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Research article

How do socio-economic characteristics of communities influence resource use and forest cover in the *Cryptosepalum* forest of North-western Zambia

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A R T I C L E I N F O

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A B S T R A C T

Forests are important ecosystems offering extensive material and immaterial benefits to people and the environment. If not well monitored and sustainably managed, forest resource use can lead to degradation, which has global environmental and socio-economic implications. There is currently limited information on the factors that lead to forest use in the *Cryptosepalum* forests of Zambia, and how these factors potentially influence forest integrity. This study aimed at establishing the socio-economic aspects that determine resource utilisation and forest loss in the *Cryptosepalum* forest of Manyinga and Zambezi Districts of North-western Zambia. Using a semi-structured questionnaire 207 randomly selected households were interviewed in 7 villages surrounding the *Cryptosepalum* forest (4 in Manyinga and 3 in Zambezi district). Additionally, three focus Group Discussions were conducted to triangulate interview data. Descriptive statistics, Pearson's Chi-square test of independence and binary logistic regression were used to analyse the data. The study established 14 forest products used by local communities in the study sites. Socio-economic factors, namely; gender, level of education, household size, wealth, and residence status significantly influenced use of 9 of the 14 forest products. Further, significant relationships ($p <$ 0.5) were established between: (1) gender and use of construction poles, wood fibre, fruits, and honey production (2) level of education and utilisation of timber, tubers, caterpillars, mushrooms, and thatching grass; (3) household size and use of construction poles, wild vegetables, tubers, caterpillars, fruits and thatching grass; (4) wealth status and use of timber, construction poles, wild vegetables, wood fibre, and fruits; and (5) residence status and use of construction poles, tubers and thatching grass. Timber harvesting, agricultural expansion, and population increase were established as key drivers of forest cover loss in the *Cryptosepalum* forest. The study recommends that policies and strategies aimed at conserving this forest focus on strict law enforcement (monitoring and control) of timber harvesting activities; and provision of agricultural inputs and/or community sensitisation on conservation agriculture interventions to curb shifting cultivation practices. The study adds to the body of knowledge on the importance of forests to rural livelihoods in Sub-saharan Africa, and the influence of socio-economic factors on forest cover and resource use.

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1. Introduction

Forests are critical in offering ecosystem services (ES) for better livelihoods at both local and national levels. These ES can be grouped into provisioning, cultural, supporting and regulating services [1–5]. They include the provision of tangible and intangible benefits to communities within their vicinity [6–9]. According to the WorldBank [10], nearly 350 million people living close to forests world-wide depend on ES for their livelihoods. Several studies across the world have demonstrated the key role of forests in human welfare through employment creation, as a source of income as well as provisioning of goods and services [11–15]. Forests are a source of energy and other basic needs (including food and medicine), for the majority of local communities, particularly the underprivileged and forest dependent individuals [11,16–18] in developing countries [19–21]. Further, they provide cash savings and act as safety nets to most rural communities during crop failure [11,22,23]. However, forest exploitation is resulting in rapid changes in forest structure and integrity. This may lead to forest degradation, which impacts on the livelihoods derived from the forests [4]. Thus, sustainable utilisation of forests and their forest products has to be promoted for continuous provisioning of ES. Further, local peoples' use and dependence on the forests and forest products have to be understood in the context of factors that influence use.

Research conducted world-wide generally demonstrates that the use and reliance on forest products by local people is mainly linked to household demographics (e.g., age and gender of the household head) as well as social and economic factors (e.g., household size, education level and total household income) [14,24–27]. For example, with respect to education, it has been reported that individuals with a higher level of education are less dependent on forest resources [25,28,29], as education tends to avail them other livelihood alternatives with more substantial returns than from forests [30]. A higher number of household members have more subsistence needs than smaller families, thereby compelling them to collect more forest products [2,31]. Furthermore, it is believed that the age of the household head has a positive relationship with forest dependency, with the younger in age being more likely dependent on forest products than the elderly [21]. Gender is also reported to influence the preference for use of some forest products, with men being more involved in wood related activities, e.g., collection of wood for sale, carpentry and construction purposes [18,20,32], collection of honey and hunting of wild animals [20,32,33]. In contrast, women are mostly engaged in the gathering and selling of fuelwood and Non-Wood Forest Products (NWFPs) like caterpillars, mushrooms, medicines, and thatching grass [20,32,33].

Social and economic factors such as population growth, agricultural expansion, household wealth status [14,21], and distance to the market [9,20] also influence the extent of dependency on forests and forest products. For example, population growth, density, and distribution over time are believed to significantly influence land use, including the value and extent of forests [34]. Similarly, immigration is regarded as a critical demographic factor influencing land use and land cover (LULC) dynamics in forest areas [35–37]. In other studies, agricultural expansion is established as the leading cause of changes in LULC [14,15,18]. In addition, household wealth status is reported to influence dependency on forests in that the poor are believed to be more resource dependent than the rich [14,20,32,38,39]. Furthermore, peoples' location in terms of closeness to forest areas, markets, and transport routes is believed to potentially influence level of dependency on forest [9,20].

However, given that communities vary in nature, differences in use and dependence on forests are expected [40,41]. These differences also occur with varying geographical locations and over longer time scales [3,42]. For example, studies of similar nature carried out in different regions or countries have yielded some differences in results with regard to the main socio-economic factors that influence forest resource use. Whereas age and education significantly influenced household dependency on forests in the Chobe enclave in Botswana [21], occupation of household head, and distance to the market were in addition to age, the main socio-economic factors positively associated with dependency on Non-Timber Forest Products in the South Nandi Forest of Kenya [9] and in the Chilimo Forest of Ethiopia [43]. In Munessa-Shashemene, Ethiopia, factors such as the distance from the forest and livestock assets were additionally significant in influencing household forest dependence [44], whereas in the Odoba Forest Reserve of the Benue State of Nigeria, marital status, household size, and years of residence were in addition to age, significantly important influencers of forest resource utilisation [45]. Further, in forest-based rural communities of Vhembe District in South Africa, farm husbandry skills, years of residence in the community and age of respondents were the main socio-economic factors that significantly influenced use of the forest resources [46]. These differences could be due to differences in forest characteristics, as well as disparities in a community's needs, ethnical and cultural make-up [14]. While studies have been conducted on social and economic factors influencing the use of forest resources and community reliance/dependence in sub-Saharan Africa as shown above [14,26,47–49], there is paucity of information in Zambia [14], with few existing studies skewed towards the Miombo woodlands [14,50,51]. In fact, there is little information on other forest formations such as the *Cryptosepalum* forests, the subject of this study. Given that the Miombo woodlands are structurally and floristically different from the *Cryptosepalum* forests, with the Miombos growing on sandy loam soils and being dominated by trees of subfamily Caesalpinioideae, particularly *Brachystegia*, *Julbernardia* and *Isoberlinia*, whereas the *Cryptosepalum* forests grow on infertile Kalahari sands and are dominated by *Cryptosepalum exfoliatum* species, differences in resource utilisation between the two forest types are eminent. In addition, due to differences in cultural and ethnic groupings surrounding a particular forest type, differences in use and preferences of forest products are also likely to exist between the communities. For example, findings of a study on Zambia's Miombo woodlands of the Copperbelt [14], whose ethnic grouping, culture and beliefs is different from that of the North-western part of the country will potentially vary from those on the *Cryptosepalum* forest. Therefore a study on the socio-economic factors that influence forest use in the *Cryptoseplaum* forest was considered vital, for the reason that the forest type is different from the Miombo woodlands, and the communities living near the forest also differ in ethnic and cultural beliefs.

General information suggests that studies on socio-economic activities relating to the *Cryptosepalum* forest are missing as it has been assumed that the dominant species are not economically important for timber and are thus little exploited [52,53]. Additionally, the *Cryptosepalum* forest is assumed to be less attractive to agricultural activities and human settlements as it stands on infertile soils and with no known water sources [53]. However, this information may not be the same overtime, and in different locations, and therefore needs to be verified, especially because of the current growths in population due to expanding mining activities in the region. Further, preliminary findings of a more recent land-use and land cover change analysis of the *Cryptosepalum* forest over time (between 1996 and 2021) using satellite images indicates changes in land use and land cover [54]. Therefore, necessitating the need to establish the drivers of change, viz-a-vis the socio-economic aspects influencing forest resource use. Understanding socio-economic characteristics of the community around the forests will provide for understanding prevailing forest cover dynamics of the *Cryptosepalum* forest. Furthermore, an understanding of households' forest resource use and dependency, as well as the factors that influence use and dependency will provide a basis for researchers and policy makers to develop target specific interventions, strategies and policies that enhance sustainable utilisation of forest resources and conservation of biodiversity. Consequently, this paper explored answers to the following key questions: (1) What are the major socio-economic characteristics of the local people living near the *Cryptosepalum* forest of Manyinga and Zambezi Districts; (2) How does the socio-economic status of a household influence forest resource use? (3) What are the local peoples' perceptions on the status of the forest and forest resources in the study sites; and (4) What are the significant determinants of forest cover loss in the study sites? Findings of the study add to the body of knowledge on the importance of forests to rural livelihoods in Sub-saharan Africa, and the influence of socio-economic factors on forest cover and resource use.

