zimbabwe are under threat from changing climatic conditions.

5. Baobab Protection and Restoration Measures

5.1 Develop a National Baobab Conservation and Monitoring Program

Given the importance of baobabs as a keystone species in the ecosystem and their role in supporting rural livelihoods, it is strongly recommended that a national program be established to support their conservation and sustainable use. This would create the institutional framework through which all further baobab monitoring, conservation, management, and commercialization activities could be implemented. A suggested name for this would be "the Sustainable Baobab Initiative of Zimbabwe."

5.2 Enrichment planting of baobab seedlings

Although the overall baobab population appears healthy in the districts studied, the lack of recruitment in rangelands (which constitutes the majority of land in communal areas) is a concern. It is therefore recommended that enrichment planting activities be promoted in all study areas and in other baobab-hosting districts across the country. The models of enrichment planting pioneered by the Baobab Guardians project in Limpopo, South Africa, and by the My Trees Trust in Zimbabwe, are strongly endorsed, with centralized nurseries supplying seedlings out to individual homesteads and the use of financial incentives to support their growth over many years.

5.3 Baobab awareness and education

Concurrent with the enrichment planting activities, a campaign of baobab awareness and education should be undertaken in the targeted communities aimed at growing knowledge around the potential values and uses of baobab trees and reinforcing positive behaviors that result in baobab conservation and protection.

5.4 Actively Promote Baobab Commercialization

Given the apparent link between baobab commercialization and baobab protection and conservation, a program to support the development of new and varied income generating opportunities around baobab should be implemented. Elements of this could include investing in the development of new baobab products and processing technologies, promoting consumer awareness to stimulate demand for baobab products, support to harvesters and SMEs further up the value chain, and policy-level actions aimed at creating a more favorable policy environment for baobab.

5.5 Study to assess link between baobab commercialization and the health of the baobab population

At the same time, a long-term study should be conducted to assess the causal links between baobab commercialization and community actions leading to improved protection and conservation of baobab trees. This work is urgently needed to conclusively demonstrate attribution. The study should comprise of two elements. One would be a straightforward comparison between the baobab populations in communities where commercial use is and is not made of baobabs. The other would be a longitudinal study looking at a community where new commercialization activities are being actively promoted, comparing the before and after situations to see if this has resulted in changes in the health of the baobab population.

5.6 Support for efforts to mitigate elephant damage

Although elephant damage was not an issue in the study areas, it is nevertheless clearly a threat to baobabs in areas of high elephant population. It is therefore recommended that additional monitoring plots are established in areas where elephants are known to be a threat, such as in national parks. Here the extent and severity of elephant damage needs to be recorded and mitigation measures implemented. Typical mitigation measures used have been planting chilis around trees, hanging bags of chili in branches, placing beehives in or close to baobabs, packing rocks and logs around the tree trunks and even spraying baobabs with an infusion of fermented elephant dung. Thus far experiments in Gonarezhou National Park in Zimbabwe and Mapungubwe National Park in South Africa have found that wrapping trees in wire mesh is the most effective method of protecting baobabs from elephants.

Figure 9: Ways to protect baobab trees from elephants

5.7 Augmenting baobab conservation efforts through voluntourism

Given their iconic nature, baobabs are highly appealing to international tourists. This appeal could be harnessed through the development of "voluntourism" initiatives around baobab monitoring and conservation. Not only would this bring in revenue and volunteer labor towards the implementation of conservation activities, it would also help elevate the profile of baobabs amongst the Zimbabwean communities hosting these voluntourists.

5.8 Pollinator research to assess the link between fruiting and the health of pollinator populations

This assessment was a single snapshot look at the baobab resource. The most critical determinant of successful baobab fruiting is the health of the pollinator populations. Baobabs are pollinated by bats and moths. As both bats and moths are facing sometimes severe exogenous threats to their populations, this is a major concern for the long-term future of the baobab populations. This could not be assessed at all in a single snapshot study. A long-term research program to monitor pollinator dynamics and the links to fruit yields in baobab trees is therefore a priority.

