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Developing a Strategy for Sustainable Income Generation From a Valuable Medicinal Plant, *Prunus africana* in Kilimanjaro region

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Abstract

Prunus africana is a commercially valuable tree species for medicinal properties of its bark, which receives a huge demand from pharmaceutical industries. However, the tree, which is endemic to mountainous areas of Africa, is endangered. Research suggests that developing strategies that enables smallholder farmers to incorporate the species into their agroforestry systems is the best way to rescue the tree from extinction while generating substantial income to the poor farmers through sustainable trading systems. There is an opportunity for farmers in highland areas of Rombo and Mwanga districts, Kilimanjaro to benefit from farming of *P. africana* as an alternative source of income. This is because the species has been found growing naturally and tended by farmers in their farms although these farmers are unaware of the commercial potentials of the tree as well as the need to conserve it. Also farmers in this region need economic diversification after experiencing serious decline in income generation due to failure/instability of coffee market. Although farmers in this area do not export the bark of the species to pharmaceutical industries, the tree is widely used for timber, fodder, shade and boundary demarcation. This report gives an overview of the status of the species in terms of uses, abundance, distribution, size and damage. It gives a strategy to domesticate and trade *P. africana* as among best alternatives for sustainable income generation to farmers in Kilimanjaro. Recommendations for further studies are also given.

Acknowldedgements

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1.0 Introduction

1.1 Background information

The human populations of developing countries worldwide continue to rely heavily on the use of traditional medicines as their primary source of healthcare. Ethnobotanical studies carried out throughout Africa confirm that native plants are the main constituent of traditional African medicines (Cunningham, 1993) and they treat different diseases of human being as well as serving as contraceptives and arbortifacients (Anedrson and Staugard, 1986). With 70-80% of Africa's population relying on traditional medicines, the importance of the role of medicinal plants in the healthcare, biotechnology and crop improvements system is enormous (Cunningham, 1993; UNEP, 2002; Mander and Breton, 2006). It is also estimated that 25% of all the prescribed medicines contain some ingredient(s) derived from plants (Mander and Breton, 2006). Medicinal plants are now being given serious attention, as is evidenced by the recommendation given by the World Health Organization (WHO) (Wondergem *et al*., 1989) that proven traditional remedies should be incorporated within national drug policies, by moves towards a greater professionalism within African medicine (Last and Chavunduka, 1986) and also by the increased commercialization of pharmaceutical production using medicinal plants with known efficacy (Sofawara, 1981).

Little attention however, has been paid to the socio-economic and conservation aspects of medicinal plant resources (Cunningham, 1993).There is a global concern that if exploitation of traditional medicine is not properly regulated, it can lead to over-harvesting of wild species, the erosion of genetic diversity and the degradation or loss of ecosystem (Diederichs *et al*., 2006). As pressure is increasing on diminishing medicinal plant supplies, constructive resource management and conservation actions must be identified, based upon a clear understanding of the surrounding medicinal plant use (UNEP, 2002). If their collection and use is not regulated, some species may become threatened with extinction. For harvesting of medicinal plants to be sustainable, market demand must be balanced with the availability of the species in the wild and recovery rates after harvesting. Medicinal and aromatic plants are an excellent entry point for making the case of how biodiversity conservation is directly linked to improvement of livelihoods. Through scientific research we can get ample knowledge on methods to germinate, propagate and cultivate valuable medicinal plants, therefore providing an alternative to their collection from the wild. Such knowledge can be transferred to local communities, who use those plants themselves, as well as depend on them economically due to their market value (IUCN, 2005).

Trade on medicinal plants has shown to generate significant income although it remains understated such that the potential is scantly known to policy makers and development planners.Trade of medicinal plants in southern Africa is mostly informal and the volumes of plant material traded in this market are not easily quantified, but consumer surveys from South Africa suggest that between 35,000 and 70,000 tonnes of plant materials are consumed per year, with a market value of US $75-150 million (Mander and Breton, 2006). On the other hand, medicinal plant trade is worth more than £200 (293 Euros) million per year in the UK, while sales of *Prunus africana* bark to European pharmaceutical industries generates up to USD 220 millions per year (Mander and

Breton, 2006). Barks from one *P. africana* tree can earn a farmer USD 10 – 20 compared to USD 3 – 5 per tree earned through cutting down and selling a normal agroforestry timber species. Domestication of *P. africana* therefore presents an enormous potential for income generation and conservation of the species as well as agroforestry systems.

1.2 Research problems and justification

The decline in world market of coffee price has affected coffee growers. Farmers in Rombo and Mwanga districts are good examples of such growers. Their levels of income have shrunk and are yet to find out an alternative and sustainable means of income generation. They embarked on selling of agroforestry species to timber dealers and vegetables grown on uprooted coffee farms but the activity is unsustainable due to lack of appropriate harvesting and silvicultural methods and also due to poor timber tree stock existing in the area. The price of vegetables is not stable and storage is difficult especially during the harvesting peak.

In a recent interview farmers admitted that they are facing a threat of deforestation in their agroforestry systems and that they are in urgent demand of innovation on livelihood diversification. Income generation through conservation of a highly valuable medicinal tree species, *P. africana*, seems to be among sound innovations that can give the people of these districts an income generation alternative while contributing to rescuing of the species. Though *P. africana* is a valuable medicinal plant that can act as a useful alternative income generating activity to people in Rombo and Mwanga, it is an endangered tree species calling for immediate and sound actions to rescue it from extinction. However, although planting of *P. africana* for its conservation at the same time as a sound alternative for income generation to the desperate farmers is a good justification for poverty reduction through conservation of biodiversity, there is a research problem of which its solution is a pre-requisite. Scientific knowledge on distribution, variation, traditional knowledge, means of utilisation and population status of *P. africana* is lacking. For planting campaigns to be successful and sustainable this gap of knowledge needs to be filled, and this is the justification of conducting this project.