The paper is organized as follows. The next section describes the materials and methods employed in the study, which includes the description and selection of study sites, sampling design, methods of data collection and data analysis. The results of the study are presented in Section 3 whereas Section 4 presents the discussion of the results. Section 5 finalizes the paper with some conclusions and policy implications of the study.

2. Materials and methods

2.1. Description of the study sites

The *Cryptosepalum* forest is locally known as 'Mavunda' (meaning thick forest). It is regarded as the biggest portion of tropical evergreen forest outside the equatorial zone, with several areas of thick forest dominated by *Cryptosepalum exfoliatum* subsp. *pseudotaxus* [53]. The forest is endemic mainly to North-western and Western Zambia (Fig. 1), with small portions of the forest also present

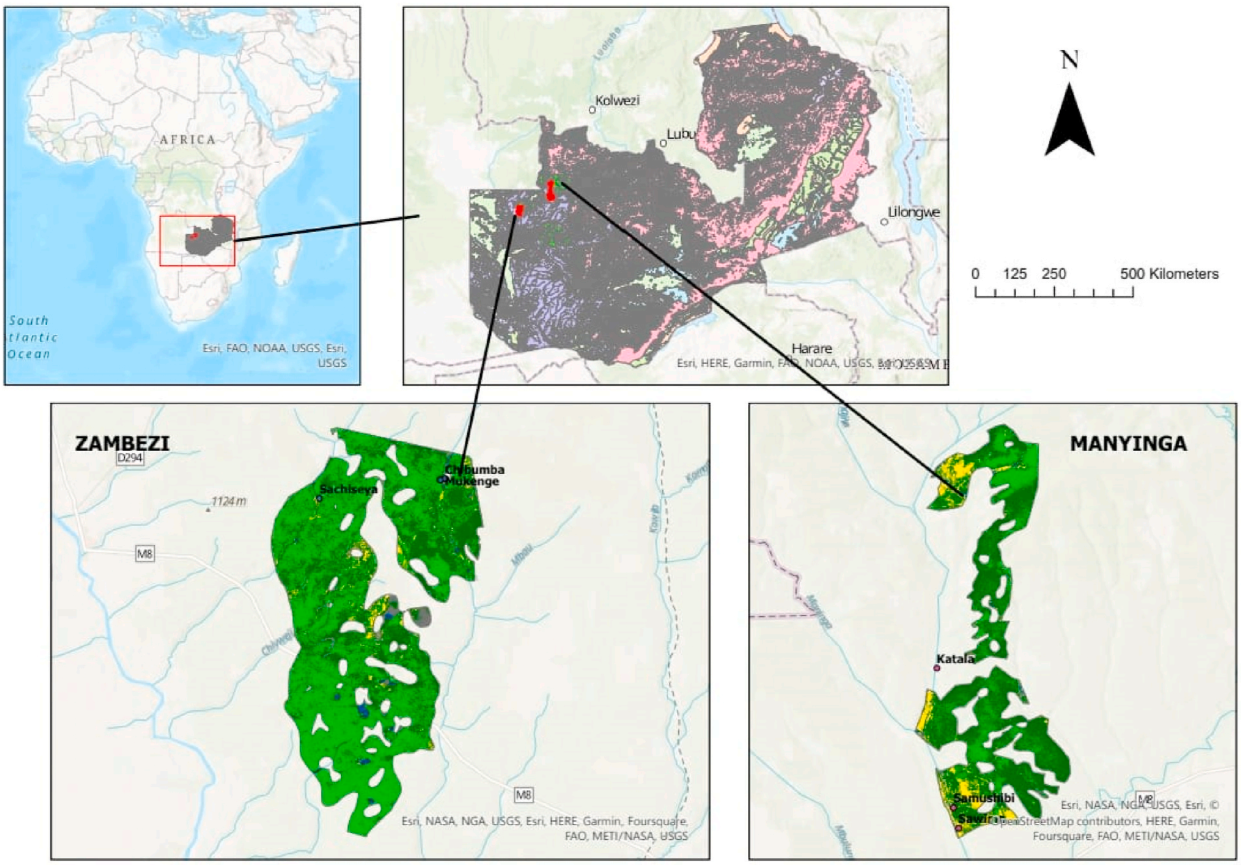

Fig. 1. Map showing the location of study sites.

in Angola, DRC and Malawi along the borders with Zambia. The *Cryptosepalum* forest is believed to appear exclusively on the higher-rainfall Kalahari sands and is found at 1100–1200 m above sea level in Zambia, taking up 3–5 % of the country's land area [53]. Its main characteristics include a tropical savanna climate, with average temperatures ranging between 20 and 22 °C. In the country's North-western Province, *Cryptosepalum* forests are restricted to and drained by the Kabompo River and its tributaries. This forms part of the drainage basin of Upper Zambezi River.

Communities living near the *Cryptosepalum* forest of Manyinga and Zambezi Districts of North-western Zambia were targeted for the study. Manyinga district is positioned between lines of longitude 24.3317732°E and latitude −13.4089962°S whereas as Zambezi district is between lines of longitude 23.1048213°E and latitude −15.5485533°S (Fig. 1). The selected study sites in Manyinga and Zambezi are 493.3 km^2 and 319.6 km^2 in size, respectively. Manyinga and Zambezi Districts receive annual rainfall averaging 1400 mm, mostly between November and March. Therefore, three distinct seasons; hot dry season (September–November), hot wet season (December–April) and the cold dry season (May–August) are predominant in both districts.

2.2. Site selection

The first step in study sites selection was the identification of forest areas with sufficient stocks of identifiable vegetation communities within the *Cryptosepalum* forest. The second step was the identification and availability of communities around the forest, which would provide information about their interactions with the forest ecosystem. Following this criterion and using 2021 satellite images (accessed from USGS website on 18th August 2021), sufficient stocks of the *Crytptosepalum* forest were identified in the Manyinga and Zambezi districts of North-western Zambia. With the help of the District Forest Officers in both Manyinga and Zambezi, villages in surrounding areas of the *Cryptosepalum* forest were established as Sawime (S −13.28950; L 024.24640), Samushibi (S −13.25968; L 024.23869), Sachilombo (S −13.22959; L 024.22914) and Katala (S −13.07053; L 024.21769) in Manyinga, and Chibumba (S −13.48670; L 023.45785), Mukenge (S −13.54365; L 023.11201), and Sachiseya (S −13.50394; L 023.33468) in Zambezi. The *Cryptosepalum* forest in the Manyinga district extends into a forest reserve called Lusongwa Forest Reserve (S −13.07201; L 024.21798), which has access restrictions for the local people. However, the forest also falls into the open areas around the forest reserve open to local communities for access and collection of forest products. The four selected villages in Manyinga, the closest to the Lusongwa forest reserve are Katala, Sachilombo, Samushibi, and Sawime.

On the other hand, the *Cryptosepalum* forest of Zambezi District selected for the study is not close to any forest reserve and has no access restrictions for the local people. The villages nearest to the *Cryptosepalum* forest in Zambezi District are Mukenge and Chibumba. The selection of different study sites in management regimes (communities living near a forest reserve and those living away from a forest reserve) enabled the researchers to compare forest use and dependency between a purely open access regime and that falling close to a forest reserve under formalised management regimes. The selection criteria encompass the main components that reveal the existing interactions between local community members (human capital) with differing socio-economic status (demographic and economic pressure) and the environment (natural forest) [55].