5.9 Implementing a Long-term Baobab Monitoring Program

A long-term baobab monitoring program, building on the work undertaken during this assessment, is a priority and is described in more detail in the next section. Particular attention should be given to the following aspects.

a) Bark harvesting: Monitoring plots should be established in some of the areas of high bark use (e.g., Nyanyadzi in Chimanimani district) to ensure there is no threat to the trees in these areas.
b) Mold growth: The incidence and degree of disease should continue to be monitored using the long-term monitoring plots established in each district. Additional monitoring plots should be established in areas of high pollution.
c) Moisture stress and climate change: If adult trees in the monitoring plots die or suffer from excessive branch loss it will be important to investigate the causes to establish potential links with climate change.
d) Annual fruit yields: Given the importance of the fruit to long term commercialization, monitoring of annual yields should be undertaken with a particular focus (where possible) on links to the health of pollinator populations.

5.10 Development and enforcement of laws and regulations around harvesting and sale of baobab fruit and bark in districts

In all districts, regulation on the harvesting and sale of baobab/wild fruit is non-existent. There is need to encourage communities to create committees that involve district stakeholders (RDC, FC, and EMA), traditional leadership (chiefs, village heads, and headmen) and resource monitors to come up with laws around the harvest of baobab fruit and bark. These laws should pay special attention to harvest quota and who can harvest.

6. Long-term Baobab Monitoring Program

Underpinning all baobab conservation and management activities should be a continuous, long-term baobab resource monitoring program. The most effective way to monitor the health of any population is to undertake regular collection of information from the same trees over time. This allows for early detection of any threats and ensures that appropriate mitigatory measures can be implemented as and when needed.

This assessment has established a number of permanent monitoring plots, in which the growth of trees can be assessed by regular girth and height measurements and then plotted over time. These measurements can be supplemented by photographs, which will allow for further visual assessments, such as comparing crown shape. It is recommended that additional monitoring plots be established in areas where specific threats are found or where additional information is required, such as monitoring for elephant damage in national parks, bark harvesting in the Chimanimani area, and mold growth in areas of high pollution.

Monitoring exercises are also an excellent opportunity to keep an eye on additional pests or threats to baobabs not currently seen. For example, bark beetles, which have not yet been seen in Zimbabwe, are a problem in East Africa where they cause branch loss and death of young trees.

Frequency of monitoring will depend on what information is collected and how often trees can be measured. Annual fruit monitoring is recommended for all plots and at the same time data on bark harvesting, elephant damage and mold could be collected and added to the database. Annual monitoring is also recommended for plots where immediate threats are found such as in National Parks where elephant damage is a problem. However, where there are no immediate threats, five-year intervals between monitoring events are enough to track trends.

Monitoring should be supported by existing natural resources monitoring teams in communities where these already exist. In Chipinge, Mudzi, and Rushinga, teams already monitor their natural resources. In Mudzi and Chipinge, monitors are selected by their communities. Their role is to lead their communities in environmental protection and utilization initiatives and they report to the RDC. In Rushinga, monitors are selected by ward councilors who chair these committees. Teams also report to the RDC.

7. Opportunities for Income Generation

There are a multitude of commercial opportunities arising from the baobab tree. Tangible products that are derived from baobab include the following.

Fruit: The baobab fruit consists of a woody outer shell, containing dozens of seeds, each one coated in a dry, off-white, powdery fruit pulp. The powder is rich in Vitamin C and a range of key minerals (calcium, potassium, magnesium, and iron) and is consumed as a traditional food and a health food ingredient. The seeds contain an oil that is traditionally used for moisturizing and is marketed as a skincare ingredient. After the oil has been expressed, the remaining seed cake can be used as a stockfeed. Linking the powder and seeds is a fibrous material that has medicinal

benefits and is used as the basis for an herbal tea. The pods are used in handicraft making, as a base for candles or lamp shades. The pods are combustible and have been used as a source of fuel and/or charcoal. They also compost to make a manure for use in horticulture.

There are also several main marketable products from the fruit.

Powder: The nutritional profile of the powder is comparable with other superfoods, and there are many potential applications for superfoods in the food and beverage industries. The biggest single category of use at present is simply as a raw superfood powder. Consumers mix the powder in with other dishes, combine it with fruit to make a smoothie, or add water to it to make a drink. It is also being bought by food and beverage manufacturers as an ingredient in a wide range of products including smoothies, fruit juices, cereals, granola bars, yogurts, snacks, confectionary, and baked goods. New categories for future product development include sports nutrition, diabetic-friendly, vegan, non-dairy, paleo, and probiotic food and beverages. Baobab powder also has certain functional attributes, serving as a thickener, an acidifier, a natural preservative, a yeast substitute, and a flavor enhancing agent. All of these suggest potential industrial applications in the food industry, and this is becoming the focus of more intense research. The market for these products has been primarily export, but there is growing local demand and increasing opportunities on the domestic market.