1.3 Study objectives

1.3.1 Overall objecive

Developing a strategy for sustainable income generation from *Prunus african* in Rombo and Mwanga districts.

1.3.2 Specific objectives

- To assess local knowledge on management, uses and harvesting techniques in place for *P. africana*
- To assess economic activities and income levels
- To educate the local communities on the potential contribution of *P. africana* to people's livelihood and encourage them to include the tree in their agroforestry system
- To assess the ecology of *P. africana*, both the wild and the domesticated populations

1.4 Main research questions

i) Currently, how do local people use, manage and harvest *P. africana*?

ii) What is the status and potential of international market for *P. africana* bark?
iii) What are the main economic activities and levels of income of the local people?
iv) What is the potential of *P. africana* as a commercial agroforestry tree species?
v) Where are the areas with superior planting stock of *P. africana*?
vi) Which is the best way for domestication of *P. africana* as a commercial agroforestry species?

1.5 Relevance of the research

•Increase in employment and knowledge opportunities for local people in the forest sector
•An established approach of using forest resources for rural economic development in a way that does not jeopardise its continued availability in future.
•Practicing the worldwide acknowlegment of biodiversity being among the three pillars of sustainable development through use of biodiversity to achieve sustainable development, i.e. Income generation through conservation activities
•Introduction of an alternative source of income generation activity to rural people who are in economic crisis hence increased income generation from the sale of barks of *P. africana* in future

1.6 Policy and implications

The major output of this research is the scientific finding which will be used as an effective tool to advice policy makers and development practitioners on how to use biodiversity as one of the major pilars of sustainable development. Today conservation and poverty reduction initiative are mainstreamed in almost all the new policies in Tanzania. It is therefore high time for the scientific community to come up with appropriate scientific advice on how best the policies can be put into practice. This project is a ideal in such contribution.

2.0 Literature review

FAO Panel of Experts on Forest Gene Resources lists *P. africana* as one of 18 top priority species for action in Africa (FAO, 1997). In Africa, as in other developing parts of the world, the market for medicinal plants lies mostly with the traditional cultures where traditional medicines remain as an important health care sources (Mander *et al*., 2006). There is also an important, but difficult to quantify, export market for crude medicinal plant products. Relatively small local, regional and export markets exist for semi-processed and processed plant based products. Generally very little plant processing occurs in Africa except by large commercial drug manufacturing companies in Europe and America. There is a big demand for *P. africana* by pharmaceutical industries, which use its bark extracts to manufacture cancer drugs (Stewart, 2003; Pomatto, 2001). Europe imports about 25% (132,000 tonnes) of all the medicinal plants, (including *P. africana*) traded internationally, and one fifth of this volume comes from Africa (Mander *et al*., 2006). This demand has led to overexploitation of the species in the wild pushing its population to very low densities and threatening it to extinction. Many scientists have suggested planting of such species by local farmers as well as imposing suitable harvesting and trade regulations as among the best ways to rescue them from dangers of extinction (Dawson *et al*., 2000).

Conservation can be improved through providing opportunities for small-scale farmers to cultivate useful forest products outside of protected areas (Ndibi and Kay, 1997; Laird and Lisinge, 1998; Dawson, 2000). As natural forests contract due to agricultural expansion, the management of farmland also for the conservation of biodiversity becomes increasingly important, especially where farmers can improve their income generation through such activities (Dawson, 2000). Until now planting campaigns for this species has been initiated in few countries. For example in 1993, Kenya established about 153ha of *P. africana* (Marshall & Jenkins, 1994) and in 1998, 628ha were established (Simons, 1998). Such initiatives together with in situ conservation programs need to take place in as many countries as possible to ensure conservation of its various populations and maintenance of a broad genetic base for the species (Cunningham and Mbemkum, 1993; Stewart, 2003). Domestication and conservation programs are likely to be successful in Tanzania where farmers have been tending the species, which establishes itself naturally in their traditional farms in Kilimanjaro (Dino, pers comm 2006).

It is also worth noting that due to the wide but disjunct distribution of *P. africana* in highland forest 'islands' across Africa (Kalkman,1965), genetic variation can be expected to vary within both small and big ranges of locations. Analysis by Dawson and Powell (1999) using molecular markers (random amplified polymorphic DNA and RAPD) indicated this to indeed be the case at the gene level. Analyzing 10 populations sampled from Cameroon, Ethiopia, Kenya, Madagascar and Uganda, Dawson and Powell (1999) revealed most genetic variation among countries (66%, $P < 0.001$), indicating the importance of regional approaches for conservation. They also revealed variation among individuals within populations, and among populations within Cameroon and Madagascar, to be highly significant, indicating the importance of developing genetic management strategies that also take account of genetic variation at a country level. Despite the geographic distance between Uganda and Cameroon; Ugandan samples were

more similar to West African populations than that from Kenya and Ethiopia. The importance of carrying out such studies remain vital in identifying, describing and documenting areas with superior or plus trees for collection of planting materials.

3.0 Methodology

3.1 Location

This work was done in two districts: Rombo and Mwanga, Kilimanjaro region due to availability of the species and long history of dealing with the species. Specifically villages which traditionaly grow or have natural stands of *P. africana* were considered. Two villages namely Kibaoni and Ubetu in Rombo district and Vuchama and Ngujini in Mwanga district were selected. Progressive farmers were trained to further-up the training to other farmers in establishment, tending, harvesting and marketing of the species. Ecological studies and nursery activities were done in collaboration with District forest officers of Rombo and Mwanga. Information on the distribution, status and market were sought from pharmaceutical industries in Dar-es-Salaam, NGOs, Forest and Beekeeping Division, Muhimbili Traditional Medicine Institute and NEMC.