2.3. Sampling design

With the help from the local headmen, the total number of households in each village were established. It was observed during the study that people in these villages live in extended families, with one family having brothers and sisters with their spouses and children (also with their spouses) living in one compound or close to each other. In Manyinga, the number of families/households in each of the villages was established as follows: Sawime - 22, Sachilombo - 18, Samushibi – 29, and Katala - 48. In Zambezi, the total number of households was distributed as Chimbumba - 35, Mukenge - 53, and Sachiseya - 71. A total of 95 households (approximately 81% sampling intensity) were surveyed in Manyinga (Sawime - 19; Sachilombo - 11, Samushibi - 24 and Katala - 41); and 112 households (approximately 70% sampling intensity) were surveyed in Zambezi (Chimbumba - 28; Mukenge - 42; and Sachiseya - 42). The sampling intensity was, therefore, adequate and more than the recommended minimum representative population sample of 20% by other authors [14,56]. This exercise involved interviewing the head of a household or his/her next of kin within the household. In cases where no eligible person was found or if the selected household was unwilling to participate, the next available household was interviewed. Before the survey was undertaken, a reconnaissance survey was conducted on 4 households within Katala Village (whose participants were excluded from the main survey), in order to test and enhance the legitimacy of the questionnaire [14,57].

In order to triangulate household survey data, as well as gather information relating to community related forest and livelihood activities, focus group discussion (FDGs) were employed in the study. With the help of the District Forest Officers and the local headmen, FDG participants were identified. These included elderly men and women who have lived in the area for a long time, as these were expected to be knowledgeable about forest resource use as well as land use practices over the years. Men and women of other age groups, including household heads, government employees at the schools and clinics, were also engaged in order to capture information on prevailing income generating activities as well as community related challenges in the area. Traditional leaders, specifically local headmen were particularly important in providing information relating to local forest resource use rules and access restrictions. The local headmen were also in charge of the overall order and organisation of the FGDs.

Three FGDs were held in three selected villages closest to the *Cryptosepalum* forest, i.e. Katala Village in Manyinga; and Chibumba and Mukenge Village in Zambezi District. A total of 68 discussants (21 in Manyinga, 25 in Mukenge and 22 in Chibumba) took part in the discussions. The FGDs were conducted to triangulate household survey data [14,18]. The wealth status ranking of each household was also established during FGDs. Discussants helped establish wealth categories as follows: Very poor, Poor, and Well-off. The household wealth ranking process was guided by Handavu et al. [14]. It included socio-economic characteristics like area of land under cultivation, size and quality of house they live in, owned property, owned livestock, and sources of income for the household. The FGDs lasted approximately 2 h.

2.4. Methods of data collection

The study employed three data collection methods: household interviews using a survey questionnaire, focus group discussions (FGDs), and direct observations. A semi-structured questionnaire (Appendix 1) comprising four main sections (Household Characteristics and Assets, Land Ownership, Farming Practices, and Forest Characteristics and Resource Use) was administered physically with the selected respondents at the interviewees' homes. The questionnaire was in English, however, during interviews, each question was orally translated into the local language (Luvale, Luchazi, Chokwe, and Mbunda) by four trained research assistants conversant with local languages. A total of c207 interviews were conducted (95 in 4 villages of Manyinga and 112 in 3 villages of Zambezi District).

Focus group discussions were also held with local community members in the selected villages described in Section 2.3. The questions that guided the discussions during FGDs are attached in Appendix 2. These included questions relating to the description of the *Cryptosepalum* forest (the Mavunda), common uses of the Mavunda, the status of the Mavunda, previous land uses in the area, prevailing land uses, forest cover changes and associated reasons, income generating activities in the area, as well as livelihood challenges being faced by the local people in the area. The FGDs were well attended by the desired local community members in each selected village, and lasted approximately 2 h.

Direct observations were also done during the interviews to counter-check some responses from respondents. Observations are important because they allow one to scrutinize what happens in real-life situations [58]. They also allow a researcher to corroborate data collected from other research methods [58]. In this study direct observations were specifically important to confirm livelihood activities in the area and whether the assets owned by the households were in line with the established wealth rankings.

2.5. Data analysis

Collected data were analyzed using the Statistical Package for Social Sciences (IBM SPSS) software version 23. Descriptive statistics such as percentages and proportions were used to summarise the demographic data. Contingency tables were generated, and Pearson's Chi-square association test was used to establish the relationships between various independent variables (gender, household size, level of education, wealth status, residence status) and the use of different forest products [26,59]. Further, the predictive ability of the above independent variables in influencing the use of forest products and perceived causes of land cover changes were assessed in a binary logistic regression model analysis [60]. This model was applied because it is suitable for establishing the influence of predictor variables on dichotomous dependent variables (i.e., with only two categories or values) [14,24,61]. The logistic regression model used in this study to determine the social and economic attributes likely to affect local communities' use and dependency on the *Cryptosepalum* forest is generally described as follows:

$$logit(Y) = In\left(\frac{\pi}{1-n}\right) = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \ldots + \beta_k X_{ki}$$

The logit is the natural logarithm (ln) of odds of Y, and odds are ratios of probabilities (π) of Y happening to probabilities (1−π) of Y not happening.

Where β0 is the intercept and β1, β2 … βk are the coefficients of the independent variables X1, X2 … Xk.

In the first instance, the outcome variable in the logistic regression model was forest products used by the local communities. The use of each forest product was input as a binary choice variable, with 1 = yes (indicating use) and 0 = otherwise. In the second instance, the outcome variables for the logistic regression model were perceived causes of forest cover loss, including timber harvesting, agriculture expansion, population increase and poor forest management. These variables were also classified as binary choice variables (1 = agreeing to the perceived cause and 0 = otherwise). Perceived causes such as fire, honey harvesting and settlements were insufficiently included in the model because only a few respondents mentioned them [14,18].

Data obtained from FGDs were analyzed objectively and subjectively [18,62] through content analysis. In this case, recorded responses from the FGDs were grouped systematically according to a discussion point, then objectively broken down into meaningful units of information [63], ascertaining the general community's stance or position on an issue that was discussed.

3. Results

3.1. Household demographic characteristics

Table 1 shows the main demographic attributes of respondents. Of the 207 interviewed, 82% of the respondents were males, whereas 18% were females. Over half (56%) of the respondents to the study have only gone up to primary school, and only about 7% have gone up to secondary school. About 37% indicated they had never attended school. Regarding wealth status, the well-off respondents accounted for 19 %, whereas the poor and very poor communities accounted for 53% and 28.50%, respectively. In both Manyinga and Zambezi, most of the respondents are under the poor category. Regarding residential status, the majority of respondents from both Manyinga (67%) and Zambezi (94 %) are local inhabitants. There were more migrants in Manyinga (33%) than in Zambezi (6%).

The study established 5 most dominant tribes in the study area, namely: Luchazi (44%); Luvale (33%); Lunda (18%); Bunda (3%); and Chokwe (1%). In Manyinga and Zambezi, the majority of respondents belongs to the 5–10 members' household size range, owning farmlands mainly within 0–2 ha (Ha). Similarly, the cultivated land size for most respondents is in the range of 0–2 Ha.

3.2. *Farming practices*

The study established shifting cultivation, mono-cropping, intercropping, and a mix of shifting and inter-cropping as the main farming practices in the study sites (Fig. 2). However, a significant difference was noted regarding farming practices between Manyinga and Zambezi districts (X2 = 63.921; df = 3, $p < 0.001$). Most (58%) respondents from Manyinga mainly practice mono-cropping, whereas in Zambezi, 39% practice shifting cultivation and 36% practice a combination of shifting cultivation and inter-cropping, with the main crops being Maize (91%) and Cassava (64%). Other crops grown at a small scale include groundnuts (8%), beans (6%), and sweet potatoes (5%). The main reasons for poor productivity for maize production were insufficient farming inputs (60%) and poor soil fertility (47%).

3.3. *Sources of household income*

The two main income sources in study sites are sale? of agricultural produce (59%) and piece work/part-time work (54%) (Fig. 3). However, respondents that indicated selling of agricultural produce as the main income source in Manyinga and Zambezi were significantly different (X2 = 29.050; df = 1; $p < 0.001$), with more respondents giving this reason in Zambezi (67%) than in Manyinga (49%). Similarly, respondents that mentioned piece-work/part-time work in Manyinga and Zambezi were significantly different (X2 = 33.364; df = 1; $p < 0.001$), with more respondents in Manyinga (76%) than in Zambezi (36%). Other sources of income mentioned include family business (Manyinga - 17%; Zambezi - 8%), full-time employment (Manyinga – 2%); charcoal selling (Manyinga – 2%); brick moulding (Manyinga 2%) and timber selling (Manyinga – 1%).