Oil: The seed oil is already marketed as a cold-pressed oil for use in the cosmetics industry. Its particular attributes include a high degree of moisturizing action (preventing Trans Epidermal Water Loss) as well as providing an array of important nutrients for the skin, including high levels of Omega 6 and 9 fatty acids and naturally antioxidant phytosterols. The oil is either bought in its pure form by consumers for topical application or is used by cosmetic manufacturers as an ingredient in skin and hair care formulations. There is substantial scope for further product development in the cosmetic and personal care sectors, and this is expected to be a major growth area in the coming years. The historical market for baobab oil has been outside Zimbabwe, but there are more and more opportunities to market the product locally.

Pods: Whole baobab fruit pods are processed into handicrafts and home décor products. The pods are fashioned into the final product either by hand or using lathes and other woodworking tools. Then they are fitted with external adornments, polished, varnished, and painted. Good quality baobab pod light fittings already have an export market in Europe. Local consumers have never seen them in Zimbabwe, but it is fair to assume they will sell well locally too.

Other non-fruit products from baobab include the following.

Bark: The fibrous bark of the baobab is traditionally used as a source of rope and to make various decorative handicrafts, including the famous "Chipinge rugs" found in southeastern Zimbabwe. The bark is carefully cut in panels and then stripped and removed from the tree. It is then manipulated until it becomes malleable and easily workable, and woven into a variety of products that are sold mostly for the home décor market.

Leaves: The edible leaves are widely consumed in Africa as a green vegetable. They are highly nutritious, being especially rich in Vitamin A, and make a tasty addition to many meals. The best method for producing them involves cultivating baobab seedlings and then regularly harvesting their leaves as with a tea bush. Some communities in Zimbabwe already consume the leaves, but there is certainly much bigger opportunity both for local and export production.

Tree seedlings: Given the iconic nature of the baobab tree, there is a market for both seeds and seedlings to collectors, gardeners and landscape designers. Seedlings can be raised *in situ* and then transported to urban centers for sale. There is also a market for seedlings as part of biodiversity offset reforestation schemes. These could be sold to corporate buyers or to individuals looking to contribute to rewilding or reforestation initiatives.

Intangible products from baobab include the following.

Carbon sequestration: Like any tree, baobabs sequester carbon and have potential value in carbon offset programs. At present, this has barely been explored and the carbon values of a baobab tree are largely unknown. Yet there is no doubt that these could be developed in future and communities could sell the carbon values of a baobab landscape as a source of regular income under a REDD+ scheme.

Tourism: Baobab trees are iconic and there are multiple ways in which they can be integrated into tourism offerings to the benefit of communities who are the custodians of the trees. The most obvious is for tourists to visit baobab trees, perhaps as part of a hiking trail through communal areas. A more nuanced approach would be to engage tourists as "voluntourists" in a range of baobab protection and conservation schemes, or potentially as contributors to various baobab value addition schemes. During the study, each district was assessed against a group of criteria for its suitability for one or more of these enterprise opportunities: fruit production/tree density, current levels of commercial production, transport infrastructure (road network within district and distance to processing plants), proximity to tourism infrastructure, and use of pesticides (commercial agriculture, malaria). A detailed account of this is included in Annex 4.

A summary of recommended enterprise opportunities by district is presented in the table below.

Table 6: Income opportunities from baobab per district

	Pow-der local	Pow-der export	Oil local	Oil export	Seed cake	Pod crafts	Pod com-post	Bark fiber	Leaves	Tree seed-lings	Carbon sequestr ation	Tourism
Bikita	X	X	X	X	X		X		X		X	X
Binga	X		X		X		X		X			X
Chipinge	X	X	X	X	X		X	X	X		X	X
Hwange	X	X	X	X	X	X	X		X	X	X	X
Mudzi	X	X	X	X	X	X	X		X	X	X	
Rushinga	X	X	X	X	X		X		X	X	X	

Notes

1. Binga is excluded from powder and oil export because of its poor road infrastructure
2. Pod handicrafts are suggested for two districts close to markets, Hwange (for Vic Falls, Hwange National Park and Bulawayo) and Mudzi (for Harare)
3. Bark fiber is only recommended for Chipinge, where it is already practiced.
4. Tree seedlings are only recommended for districts in close proximity to main markets
5. Binga is excluded from carbon sequestration because it is already part of an existing REDD+ project and no further opportunities exist
6. Tourism is only recommended for districts with existing tourism infrastructure