3.2 Design and data collection

3.2.1 Socio-economic data

At least 5% of the households from two villages where *P. africana* is growing naturally and/or planted were selected from each district. Random numbers were used to select the 5% of households from the village registers. Stratification was applied in order to draw farmers from across the villages. Rapid Ethnobotanical Appraisal (REA) (Martin, 2004), Participatory Rural Appraisal and questionnaires were used to collect information on local knowledge, management, uses, and means of harvesting and the ecology of tree resources with specific focus on *P. africana*. These tools were also used to collect data on various economic activities, marketing infrastructure and income levels. The head or representative of each households, relevant District forest officers, Heads of environmental NGOs and Chairpersons of Village Environmental Committees and herbalists were also interviewed.

The study used comparative design to get variation of survey information in order to triangulate the information gathered through specific tools. Farmers were given seminars and encouraged to participate thoughout the various activities of the research, their opinions on the proposed research was integrated in the project. In addition, farmers were encouraged to establish village or individual nurseries by using locally available materials and plant *P. africana* in their farms. Secondary data on the species and any information relevant to the project were collected from various sources to compare and discuss the findings of the research.

3.2.2 Ecological Data

Distribution and abundance of *P. africana* in the study villages and adjacent natural forests were assessed as follows:

- In the forest reserves: Sampling intensity of 0.01% was used and 10m wide x 50m long plots were laid either East-West or North-South on continous transects. The length and number of transects depended on the number of plots which were determined after getting the size/area of the forests. Distance between transects was 100m within each plot. *Prunus africana* trees and saplings were counted, measured/assessed on density, DBH, height, physical damages and attack by disease/pests.

– In home gardens: Farmlands from 5% of total village households were selected for the survey. Data collected were the same as it was in the forests. However, all trees in the selected farmlands were surveyed since using plots in farmlands was unsuitable because most of the *Prunus* individuals were confined along farm boundaries.

Selection of the mother trees as a source of future propagating materials was done with the aid of District forest officers. Establishment of the demonstration nursery, however used seeds from any available source.

3.3 Data analysis

Data collected by REA, questionnaires, field observations and ecological data were cleaned and analysed by using both qualitative and quantitative methods to generate descriptive and inferential statistics using computer packages like excel and SPSS. Measures of central tendency, frequencies and dispersion was analysed to describe information gatherd on uses, harvesting and management of *P. africana* and other socio-economic data. Content analysis was used to analyse detailed qualitative data such as one collected through verbal discussion with key informants. Descriptive statistics was done to compare distribution, size and abundance of *P. africana* between different villages and between different districts.

4.0 Findings

4.1 Socio – economic characteristics of the study area

The socio-economic characteristics of the respondents examined in this study were age, household size, education level, gender and household income.

4.1.1 Respondent's age and household size

The age of the respondents ranged between 18 and 60 years old. The results showed that the majority (90%) of the respondents were in the age category of 26-60 years, the least (4.7%) were of the age category of 65 years and above. Age of respondents was found to be positively associated with number of people who dared to undertake conservation related activities. In other words, older people (more or equal to 45 years) are more willing to engage in biodiversity conservation activities than younger people. The fact that the majority of youths own less land compared to the land owned by the older people and that most of the young people move away to urban areas in search of other jobs tends to favour this observation. By having substantial amount of land, older people had the potential to engage in such activities as tree planting in their own lands.

Mbwambo (2000) and Paulo (2004) who undertook their studies in Udzungwa and Uluguru Mountains respectively observed the same situation that older people planted more trees than young people because they own relatively substantial portions of land. In line with land ownership, youth migration to mainly Morogoro and Dar es Salaam cities in search of works and other small-scale businesses also affects their contribution in biodiversity conservation.

The results showed that more than half (68%) of the households in the study area had an average of 5-10 persons (Table 1). Moreover a small percentage (24.6%) of the households had a family size (1-4 persons), which is within the National census average (URT, 2002).

Table 1: Distribution of respondents by household composition

Number of persons per household	Number	Percentage
1-4	14	24.6
5-10	39	68.4
Above 10	4	8.0
Total	57	100

The average household size for the study area was 6.2 people, which is above the district average household size of 5.4 (URT, 2002). Although the relationship between household size and contribution to conservation activities was not analysed, several studies have showed that the bigger the family/household the less the contribution to biodiversity conservation (Sahlins, 1972 cited in Kajembe *et al*., 1999) The possible reason is that people tend to focus more on activities which are directly associated with their immediate subsistence living than caring much about biodiversity conservation activities. This observation is consistence with the *Chayanou's rule* which states that "in a community of domestic producing groups, the greater the relative working capacity to the household the less its members work" (Kajembe *et al*., 1999).

4.1.2 Level of Education

Result showed that about 81.7% of the respondents had completed primary education, 14.0% secondary education and only 5.3% had no formal education. Education is a very important factor in biodiversity conservation because it creates awareness, positive attitude, values and motivation for better natural resources management among the people (Katani, 1999).

4.1.3 Economic activities and income levels

The results have revealed that the main economic activities of the people in the study area was food and cash crop cultivation (76.3%), livestock farming mainly zero grazing (7.9%), business and petty trading and formal employment (15.8%). The main cash crop is coffee and they mainly depend on bananas for food.

Average household income from farm produce is TAS 36,000 per month. The off-farm income was not included here due to difficulties in capturing reliable information relating such activities. It was observed that people were engaged in casual labor such as construction of roads, water intake maintenance and market. Others were involved in marketing of farm products, farm inputs and forest products including timber and wood fuel. The results further revealed that people in the study area are relatively better off economically compared to other rural Tanzanians although their income is declining due to instability of coffee price in the market (Table 2). The average income for rural Tanzanians is TAS 280 USD per year (NBS, 2002).