3.4. *Forest resources used and their abundance*

3.4.1. *Forest resource use*

The study established fourteen (14) forest products collected and used by household members in the study sites (Fig. 4). The most frequently obtained forest products include firewood (98%), mushrooms (48%), medicine (45%), wood fibre (41%), and wild fruits (35%). However, the study established some significant differences in preference for some forest products, namely: charcoal (X2 = 6.97; df = 1; p < 0.01), construction poles (X2 = 16.56; df = 1; p < 0.001), wild vegetables (X2 = 6.40; df = 1; p < 0.05) tubers (X2 = 80.37; df = 1; p < 0.001), caterpillars (X2 = 17.13; df = 1; p < 0.001), mushrooms (X2 = 9.23; df = 1; p < 0.01, wild fruits (X2 = 24.06; df = 1; p < 0.001), and thatching grass (X2 = 132.05; df = 1; p < 0.001) between respondents from Manyinga and those in Zambezi district. Except for the wild fruits, most households in Manyinga are less involved in collecting other forest products than those in Zambezi district.

Out of the fourteen (14) products, nine (9), including charcoal, firewood, medicine, roots/tubers, caterpillars, honey, mushrooms, thatching grass and wild animals, are harvested by every household regardless of their wealth status (Table 2). However, wealth status was significantly associated with the use of five (5) forest products namely; timber (X2 = 7.02; df = 2; p < 0.05; n = 14), construction poles (X2 = 6.12; df = 2; p < 0.05; n = 172), wild vegetables (X2 = 8.75; df = 2; p < 0.05; n = 19), wood fibre (X2 = 5,91; df = 2; p < 0.05; n = 180) and wild fruits (X2 = 8.16; df = 2; p < 0.05; n = 119). Except for timber, the very poor and poor households relied more on the other four (4) forest products than the well-off households.

The gender of the head of the household significantly influenced the use of construction poles (X2 = 10.65; df = 1; p < 0.001; n = 72), wood fibre (X2 = 19.38; df = 1; p=<0.001; n = 180), honey (X2 = 6.23; df = 1; p < 0.05; n = 70), and wild fruits (X2 = 5.29; df = 1; p < 0.05; n = 119), with the male-headed households obtaining more of these forest products (except for fruits) compared to those households headed by females.

Table 1
Demographic characteristics of respondents from Manyinga and Zambezi.

Demographic characteristics	Category of demographic characteristics	Manyinga District (%)	Zambezi District (%)	Both districts (%)
Gender	Male	85.3	79.5	82.1
	Female	14.7	20.5	17.9
Education Level	No school	18.9	52.7	37.2
	Primary	75.8	39.3	56.0
	Secondary	5.3	8.0	6.8
Wealth category	Very poor	21.1	34.8	28.5
	Poor	54.7	50.9	52.7
	Well-off	24.2	14.3	18.8
Residential status	Indigenous	67.4	93.7	81.7
	Migrants	32.6	6.3	18.3
Household size	Mode range	5–10		44.9
Land holding size, Ha	Mode range	0–2		58.8
Cultivated land size, Ha	Mode range	0–2		57.7

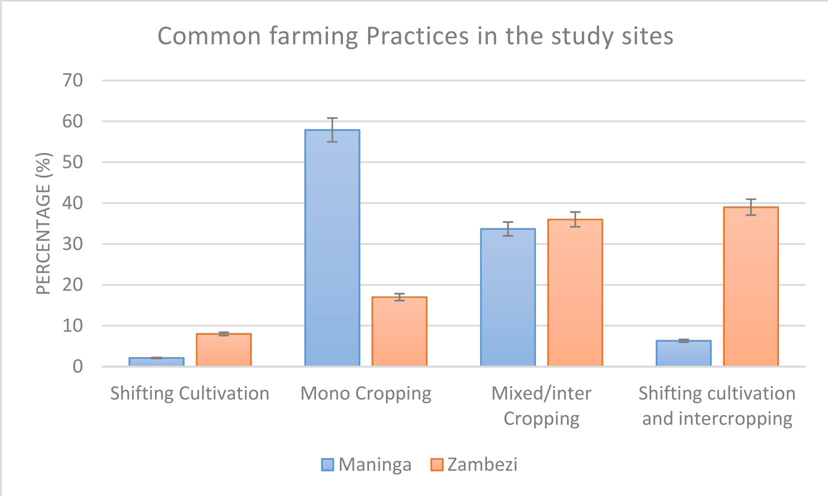

Fig. 2. Farming practices in Manyinga and Zambezi Districts.

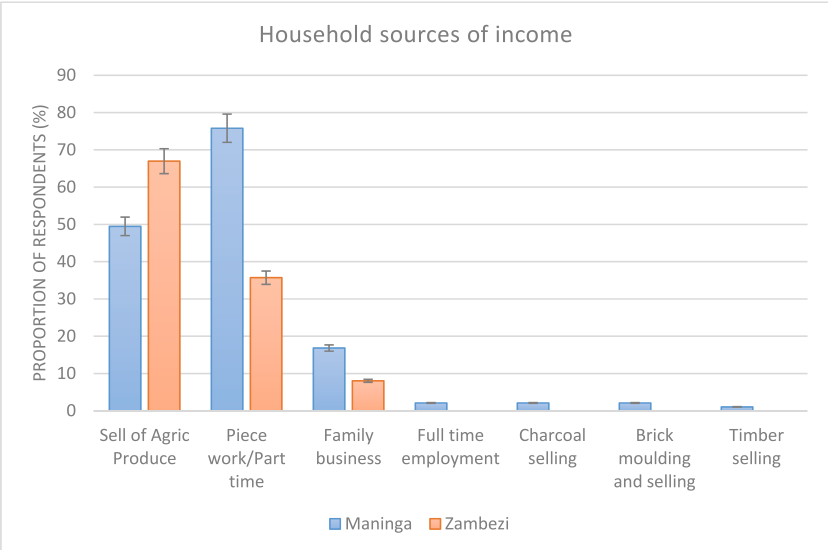

Fig. 3. Sources of income for respondents in Manyinga and Zambezi district.

The level of education had a positive relationship with the use of timber (X2 = 31.03; df = 2; $p < 0.001$; n = 14), roots/tubers (X2 = 7.54, df = 2; $p < 0.05$; n = 65), caterpillars (X2 = 7.45; df = 2; $p < 0.05$; n = 160), mushrooms (X2 = 6.95; df = 2; $p < 0.05$; n = 176) and thatching grass (X2 = 19.20; df = 2; $p < 0.001$; n = 105). Besides the use of timber, the study established that the less educated (no education–primary school level) were the most users of all the other forest products compared to those who had attained secondary school level.

3.4.2. Abundance of forest products

The abundance of each forest product was also assessed in the study (Table 3). A total of 9 forest products were perceived to be abundant (over 50%) by local communities in Manyinga, namely: firewood (98%), construction poles (94%), wood fibre (91%), medicine (86%), mushroom (87%), honey (78%), wild fruits (71%), roots/tubers (66%), and caterpillars (60%). In the Zambezi district, a total of 10 forest products were perceived to be abundant, namely: firewood (95%); wood fibre (89%); thatching grass (89%); %); caterpillars (79%); construction poles (74%); roots/tubers (73%); medicine (73); mushrooms (69%); wild fruits (59%); and wild vegetables (57%).

Statistical differences were observed in the level of abundance of 10 forest products in Manyinga and Zambezi districts, including timber (X2 = 19.33; df = 2, $p < 0.001$); charcoal (X2 = 21.56; df = 2; $p < 0.001$); construction poles (X2 = 16.51; df = 2; $p < 0.001$); medicine (X2 = 18.40; df = 2; $p < 0.001$); wild vegetables (X2 = 61.77; df = 4; $p < 0.001$); fibre (X2 = 10.48; df = 3; p = 0.015); honey

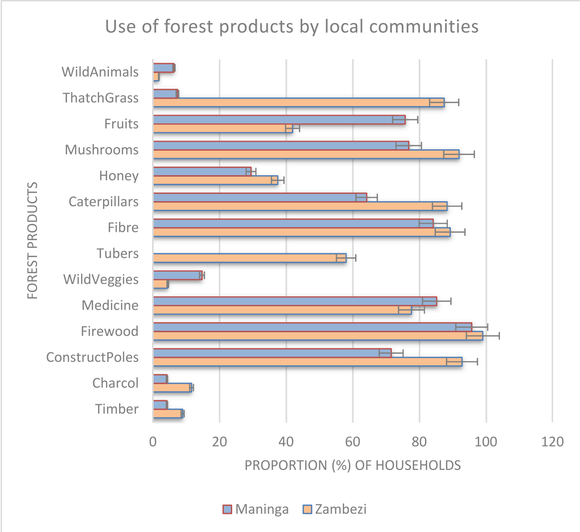

Fig. 4. Forest products used by respondents in the study area.