Each of the selected districts has potential to further develop income opportunities around baobab. In all cases, there are several different potential revenue streams from baobab, and there is no doubt that the durability and resilience of baobab in the face of changing climatic conditions will make it an increasingly important component of community livelihood strategies. Much of the work to develop these income opportunities will take place on the ground. However, there are also several higher-level activities that are needed to support efforts at the grassroots level. These include the need to develop and adhere to minimum quality standards around baobab products, to continuously innovate with the development of new baobab products for the market, to support research that substantiates the health and other benefits of baobab, to raise consumer awareness around baobab products, and to cultivate closer linkages with the tourism sector.

8. Outline for a proposed second phase of activities

Building on the groundwork established by this project, a second phase of activities are proposed as follows.

Output 1: Develop a national baobab conservation and monitoring program, through which all further baobab monitoring, conservation, management, and commercialization activities could be implemented. The proposed name for this would be the Sustainable Baobab Initiative of Zimbabwe. All other outputs within this second phase of activities would fall under the framework of the Sustainable Baobab Initiative.

Output 2: Implement a baobab monitoring and research project exploring key activities:

- Regular data collection from the trees identified and established for long term monitoring under this study;

- Identification of protected areas where baobab trees may appear to be under particular threat from elephant damage and establishment of long-term monitoring plots in these areas;
- Identification and establishment of long-term monitoring plots in areas of high bark harvesting;
- Expanded resource assessment in districts beyond those included in this study (e.g., Kariba, Hurungwe, Mbire, Centenary, Mt Darwin, Chimanimani, Chiredzi, Mwenezi, Beitbridge); and
- Identification and establishment of long-term monitoring plots in these new districts.

Commissioning of a variety of ecological studies to assess baobab health and resilience focusing a range of key topics:

- Pollinator research to assess the link between fruiting and the health of pollinator populations;
- Detailed research on the potential threats to baobabs (if any) from climate change; and
- Linkages between pollution and higher incidences of mold on baobabs.

Output 3: Establish a Baobab Guardians (or similarly-titled)[3] project in Zimbabwe. This would involve training up cadres of Baobab Guardians in selected communities who would launch a number of initiatives:

- Develop and manage nurseries of baobab seedlings;
- Support enrichment planting activities by individual households. Seedlings would be provided and financial incentives offered to plant and protect emerging baobab seedlings over multiple years;
- Undertake selected baobab awareness and education activities aimed at growing knowledge around the potential values and uses of baobab trees and reinforcing positive behaviors;
- Protect young and emergent wild baobab seedlings in rangeland areas from livestock predation; and
- Act as field-based research assistants for the baobab monitoring and research project.

Output 4: Undertake a systematic program of baobab commercialization in identified districts. Activities would include a range of focal areas:

- Identifying suitable enterprise opportunities and configurations for each of the selected communities;
- Facilitating linkages to potential commercial partners from outside these communities;
- Commissioning research and development trials to develop new products that could be potentially produced by supported enterprises;
- Supporting a range of enterprise development and capacity-building activities, including on production, processing, marketing, branding, and packaging;
- Facilitating inward investment into these communities to establish processing infrastructure required; and
- Undertaking consumer awareness-raising programs to elevate consumer interest in baobab products.

Output 5: Develop a long-term research program to establish causal links between baobab commercialization and baobab conservation:

- Developing research framework to compare conservation status of baobabs in areas with and without commercialization;
- Developing research framework for longitudinal studies comparing conservation status of baobabs before and after commercialization; an

[3] Note that "Baobab Guardians" is a proprietary term used by the Baobab Foundation in South Africa, whose permission would be required to use this term in Zimbabwe.

- Implementing research projects with appropriate research partners.

Output 6: Develop a program of baobab tourism in selected districts. Such tourism activities could involve several outputs:

- Implementing a voluntourism initiative, bringing in paying volunteers from overseas to work alongside the Baobab Guardians on baobab monitoring and conservation activities;
- Identifying and mapping out potential tourism routes that visit iconic baobabs in selected communities;
- Compiling and preparing guide materials relating to the baobab trees on selected routes for use by tourism operators;
- Facilitating inward investment by tourism operators to operationalize new baobab tourism routes.