Table 2: Income distribution per household per month

Category	Income (TAS)	Frequency	Percent
Very low income	1,000-10,000	6	10.6
Low income	11,000-20,000	10	17.5
Medium	21,000-200,000	36	52.6
Very good income (Rich)	>200,000	5	19.3
Total		57	100.0

The results indicate that most of the people who are categorised as rich are those who own saw mills for timber processing, big farms for cultivation (>10ha), modern houses and vehicles.

The study further noted that pit sawing is a lucrative business in the area and most of those categorized as rich in Rombo are the ones who are engaged in that business. It was further revealed by respondents that the business has gained momentum in recent years replacing the old coffee business, which is now on a decline. It appears that there is a negative relationship between engaging in biodiversity conservation activities and the level of income. This implies that the higher the income the less the contribution in conservation efforts. Therefore, while the poor people are struggling to conserve environment in order to meet the immediate subsistence needs and market demands for their agricultural produce, rich ones are more concerned in trading activities.

Regarding the magnitude of income generated from farm produce, Table 3 presents a summary of different incomes obtained through sales on farm products as reported by respondents. Majority of respondents (89.5%) depend on farm income generating activities supplemented by unreliable off-farm activities as qualified by respondents. Sales of medicine were not mentioned as a source of income (i.e. no body was engaged in sales of traditional medicines). It was however revealed that traditional medicine in the study villages is given free to the needy patients. In another study it was revealed that medicinal plants contribute to the income of both herbalists and traditional midwives through treating patients or selling plant medicines (Hamza 2004). The author revealed that herbalist can earn an annual gross income of between TAS170,000 to TAS 500,000 and cost of treating a sick person ranged from TAS 200 and 3,000.

Table 3: Amount of money (TAS) respondents earn from on farm sources per month

Income per month	Number of Households	Percent (%)
10,000-50,000	22	38.6
51,000-250,000	22	38.6
>250,000	3	5.53
Not knowing	10	17.5
Total	57	100

4.1.4 Trend analysis of coffee as important commercial crop

Coffee production and price is claimed to be on decline due to various reasons. The price was low (TAS 10-250/kilo) during Nyerere's era (1960-1985), however, the shilling was stronger during that period than today and therefore farmers had a stronger purchasing power. Likewise the production was very high during that period to subsidies given to farmers by the government. Soils were also better and there were less diseases and pests. During Mwinyi's era (1985-1995), the collapse of Cooperative unions and emergence of free market made the price of coffee to shoot up to TAS 800/kg but later on, there was a sudden drop to TAS 300/kg. The decline was partly due to poor world market for coffee and mushrooming of myriads of buyer companies. There also emerged a lot of pests and diseases, which contributed to the decline in the production (From 500kg to less than 200kg per ha). The decline in production (Plate 1) was claimed to be due to application of wrong and/or expired pesticides, as farmers were not able to buy genuine products. The government also ceased to provide the subsidies, which were then given to farmers.

These scenarios compelled most farmers to uproot their coffee plants and replaced them with horticultural crops such s carrots, green pepper, tomatoes and fruits. Mkapa's era started with poor price until then when the price started to rise reaching up to TAS

800/kg. However the respondents complained that despite the good price, price has been fluctuating causing some uncertainties to the growers and indeed the shilling value had remained very low against the dollar (USD). Moreover, the respondents claim that due to existing problems high costs of pest control, poor production and poor market most farmers have now shifted to horticultural crops and forest products specifically timber which have good market price. The price of treating people from traditional medicine and sales of the same can also encourage farmers to become herbalists (Minja 1992; Hamza 2004). There is a need therefore for the *P. africana* to be promoted to give this people alternative source of livelihoods.

4.1.4 The Potential of Prunus africana as a commercial agro- forestry tree

Prunus fricana is well known by all (100%) respondents in the study areas. More than 90% knew that *P. african* is indigenous and not introduced. Moreover *P. africana* was observed growing naturally on agroforestry farmlands and in the neighbouring forests. Farmers do not plant it voluntarily but it grows naturally with the aid of frugivore dispersal. Farmers usually leave and tend a few wildings in their farms. Generally the results suggest that farmers have good knowledge on selection of trees for incorporation in their agroforestry system based on their use. Farmers of both districts were given two seminars to create awareness on the opportunities vested on *P. africana*. The farmers positively received both seminars and in conclusion they anonymously promised to take advantage of the opportunities (medicinal value of the tree) by planting more *P. africana* in their farms and intensify conservation of the same in the natural forests.

Although *P. africana* is not very much commercialised in Tanzania, these results indicate that it is among the most preferred species in that society, ranking forth amongst 10 mostly preferred and important trees for multipurpose uses in the study area (Fig 1). Other most important trees mentioned by respondents along with *P. african* were such as *Cordia african*, *Gravillea robusta* and *Cypress*. These trees are mostly used for timber, firewood, shade and soil conservation in their farms.