Table 2
Statistical associations of the use of forest products against different socio-economic factors.

Product	Statistical association with different Socio-economic factors											
	Gender df = 1		*Education df = 2*		Household size		Wealth status		Residence status		*District df = 1*	
	χ2	p-value	χ2	p-value	χ2	p-value	χ2	p-value	χ2	p-value	χ2	p-value
Timber	3.268	0.071	31.034	0.001[a]	9.050	0.060	7.021	0.030[a]	1.035	0.309	1.814	0.178
Charcoal	1.814	0.178	3.304	0.912	5.238	0.264	1.116	0.572	0.007	0.933	6.973	0.008[a]
Construction poles	10.654	0.001[a]	4.224	0.121	11.485	0.022[a]	6.123	0.047[a]	4.802	0.028[a]	16.565	0.000[a]
Firewood	1.115	0.291	4.020	0.134	1.265	0.867	2.192	0.334	1.152	0.283	2.400	0.121
Medicine	1.975	0.160	0.420	0.810	8.012	0.091	3.889	0.142	3.647	0.060	1.934	0.164
Wild vegetables	0.067	0.796	0.212	0.900	9.996	0.040[a]	8.753	0.013[a]	2.399	0.121	6.401	0.011[a]
Roots/tubers	0.292	0.589	7.544	0.023[a]	16.697	0.002[a]	0.950	0.622	11.939	0.001[a]	80.371	0.000[a]
Wood fibre	19.386	0.001[a]	1.318	0.517	2.994	0.559	5.910	0.005[a]	1.187	0.276	1.167	0.280
Caterpillars	0.030	0.862	7.452	0.024[a]	24.697	0.000[a]	2.804	0.246	0.025	0.873	17.127	0.000[a]
Honey	6.345	0.013[a]	2.789	0.248	1.647	0.800	5.119	0.077	3.388	0.066	1.480	0.224
Mushrooms	0.076	0.783	6.953	0.031[a]	3.124	0.537	4.621	0.099	0.024	0.876	9.231	0.002
Wild fruits	5.295	0.021[a]	3.599	0.165	17.581	0.001[a]	8.161	0.017[a]	2.276	0.131	24.064	0.000[a]
Thatching grass	0.200	0.655	19.200	0.000[a]	34.866	0.000[a]	4.227	0.121	16.395	0.000[a]	132.047	0.000[a]
Wild animals	0.164	0.686	0.984	0.612	4.111	0.391	3.328	0.189	1.871	0.171	2.839	0.092

Additionally, household size was observed to be significantly associated with the use of construction poles (X2 = 11.48; df = 4; p < 0.05; n = 172), wild vegetables (X2 = 9.99; df = 4; p < 0.05; n = 19), roots/tubers (X2 = 16.69; df = 4; p < 0.01; n = 65), caterpillars (X2 = 24.69; df = 4; p < 0.001; n = 160), wild fruits (X2 = 17.58; df = 4; p < 0.001; n = 119), and thatching grass (X2 = 34.86; df = 4; p < 0.001; n = 105).
The residence status significantly influenced the use of construction poles (X2 = 4.80; df = 1; p < 0.05; n = 172), roots/tubers (X211.93; df = 1; p < 0.001; n = 65), and thatching grass (X2 = 16.395; df = 1; p < 0.001; n = 105), with the indigenous people being more involved in the collection of forest products than migrants.
[a] Significant at 0.05 level of confidence.

(X2 = 23.98; df = 3; p < 0.001); mushrooms (X2 = 9.46; df = 2; p < 0.01); fruits (X2 = 8.70; df = 2; p < 00.05); and thatching grass (X2 = 77.91; df = 2; p < 0.001). The study established that except for charcoal, wild vegetables, and thatching grass, the other forest products were perceived to be more abundant in Manyinga than in the Zambezi district.

3.4.3. *Determinants of forest product utilisation*

A binary logistic regression model was applied to assess the predictive ability of five (5) social and economic elements, namely: gender, level of education, size of household, wealth status and residence status, in influencing households' utilisation of forest products. The results of the Omnibus test of model coefficients revealed a good fitting model for 9 out of the 14 forest products used by the local communities, with the exception of charcoal, firewood, medicine, wild vegetables and wild animals, whose Omnibus test of model coefficients' p values were more than 0.05 (Appendix 3). Thus, Table 4 shows results of the models containing statistically significant Omnibus test of model coefficients. Detailed results of the full models showing the influence of each predictor variable on use of all forest products are shown in Appendix 4.

Table 3
Level of Abundance of forest products.

Product	Level of abundance (%) Manyinga					Level of abundance (%) Zambezi				
	Abundant	Not Abundant	Don't know	No longer abundant	Not found	Abundant	Not Abundant	Don't know	No longer abundant	Not found
Timber	21.1	43.1	0.0	34.7	0.0	8.9	25.0	0.0	96.4	0.0
Charcoal	13.7	86.3	0.0	0.0	0.0	31.2	58.9	9.8	0.0	0.0
Construction poles	93.7	5.3	0.9	0.0	0.0	73.7	25.3	1.0	0.0	0.0
Firewood	97.9	2.1	0.0	0.0	0.0	94.6	8.9	0.0	0.0	0.0
Medicine	85.7	8.0	0.0	0.0	0.0	72.6	27.4	0.0	0.0	0.0
Wild vegetables	29.5	46.3	8.4	4.2	11.6	57.1	31.2	9.8	0.0	1.8
Roots/tubers	66.3	25.3	8.4	0.0	0.0	73.2	25.0	1.8	0.0	0.0
Wood fibre	91.1	0.9	0.9	3.6	0.0	89.5	3.2	7.4	0.0	0.0
Caterpillars	60.5	27.4	3.1	0.0	0.0	79.5	18.7	1.8	0.0	0.0
Honey	77.9	20.0	2.1	0.0	0.0	45.5	48.2	2.7	3.6	0.0
Mushrooms	86.6	11.6	1.8	0.0	0.0	69.5	28.4	2.1	0.0	0.0
Wild fruits	71.4	25.0	0.0	3.6	0.0	58.9	41.1	0.0	0.0	0.0
Thatching grass	30.5	65.3	4.2	0.0	0.0	89.3	8.0	2.7	0.0	0.0
Wild animals	0.0	74.7	1.1	24.2	0.0	0.0	83.0	0.0	16.9	0.0

The model revealed that predictor variables had varying influences on use of particular forest products. For example, while the collection and use of timber was significantly associated with the level of education ($p = 0.025$), a households' use and collection of construction poles was significantly influenced by all the 5 predictor variables (gender $p < 0.01$; education level $P < 0.05$; household size $p < 0.001$; wealth status $p < 0.001$; residence status $p < 0.05$). Gathering and use of tubers was significantly determined by the level of education ($p < 0.05$), household size ($p < 0.001$); wealth status ($p < 0.005$) and residence status ($p < 0.01$), whereas gathering and use of wood fibre was significantly determined by gender of the household head ($p < 0.001$), with the males being the most involved in the collection of this product. Collection of caterpillars was significantly determined by household size ($p < 0.05$) whereas honey harvesting was significantly determined by the gender $p < 0.05$), level of education ($p < 0.01$) as well as the wealth status (very poor $p < 0.05$ and poor, $p < 0.05$) of the household. Collection of mushrooms was also significantly influenced by the level of education (no education, $p < 0.01$) and the wealth status (very poor, $p < 0.01$) of the household. Collection of fruits was significantly influenced by gender ($p < 0.05$) and household size ($p < 0.001$). The bigger the family size in a particular household, the higher the likelihood of collecting wild fruits for consumption. Collecting grass for thatching was significantly determined by level of education (no education, $p < 0.05$); size of the household ($p < 0.001$); and residential status ($p < 0.001$), with the migrants being more influential on the use than the indigenous inhabitants.