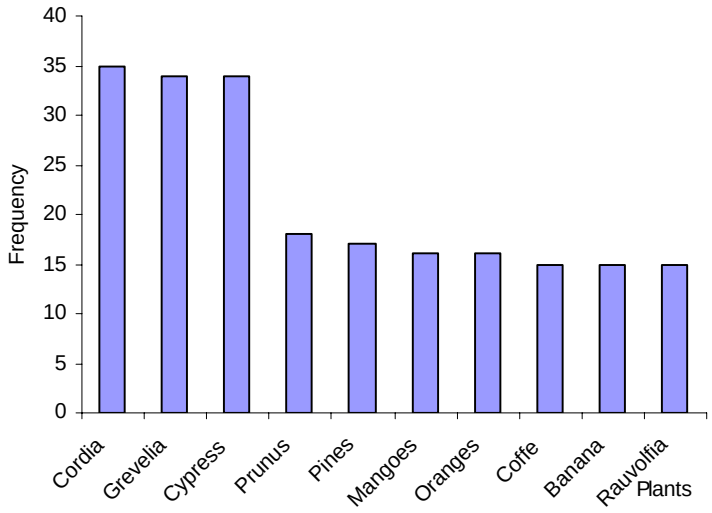

Fig. 1 Important and preference of different plant species in Rombo and Mwanga districts

However the results indicated that *P. africana* is mainly used as fuel wood in the study area, although it is also an important tree for timber, fodder and medicine (Fig 2). Those who are in timber business claim to be selling one lumber of *P. aficana* at about TAS 15,000. In terms of medicinal uses *P. aficana* is used to treat a variety of illnesses, the most common ones being: malaria, and stomach pains for kids (in combination with honey), coughs, fire burns and tooth pains. The bark of the tree is also used in treatment of meat and milk with bacterial infections. It is however not known as a treatment for urinary system complications or prostate cancer except for one herbalist in Vuchama, Mwanga. The tree is also an important for soil conservation and shading due to heavy leafing and litter production. In other parts of the world it treats prostate cancer and there are a lot of beliefs associated with the tree such as using it as a main supporting central beam in their traditional houses to keep away evil spirits (Mander, *et al*. 2006).

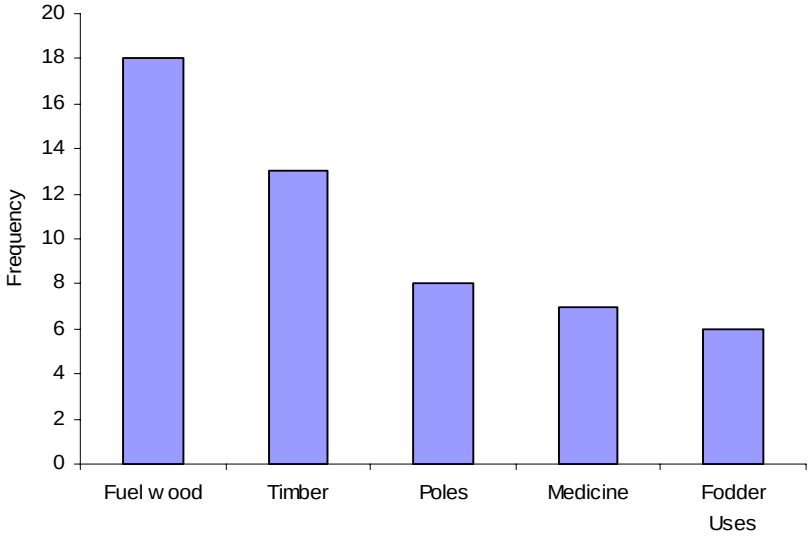

Fig.2 Different uses of Prunus africana in Rombo and Mwanga districts

Prunus africana is locally used although in some places like Rombo some of the farmers have some prospects of commercializing it since they claim that their fellow Kenyans are selling the tree bark to some pharmaceutical industries in Europe. In southern Africa, *P. africana* is not known to be traded between countries (Mander *et al.* 2006). The large local and regional trade of medicinal plants is mostly informal in Africa (Mander *et al.* 2006). The informal medicinal plant trade in southern Africa is characterised and handicapped by fragmented and uncoordinated raw material supply, lack of communication and co-ordination relating to demand, limited product diversity and limited institutional organisation. This represents a challenge to government, non-government organisations and any other institutions involved with interventions in the sector. In Tanzania, the Government recognises the importance of traditional healers and there is a fully flagged Institution (Muhimbili Traditional Medicine) dealing with traditional medicine (mostly plants). The Government also encourages and support research on traditional medicine.

The medicinal plants industry in southern Africa is one of few industries that have escaped large-scale commercialisation; consequently it remains as a largely informal industry with virtually few or no official trade statistics (Mander *et al*. 2006). China is the leading exporter of plant materials into international markets, with other countries such as India, Egypt and Chile playing a significant supply role. To date, there is a surge of interest in bio prospecting, with pharmaceutical companies, research agencies and universities investigating in the identification of commercially useful plants in southern Africa.

It is estimated that over 80% of the rural people in Tanzania still depend on traditional healers and herbs for their primary health care needs (Mahunnah, 1993; Derry *et al*. 1999). The dependence on medicinal plants by many rural people is due to their relatively

easy accessibility and availability, low cost, acceptance by local communities and low number of dispensaries and doctors in rural areas (Minja, 1992). In spite of these uses, there is no single industry in Tanzania, which manufactures *P. african* drugs for local or international markets. In Africa there is generally very little drug manufacturing from plants (Mander, *et al*. 2006).

4.1.5 Harvesting techniques

On the harvesting techniques the results indicated that local people have knowledge and long time history on the use of that tree. The harvesting mode as mentioned by respondents is through felling of the whole tree if one wants to have timber or poles otherwise for medicinal and fodder uses one can peal the bark, prune the leaves or cut the branches leaving the tree to continue growing for further uses. However, the species is highly damaged due to poor harvesting methods and farmers revealed that the species population has declined in their home gardens for the past 20 to 30 years. Lack of awareness, among local people, of the commercial value and proper harvesting techniques for the species together with lack of information on the worldwide conservation needs for the species contribute significantly to its declining population.