Through the Exp (B) values (Table 4), the model also shows the most likely scenario of an independent variable (socio-economic factors) influencing a dependant variable. For example, for timber, although all the five socio-economic factots were likely to influence use, it would seem gender and education level were more likely to influence use (i.e. 6 times and 4 times more than the other factors respectively). Whereas for construction poles, gender and wealth status were both 4 times more likely to influence use than the rest of the socio-economic factors. Similarly, gender and wealth status were also more likely to influence use of fibre, caterpillars and honey than the other factors. Wealth status was 2 times more likely to influence collection of mushrooms, whereas gender, household size, and residence status were 2 times more likely to influence the collection of fruits.

3.5. Land clearance and perceptions on the status of forest cover

3.5.1. Land clearance

The results show that approximately 67% of the respondents have cleared land in the study sites in the last 10 years. A chi-square test of independence showed that respondents who have cleared land in Zambezi are significantly more than those from Manyinga districts ($X2 = 17.25$; $df = 1$; $p < 0.001$). The land cleared per household mainly ranged from 0 to 2 Ha and the main reasons for clearing land included; increasing agricultural productivity (64%), loss of soil fertility of previous land (23%), and recently allocated farmland (13%). A statistical difference was observed between the two districts in regard to the reasons given for land clearing ($X2 = 9.98$; $df = 2$; $p < 0.01$). There were more respondents from Zambezi indicating increasing agricultural productivity (74%) and loss of soil fertility of previous land (32%) as reasons for land clearing compared to those that mentioned the same reasons (57%) and (16%) in Manyinga district respectively. However, more respondents in Manyinga (21%) indicated that they cleared land because the land was recently allocated to them compared to those from Zambezi (2%).

3.5.2. Perceptions on the extent of forest cover

Local peoples' perceptions of the forest cover of the *Cryptosepalum* forest was assessed. All (100%) respondents from Manyinga perceived a reduction in forest cover in the study site over the years. Most (88%) of respondents in Zambezi also indicated reduced forest cover with only 11.61% indicating that there has been no change.

Seven reasons were established as reasons for forest cover loss in the two study areas (Fig. 5), with timber harvesting being perceived as the main reason (96%) for forest cover loss in Manyinga district, whereas agriculture (63%) and population increase

Table 4
Influence of socio-economic elements on use of different forest products.

Dependent variable	Independent variable	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
								Lower	Upper
Timber	Gender	17.919	6180.660	0.000	1	0.998	6.052–8	0.000	
	Education level	1.363	0.609	5.002	1	0.025[a]	3.906	1.183	12.892
	Household Size	−0.181	0.268	0.457	1	0.499	0.834	0.494	1.410
	Wealth status	0.612	0.538	1.296	1	0.255	1.845	0.643	5.294
	Residence Status	0.708	0.670	1.117	1	0.291	2.031	0.546	7.555
Construction poles	Gender	1.411	0.511	7.633	1	0.006[a]	4.102	1.507	11.165
	Education level	−0.864	0.416	4.321	1	0.038[a]	0.421	0.187	0.952
	Household Size	−1.077	0.244	19.474	1	0.000[a]	0.341	0.211	0.549
	Wealth status	1.573	0.448	12.335	1	0.000[a]	4.819	2.004	11.592
	Residence Status	−1.034	0.498	4.308	1	0.038[a]	0.356	0.134	0.944
Tubers	Gender	−0.149	0.455	0.107	1	0.744	0.862	0.353	2.103
	Education level	−0.780	0.328	5.648	1	0.017[a]	0.459	0.241	0.872
	Household Size	−0.746	0.189	15.521	1	0.000[a]	0.474	0.327	0.687
	Wealth status	0.672	0.310	4.703	1	0.030[a]	1.958	1.067	3.594
	Residence Status	−1.884	0.633	8.853	1	0.003[a]	0.152	0.044	0.526
Fibre	Gender	1.906	0.518	13.566	1	0.000[a]	6.728	2.440	18.552
	Education level	−0.677	0.415	2.669	1	0.102	0.508	0.225	1.145
	Household Size	−0.182	0.226	0.651	1	0.420	0.834	0.536	1.297
	Wealth status	0.519	0.422	1.516	1	0.218	1.680	0.736	3.839
	Residence Status	−0.426	0.528	0.650	1	0.420	0.653	0.232	1.840
Caterpillars	Gender	0.242	0.485	0.249	1	0.618	1.274	0.492	3.298
	Education level	−0.633	0.331	3.660	1	0.056	0.531	0.278	1.016
	Household Size	−0.392	0.162	5.829	1	0.016[a]	0.676	0.491	0.929
	Wealth status	0.071	0.309	0.052	1	0.820	1.073	0.585	1.967
	Residence Status	−0.117	0.439	0.071	1	0.789	0.889	0.376	2.102
Honey	Gender	1.346	0.518	6.752	1	0.009[a]	3.841	1.392	10.601
	Education level	−0.988	0.321	9.489	1	0.002[a]	0.372	0.199	0.698
	Household Size	−0.117	0.153	0.583	1	0.445	0.890	0.659	1.201
	Wealth status	0.689	0.285	5.833	1	0.016[a]	1.992	1.139	3.485
	Residence Status	−0.688	0.452	2.318	1	0.128	0.503	0.207	1.219
Mushrooms	Gender	−0.123	0.581	0.045	1	0.832	0.884	0.283	2.762
	Education level	−1.222	0.405	9.099	1	0.003[a]	0.295	0.133	0.652
	Household Size	−0.279	0.195	2.050	1	0.152	0.757	0.517	1.108
	Wealth status	0.947	0.388	5.947	1	0.015[a]	2.578	1.204	5.519
	Residence Status	0.198	0.532	0.139	1	0.710	1.219	0.430	3.458
Fruits	Gender	0.953	0.424	5.052	1	0.025[a]	2.594	1.130	5.958
	Education level	−0.258	0.291	0.787	1	0.375	0.773	0.437	1.366
	Household Size	0.618	0.164	14.153	1	0.000[a]	1.856	1.345	2.561
	Wealth status	0.011	0.271	0.002	1	0.967	1.011	0.595	1.718
	Residence Status	0.717	0.404	3.159	1	0.075	2.049	0.929	4.519
Thatching grass	Gender	0.028	0.459	0.004	1	0.951	1.029	0.418	2.531
	Education level	−0.970	0.320	9.218	1	0.002[a]	0.379	0.203	0.709
	Household Size	−0.980	0.191	26.329	1	0.000[a]	0.375	0.258	0.546
	Wealth status	0.503	0.295	2.916	1	0.088	1.654	0.928	2.948
	Residence Status	−1.759	0.452	15.149	1	0.000[a]	0.172	0.071	0.418

[a] Significant at 0.05 level of confidence.

(39%) were perceived as the main reasons for forest cover loss in Zambezi district. The other perceived reasons with little influence included settlements, poor forest management, fires and honey harvesting.

Using the Chi-square test of independence, the study established some statistical differences in regards to some of the perceived reasons for forest cover loss between Manyinga and Zambezi District, namely: timber harvesting ($\chi 2 = 139.670$, df = 1; $p < 0.001$); Agricultural activities ($\chi 2 = 37.392$, df = 1; $p < 0.001$); population increase ($\chi 2 = 9.277$, df = 1; $p = 0.002$); and poor forest management ($\chi 2 = 6.041$, df = 1; $p = 0.014$).

3.5.3. Determinants of loss of forest cover

This research work further sought to determine the likelihood of five predictive social and economic variables (i.e. gender of household head, level of education, size of household wealth status, and residence status) in influencing loss of forest cover in the study sites. Thus, four regression models containing timber harvesting, agricultural expansion, population increase, and fire were developed. Settlements, poor forest management and honey harvesting were discarded from the model, as these were only mentioned by a few respondents to the study and were, therefore, insignificant. Pooled results of the model with the Omnibus Test of Model Coefficients revealed a good fitting model with timber harvesting ($X2 = 70.306$; df = 10; $p < 0.001$), agricultural expansion ($X2 = 43.340$; df = 10; $p < 0.001$); and population increase ($X2 = 24.727$; df = 10; $p < 0.01$) showing significant values.

The results of the regression model analysis showed that gender ($p < 0.05$), particularly female members had a significant influence

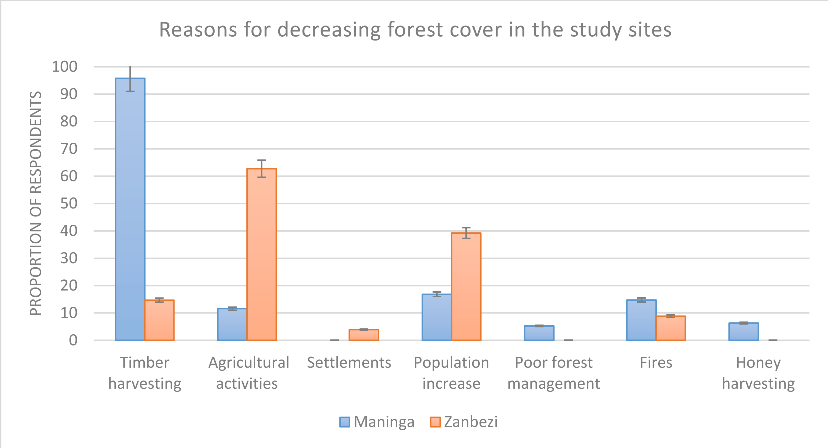

Fig. 5. Local peoples' perceived reasons for forest cover loss.

on engagement in agricultural activities in the study sites (Table 5; Appendix 5). The size of the household ($p < 0.05$) as well as the residence status ($p < 0.01$) also significantly influenced involvement in agricultural expansion activities. The larger the household the more engagement in agricultural activities, whereas the local inhabitants ($p = 0.001$) influenced engagement in agricultural activities more than the migrants (Appendix 5). The level of education influenced population increase ($p < 0.05$), with the less educated (no education, $p < 0.01$; primary education, $p < 0.01$) being significant determinants of population growth (Appendix 5). The level of education, particularly the secondary school level ($p < 0.01$) influenced engagement in timber harvesting practices. Households bigger in size ($p < 0.001$) also significantly influenced involvement in timber harvesting activities.

The regression model further showed that gender was 3 times more likely to influence engagement in agricultural expansion activities than the other factots, whereas the level of education was 2 times more likely to influence population growth and 5 times more likely to influence engagement in timber harvesting activities than the other factors. In addition, residence status was 6 times more likely to influence engagement in timber harvesting activities (Table 5).

4. Discussion of results

4.1. Household income sources and farming practices

Selling of agricultural produce and piece work/part-time work were observed to be the common income sources in the study sites. Similar observations have been made in the Bereku Forest of Tanzania [26] and the Zambezi Region of Namibia [18]. A study on the Copperbelt Miombo woodlands of Zambia also reported that selling farm products was an essential source of revenue for families [14].

Table 5
Influence of social and economic elements on land use and land cover change.

Dependent variable	Independent variable	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B) B	
Agriculture	Gender	1.005	0.483	4.326	1	0.038[a]	2.733	1.060	7.048
	Education level	−0.404	0.321	1.585	1	0.208	0.668	0.356	1.252
	Household Size	−0.388	0.163	5.670	1	0.017[a]	0.678	0.493	0.934
	Wealth status	0.077	0.298	0.067	1	0.796	1.080	0.602	1.937
	Residence Status	−2.512	0.750	11.230	1	0.001[a]	0.081	0.019	0.352
Population increase	Gender	−0.746	0.443	2.829	1	0.093	0.474	0.199	1.131
	Education level	0.627	0.312	4.033	1	0.045[a]	1.872	1.015	3.453
	Household Size	0.174	0.152	1.316	1	0.251	1.191	0.884	1.604
	Wealth status	0.148	0.294	0.254	1	0.614	1.160	0.652	2.064
	Residence Status	−0.609	0.464	1.725	1	0.189	0.544	0.219	1.350
Timber harvesting	Gender	0.071	0.445	0.025	1	0.873	1.074	0.449	2.569
	Education level	1.573	0.448	12.335	1	0.000[a]	4.819	2.004	11.592
	Household Size	0.789	0.175	20.272	1	0.000[a]	2.202	1.562	3.105
	Wealth status	−0.052	0.286	0.033	1	0.856	0.950	0.542	1.663
	Residence Status	1.869	0.465	16.172	1	0.000[a]	6.483	2.607	16.123
Fire	Gender	0.241	0.630	0.146	1	0.703	1.272	0.370	4.377
	Education level	−0.609	0.445	1.873	1	0.171	0.544	0.227	1.301
	Household Size	0.085	0.227	0.142	1	0.706	1.089	0.699	1.698
	Wealth status	0.150	0.400	0.141	1	0.708	1.162	0.530	2.545
	Residence Status	0.336	0.548	0.375	1	0.540	1.399	0.478	4.099

[a] Significant at 0.05 level of confidence.

However, in the former study, charcoal production was reported as the first and most crucial income source in the study sites [14]. In the current study, respondents who earned income from agriculture in Zambezi were significantly more than those in Manyinga. The reverse was true for those involved in piece-work/part-time work in Manyinga and Zambezi districts. Some community members in Manyinga indicated that they have no markets to sell their agricultural produce and were unable to take their agricultural produce for sale to Central Manyinga district markets due to the bad road network. Thus, most of their produce were mainly for home consumption. Apart from selling of charcoal and timber, no other income source from forest related activities was mentioned by the respondents. Findings of the current study are different from other studies within the region, (e.g. Refs. [14,15,21,51], which revealed community dependency on forest products (such as charcoal, mushrooms, caterpillars, honey) for income generation. This may be attributed to the fact that in this study, the selected study sites are remote and underdeveloped, with the nearby town centres having very low population, thus resulting in very low demand for the products. Inaccessibility of the rural areas due to poor road networks may also compound the problem. As reported by scholars, distance and accessibility to the markets can influence the extraction of forest products for income [9,20]. Findings of this study, however, are similar to that on the Miombo woodlands of Kipambawe division of South-west Tanzania [21], which established that community members in the study site did not gather woodland products for income generation but for home consumption.

The current study established that shifting cultivation, mono-cropping, intercropping, and a mix of shifting and inter-cropping are the key farming practices in the study area. Significant differences were observed between the farming practices in Manyinga and Zambezi, with households in Manyinga mainly practicing Mono-cropping. In contrast, those in Zambezi mainly practicing shifting cultivation or a combination of shifting cultivation and inter-cropping. We observed that community members in Zambezi were more involved in agricultural activities, specifically shifting cultivation, than in Manyinga. Shifting cultivation was also reported as the predominant farming system among farmers in rural areas of Copperbelt Miombo woodlands [14]. In the current study, poor soil fertility is the main reason for practicing shifting cultivation. These findings reinforce earlier predictions on the potential of shifting cultivation practices in the *Cryptosepalum* forest due to its existence on poor nutrient soils Hogan and WWF [53]. The shifting cultivation practices in the villages of Zambezi could also explain why more open than dense forest areas were observed in the *Cryptosepalum* forests of Zambezi than Manyinga District [54]. Shifting cultivation is reported to significantly contribute to forest cover change in most African ecosystems [14,64,65] and is thus an important factor to consider in the development of policies and strategies aimed at forest conservation.

Furthermore, unlike in the Manyinga site, where access to forest resources is only permitted in areas outside the forest reserve, access to forest areas in the Zambezi site is open to community members. Therefore, community members in the Zambezi site easily practice shifting cultivation. In addition, the forest areas in the Zambezi site were previously under timber concession licenses, which has led to the opening up of forest areas for other land uses. For example, a response by one of the respondents from Zambezi during a FGD after being probed about the on-going shifting cultivation practices was that:

> '*We practice shifting cultivation in the open areas. These areas were opened up by timber harvesters and not us'. The forests are gone, the timber is already finished. There is nothing out there to protect'*

The above response supports previous researchers who reported that forest logging often sets the stage for various interventions and synergies that can lead to deforestation and forest degradation or transformation of the forest into other land uses Putz and Redford [66] and Chazdon [67]. For example, the forest areas of Zambezi have been opened up for agricultural activities after the cessation of logging activities which involved harvesting of *Guibourtia coleosperma* (Rosewood) which co-exists with the *Cryptosepalum exfoliatum* in the *Cryptosepalum* forest. Although farming practices are also conducted in Manyinga, these are mainly restricted to farmlands. In addition, because of the restriction of access due to the presence of a forest reserve in Manyinga, the local people are more aware and sensitive about the rules concerning unpermitted cutting down of trees. This was established during FGDs as confirmed by the headman of one of the villages in Manyinga, that local community members were aware of where they could collect forest products. An issue of concern, however, is the potential commencement of shifting cultivation practices in Manyinga following the cessation of timber harvesting practices [66]. These findings, therefore, call for the need to design appropriate management strategies and interventions, considering potential forest degradation that may occur from such land uses.