4.2 Ecological data

4.2.1 Distribution and Abundance

4.2.1.1 Distribution

Prunus africana is widely distributed in homegardens close to the natural forests and the stock was sparse away from these forests. Similarly, the species is common in the entire Forest reserves with stock increasing with altitude. The lower part of the forest had sparse stock perhaps as a result of illegal exploitation of the tree or due to environmental conditions. Within homegardens, most of the trees were found along the boundaries of individual farms (Plate 2) because farmers tend to remove most plants growing naturally inside the farms to get room for cultivation of food crops. Usually plants along the boundary are either planted or grow naturally.

Plate 2*: Prunus africana* growing along the road side in Ngujini, Mwanga

4.2.1.1 Abundance

i) Stems per hectare

The natural forest adjacent to the study villages in Rombo had higher population density of *P. africana* (64-120 stems/ha) compared to the Mwanga forests (27-48 stems/ha) (Fig. 5). The lower population abundance recorded in Mwanga could be due to either cutting

of the trees for domestic uses by the communities around the forests or less unfavourable growing conditions. Both Minja and Kindoroko forest reserves in Mwanga are less guided compared to the natural forests in Rombo. On the other hand, the population density in the homegardens of both districts (Rombo and Mwanga) was very low (6-7 stems per ha). There were no records of *P. africana* trees in the homegardens of Vuchama, Mwanga. The lower population density in homegardens could be due to seedlings/saplings removal by peasants during farm preparations. The study sites have very serious land shortages and therefore peasants usually maximize the land sizes by keeping only a few stems of trees. The low number of stems in home gardens shows that more efforts are needed for "ex-situ" gene conservation of the species. The current efforts to educate communities on the commercial value of *P. africana* may intensify illegal harvesting of the species if proper measures are not taken to protect the species. IUCN and WWF estimates that as many as 60,000 plant species may disappear before the middle of this century if effective conservation measures are not taken (Klemm 1990).

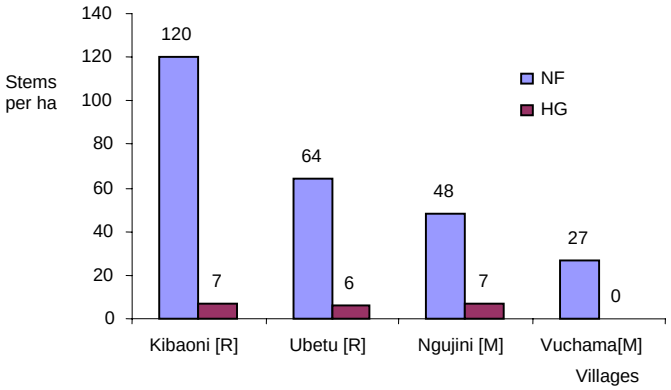

Fig 5. Number of Prunus stems per hactare in Natural Forests (NF) and Homegardens (HG) in selected villages of Rombo (R) and Mwanga (M) districts

ii) Saplings stock

Saplings are individuals with dbh of less than 5cm. The abundance of saplings in natural forests was considerably high in Rombo and it ranged between 1,000 – 1,500 saplings per ha (Fig. 6 and Plate 4). Conversely, the population abundance was fairly low in Mwanga district (75-230 stems per ha). Homegardens of both districts had very few saplings with an average of 20 saplings per ha in Rombo and 5 saplings per ha in Mwanga. There were no saplings recorded in homegardens of Vuchama village in Mwanga.

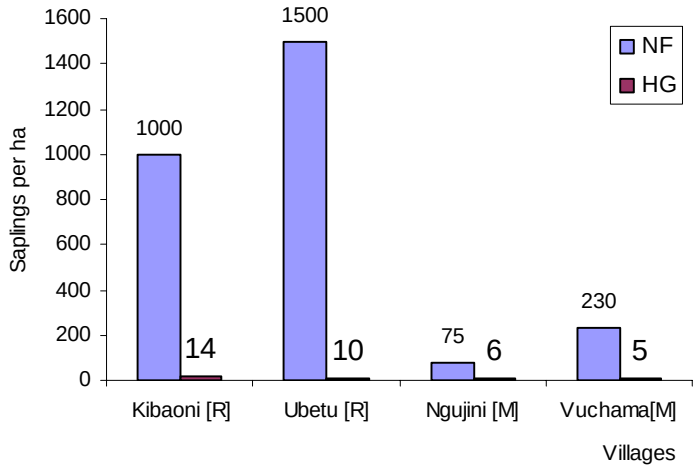

Fig. Number of Prunus saplings per hactre in Natural forests (NF) and Homegardens (HG) in selected villages in Rombo (R) and Mwanga (M) districts

Plate 4: Prunus African saplings plants on the farm in Kindoroko FR, Mwanga

The observed abundance of *P. africana* in the homegardens between districts is largely a result of ecological and cultural differences. Homegardens in Rombo are more diverse in terms of species composition (Fernandes, *et al.* 1984) and peasants usually tend a variety of tree plants whether planted or naturally established for a number of years before removing the undesirable ones (Dino 2004). The agro-ecosystems with high richness in plant diversity have a potential to attract a number of fauna species for various ecological interactions. Through these interactions, *P. africana* seeds are dispersed by animals mainly birds and mammal frugivores while the culture of tending any saplings plants on the farm add up the saplings abundance. Peasants in Mwanga usually remove most seedlings, which, they find on farm. The fact that there are more saplings in Rombo than in Mwanga but more tree density in Mwanga than in Rombo homegardens implies that disturbance regimes have an effect, on *P. africana* population density. Most *P. africana* saplings are used as fodder in Rombo and therefore very few are left to grow to tree size.

4.2.2. Tree size and damages

i) Diameter: Assessment of diameter of *Prunus africana* was done in both homegardens and the natural forests adjacent to the study villages. Tree diameter in forests adjacent to study villages was bigger than that for the trees found in the corresponding homegardens; 32-42cm and 16-26cm in natural forests and homegardens respectively (Fig. 3). Trees in the home gardens of Mwanga had bigger dbh (26cm) than the ones in Rombo (16-19cm). In Vuchama, *P. africana* was not found in farmlands. There were, however, a few

individuals in their traditional sacred forests called "*Mbungi"*. These forest "islands" are usually very rich in biodiversity since cutting of trees is strictly prohibited.

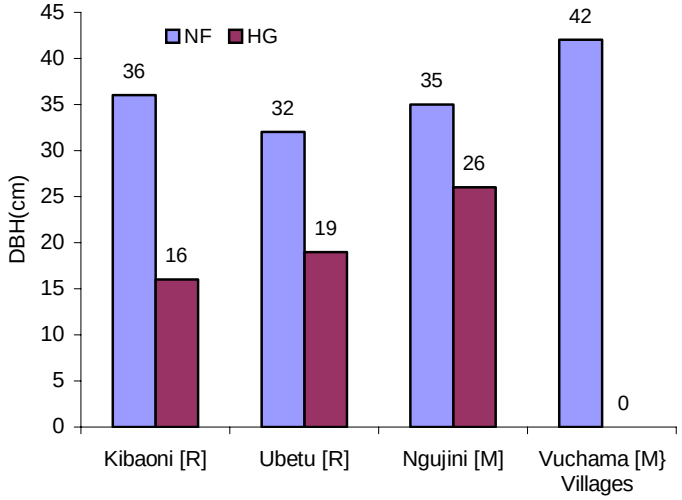

Fig. 3 Mean diameter (DBH) (cm) of Prunus in Natural forest (NF) and Homegardens (HG) in selected villages of Rombo (R) and Mwanga (M) districts

Lack of serious human interference in the natural forests may have contributed to the presence of bigger sized trees in terms of diameter compared to homegarden populations in the study areas. The natural forests used in this study were either reserves under the Forest and Beekeeping Division (FBD) or Tanzania National Parks (TANAPA). Forest policy (MNRT, 1998a) and Wildlife policy (MNRT, 1998b) prohibit forest exploitation in reserved areas. Lack of knowledge and market of *P. africana* as a valuable medicinal tree is yet another factor which favours the tree against serious exploitation. The tree is also difficult to saw and therefore many people opt for other timber tree species such as *Grevilea robusta* and *Albizia schimpera*, which are abundant in the study areas.

The trees were getting bigger in size with altitude, the higher altitude having bigger trees than lower altitude. Although the trees looked bigger in higher altitudes there was no significant difference in dbh between the upper and lower altitudes ($P<0.05$). The differences in diameter between the districts were smaller compared to the differences between villages. Furthermore, there were significant differences in dbh between villages and between home gardens ($P <0.001$ and $P< 0.02$ respectively). The differences may largely be due to the smaller sample sizes within villages and the variability between homegardens located in the drier and wetter areas.

i) Heights

As expected, trees in the natural forests were taller than those found in the homegardens (Fig. 4). Similarly, tree height for forest trees differed across the villages with Ngujini (Mwanga) and Ubetu (Rombo) villages having the tallest (25m) and the shortest (20m) individuals respectively. The tree heights in the homegardens appeared shorter than in natural forests and had similar trends as the diameters recorded where trees in Mwanga

district were taller (17m) than the ones in Rombo (10-13m). Height of matured *P. africana* is 10-25m, but can reach up to 40m (Hall, *et al.* 2000).

The observed variation in tree heights between homegarden populations from the two districts could be a result of variation in local uses. People from the two districts use the tree differently due to differences in culture and traditional ecological knowledge (TEK). People from both districts are livestock keepers but with different ways of domestication. In Rombo, zero grazing is the most dominant method while Mwanga residents prefer free range grazing. In zero grazing, farmers select and collect fodders for the livestock in closet. *Prunus africana* is one of the tree species, which is preferred as fodder, and through frequent cutting of branches/twigs/shoots growth is impaired as observed in this study.

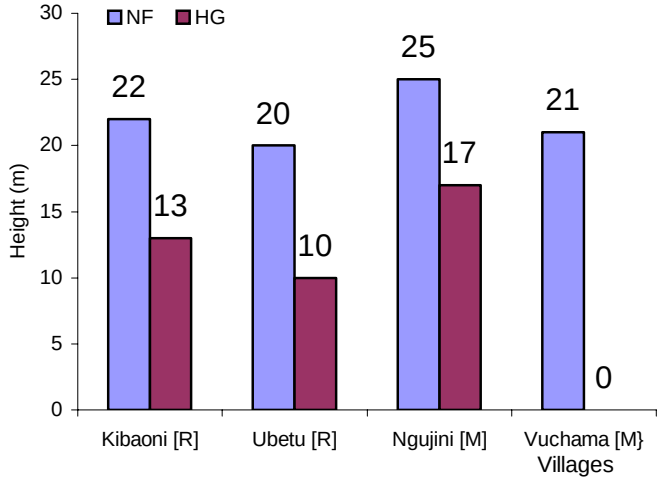

Fig.4 Mean height (m) of Prunus in Natural forest (NF) and Homegardens (HG) in selected villages of Rombo (R) and Mwanga (M) districts

iii) Tree damages

The physical appearance of homegarden populations in Rombo presented trees, which are topped, stunted and highly wounded than the ones in Mwanga. Farmers use the tops and branches to make tool handles especially for hand hoes and axes while shoots and twigs are used for fodder. One farmer in Rombo who was more than 70 years old revealed a tree which he have been seeing since childhood, but the tree had a diameter at breast height of 30cm and a height of just 5 meters due to disturbances by farmers during fodder collection (Plate 4). This tree, which was ultimately felled, is an evidence of how disturbance can affect tree growth. The species can grow up to 40m high under suitable conditions and in absence of disturbance (Hall *et al* 2000).

Plate 4: Stunted/felled *Prunus africana*

4.3 Selection of mother trees

In TANAPA and Kindoroko forest reserves, five trees each with good straight bole, well branched, canopy density, over 25m height and diameter of more than 40cm were identified and pre-selected for use as sources of propagating materials (Table 4). On the average the trees in Mwanga were bigger and taller than those in Rombo. It was difficult to use GPS in these forests due to dense tree canopy; however, a sketch map from a well recognized reference point was drawn for future uses.

Table 4 Diameter and height of mother trees in Rombo and Mwanga districts

Serial No.	Rombo		Mwanga	
	DBH (cm)	Height (m)	DBH (cm)	Height (m)
1	75	27	82	31
2	62	24	66	29
3	60	29	51	28
4	45	26	48	23
5	36	22	70	27

4.4 Tree nursery

Plate 5: *Prunus african* nussey

A tree nursery was established in Mwanga from seeds collected from Kindoroko forest reserve as a demonstration unit (Plate 5) and to develop a stock, which will later be distributed to farmers during the beginning of the short rains of October-December. Similar exercise has been conducted in Rombo (Dino, 2004). Seeds were collected from both the selected mother trees and other mature trees. There is seasonal variation of seed production for *P. africana* trees. Germination capacity after three weeks was about 62% while mortality of 25% was recorded at the time of lifting. In September 2006 107 seedlings with an average height of 12cm were distributed to farmer for planting out during October- December short rains. Difficulties in seed procurement, germination, mortality rate and slow growth of *P. africana* seedlings are some of the limitations of seed production.

Seeds and vegetative propagation each have their relative merits and demerits. When growing from seeds, plants are generally stronger and express genetic diversity. On the other hand, vegetatively reproduced plants are direct clones of the parent. This is preferred multiplication technique because particular attributes of the parent such as medicinal constituents, large fruits, thick bark or rapidity of growth must be reproduced in propagated plants (Crouch, 2006). Vegetative reproduced plants often reach reproductive maturity faster than those grown from seeds. International Centre for

Research in Agroforestry (ICRAF) is currently working on vegetative propagation of *P. africana* and it is expected that the success of this work will motivate more people to plant the tree.

4.5 Strategies for domestication

Seminars held in Rombo and Mwanga clearly showed that farmers are prepared to participate in the domestication of *P. africana*. The first seminar motivated some farmers to plant trees and was eager to learn proper domestication methods of the species. During the second seminar, farmers anonymously agreed to plant and tend the species during the short rain season from the wildings and later from planned nurseries. More information is however, needed on *P. africana* as a basis for linking the farmers and the buyers. Guarantee of the availability of markets and raw materials is very vital for both farmers and buyers. In order to build a strong base for the business, farmers need to organize themselves through Farmers Associations while researchers become the link between these two groups. It is from that perception that we are proposing to further up this study in order to generate invaluable information, which will facilitate both farmers and buyers of *P.african* bark to make sound judgment for the business.

5.0 Conclusions and recommendations

5.1 Conclusion

This study has given baseline information on the status of *P. africana* in Kilimanjaro region. The species is available in natural forests and neighboring homegardens. At present the tree is widely used as fuel wood, timber, poles and fodder and less as medicinal plant. Most farmers are not aware on the potential of *P. africana* as a cure against prostate cancer and have a potential to generate income and improve their livelihood if pharmaceutical industries and/or companies engaged in the sale of *P.africana* bark establish sustainable trade with them. Conversely farmers are aware of the potential of *P. africana* as a medicinal plant for commonly known diseases such as malaria, stomach pains for kids, coughs, fire burns and tooth pains. Awareness and capacity building for local institutions and farmers to promote the importance of the species for medicinal purposes, income generation and conservation of the species was positively received by the farmers and the districts authorities. Some farmers in Mwanga have started planting the species while three farmers in Rombo have grown more than 30ha of the species. Farmers positively received the available nursery stock in Mwanga in the same manner in which farmers of Rombo showed in the previous studies. Management and conservation of the tree is sustainable in the natural forests but appears to be unsustainable in homegardens due to land shortages.

Prunus africana was more abundant in the upper altitudes than the lower altitudes. The size (girth) and height of the trees also followed the altitudinal trend. Five superior trees on the basis of diameter, height, canopy density and seed/flower production were selected for future collection of propagating materials. Tree damage by farmers in the lower altitude rendered them stunted, limiting their increment in size. Saplings were abundantly and sparsely recorded in the natural forests and homegardens respectively. Seed procurement, storage and germination are challenging and perhaps vegetative propagation could be a solution to these dilemmas.

5.2 Recommendations

For future conservation and commercialisation initiatives regarding the species it is recommended that research and intervention efforts in Tanzania should be geared towards the following:

(i) A comprehensive survey covering the entire Eastern Arc Mountains, Mount Kilimanjaro, Iringa, Meru and Hanang in the natural forests and farms to get data on population size, distribution, management and physical condition of the species

(ii) Taking stock of the planting programs in Mwanga and Rombo to justify exploration for the local and international markets

(iii) Molecular studies on genetical diversity in order to know future population trends

(iv) Collaborate with International institutions such as ICRAF to work on an efficient and effective propagation methods

(v) In order to reduce unsustainable harvesting practices and create new businesses in medicinal plants sector, appropriate institutional vehicles need to

be established to pull rollplayers together for working towards common objectives of conservation and maximisation of economic returns

(vi) Through the government machinery, increase opportunities for market of the *P. africana* bark or semi-processed products.

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