4.2. Forest resource use and factors influencing its use

Of the 14 forest products, firewood is the most commonly obtained in both the Manyinga and Zambezi sites, with over 98 % of respondents depending on the product as an energy source. The study established that firewood is collected by the local communities, regardless of their wealth rank, size of household, level of education, head of the households' gender, and residence status. These findings agree with several studies elsewhere including in Tanzania [21], in Kenya [9] and in Pakistan [15] which have also demonstrated rural communities' dependence on firewood for energy. Although the potential impact of firewood collection was not studied, tree disturbance for firewood collection purposes has been reported to contribute to land cover changes elsewhere [33,48,68], especially in densely populated areas. In the current study, other more frequently obtained forest products include mushrooms, medicine, wood fibre and wild fruits. These results are congruent with those on the Zambian [14] and Tanzanian [4] Miombo woodlands.

Interestingly, this study established some differences in the use of forest products between village communities in the Manyinga and Zambezi Sites. Except for wild fruits, households in the Zambezi site are more involved in collecting and using 7 forest products namely; charcoal, construction poles, wild vegetables, tubers, caterpillars, mushrooms, and thatching grass. The potential reason for more involvement in forest resource use by communities in Zambezi district may be the unregulated access to forest areas compared to

Manyinga, where people are restricted to collect forest products only in open areas surrounding the Lusongwa forest reserve. These findings indicate the potential influence of land tenure systems on the use of forest products [9,69,70]. Despite having more forested lands (therefore more abundant forest resources), households in Manyinga do not collect as many forest products due to zone access restrictions which specify that community members can only collect products not part of the forest reserve. In contrast, the forested areas around the *Cryptosepalum* forest of Zambezi are under an open access regime to community members, thus enabling members to be more active in using and collecting forest resources. These findings reiterate reports that rural peoples' reliance on forest resources is also determined by governing institutions and policies that prohibit or allow access to these forests [20].

4.2.1. Influence of household size on use of forest resources

The majority of interviewees in both Manyinga and Zambezi sites indicated household size ranging from 5 to 10 members. This study established that household size was significantly associated with the use of construction poles, wild vegetables, roots/tubers, caterpillars, wild fruits and thatching grass. Household size is believed to determine the per capita gathering and use of forest products [26]and therefore influences human impact on forest resources. Regarding construction poles and thatching grass, the most possible reason for this discovery is that bigger families have a higher likelihood of requiring more/bigger housing units to accommodate the big number of household members, thus demanding more construction poles and thatching grass for constructing and roofing the houses [14,26,51]. Similarly, the significant association of household size to collection of wild vegetables, roots/tubers, caterpillars and wild fruits indicate that bigger families compared to smaller ones, require more of these products, in order to meet their basic needs [2,16]. These findings are also in agreement with findings observed in Ethiopia [2], Burkina Faso [24] and Uganda [47] which revealed a significant relationship amid forest dependence and size of a household. In other studies, household size significantly correlates with environmental degradation [71,72]. Thus the size of a household is a key pointer of how population growth can negatively affect forest resources [14].

4.2.2. Influence of level of education on forest resource use

In this study, the levels of education of respondents from the villages of both Manyinga and Zambezi were relatively low, with very few completing secondary school. This could be qualified by the absence of secondary schools in the two sites where the study was conducted. This study established that children from the villages in Manyinga have to go to central Manyinga District for secondary education, which is approximately 21.5 km from the nearest village (Sawime), and 50 km from the furthest village (Katala). Similarly, children from the villages of Zambezi have to go to Central Zambezi District for secondary education, approximately 30 km from the nearest village (Sachiseya), and 50 km from the furthest village (Chibumba). Therefore parents have to either organise accommodation for the children in central Manyinga or central Zambezi Districts, or the children end up stopping school (due to lack of finances) at primary or junior secondary school level. In most cases, the girls get married at very tender ages, whereas the boys start to engage in piece work to earn a living. The low levels of education in the selected sites of this study indicate fewer livelihood options and, therefore, more dependence on local forest resources [14,21,73]. For example, in this study, education significantly influenced timber extraction as well as use of non-timber forest products like caterpillars, mushrooms, and thatching grass. On the one hand, the more educated respondents (up to the secondary level) were more engaged in timber harvesting activities than the less educated. On the other hand, the less educated respondents (no education-primary school level) were more involved in the collection of NTFPs and were thus likely to depend more on forest products [14,21,73]. Findings of this study are consistent with those findings obtained elsewhere, indicating that the less educated are more likely to be forest-dependant than the more educated members of the rural community. For example, in the Chobe enclave of Botswana, forest dependency was observed to be decreasing with increasing level of eduction [21]. Similar results were observed in southern Burkina Faso [24]; in Chiradzulu District of Malawi [28] and in the Copperbelt Miombos of Zambia [14]. Education is expected to influence a household's engagement in various livelihood activities. For example, higher education improves economic power and a broader asset base [20,28], thus reducing forest dependence [21]. Therefore, education is an enabling factor that could provide livelihood alternatives for forest-dependent communities, thus diverting them from gathering forest resources.

4.2.3. Influence of wealth status on forest resource use

The study established that most households in the sampled villages of Manyinga and Zambezi districts were generally poor. During the focus group meetings, discussants felt that no one in their communities was fit to be labelled as rich. Thus, the household was either very poor, poor, or well-off. Unfortunately, the established poverty levels in the sampled villages indicate a likelihood of high forest dependency by the local people. As noted by researchers, the poor than the rich are more resource dependent [20], and most of their daily needs are usually derived from forests. In the current study, however, wealth status had little influence on the use of forest products, as most households collect and use many forest products (9 out of 14 products) regardless of their wealth status. This finding reflects the initial report given during Focus Group Discussions that the communities were generally poor and that none of the community members could be rated "rich" in the wealth categorisation process. The findings are also similar to those in the rural Miombo woodland of Kipembawe division, south-west of Tanzania, which established that 19 products were used by community members regardless of their economic status [4]. These findings reiterate that whether well-off or poor, community members depend on nearby forest resources for goods and services, either because they have no other alternatives, are accustomed to the forest resources, or cannot afford existing alternatives. All the sites surveyed in this study are found in remote areas of Manyinga and Zambezi districts, which are far from the central business areas. Most local people in these areas have limited access to the markets and central district areas, therefore, limited access to alternative sources of livelihood. Thus, the goods and services they have ready access to are mainly the products commonly gathered by community members as well as products collected from nearby forests. Findings of the current study, however, contradict other observations [14,39,74] which reported that households and individuals with low income levels were more dependent on forest products than their richer counterparts in the Miombo woodlands. The study on the Copperbelt Miombos of Zambia, for example established that wealth status influenced the use of many forest products, including firewood collection [14]. In the current study, and similar to others [4,9], firewood was established as the key source of energy in the villages of both Manyinga and Zambezi, and is thus collected and used by both the poor and well-off community members. Interestingly however, is the significant relationship observed between wealth status and engagement in timber harvesting activities. The study established that most households involved in timber harvesting activities were classified as well-off than poor. This is probably because their engagement in timber harvesting activities requires much higher investments and results in higher returns; economic power and therefore are able to own more valuable assets (e.g. motor bike, television, and satellite dish), build better housing units (i.e. with cement blocks and iron sheets), and own more livestock and farm land. Important to note, however, is that only a minority of the respondents indicated their involvement in timber harvesting activities in both Manyinga and Zambezi Districts.

4.2.4. Influence of gender on forest resource use

In this study, gender had no significant relationship with the use of most forest products, except for construction poles, wood fibre, honey harvesting, and wild fruits. Men were found to be more involved in using construction poles, wood fibre, and honey harvesting, whereas women were more engaged in collecting wild fruits than men. These findings agree with other studies which report that men are more involved in activities involving wood extraction (e.g. collection of wood for sale, carpentry and construction purposes) [18,20,32]; honey harvesting and hunting of wild animals [20,32,33]. Whereas, women are mostly involved in collecting NTFPs [20,33], which in the current study was collecting wild fruits. A study in the Zambezi region of Nambia, established more engagement of men than women in collecting construction poles, whereas women were more involved in collecting NTFPS, such as thatching grass and reeds [18]. In the Zambian Copperbelt Miombos, it was established that men are more involved in charcoal and honey production, whereas women are more involved in collecting wild fruits [14]. Findings of the current study, as well as findings by other researchers [14,18,20,75] regarding the effect of gender on consumption of products collected from forests are especially important in developing management strategies for sustainable forest resource use, targeting women and men. For example, regarding the collection of wood materials, the targeted management strategies for conservation purposes should mainly focus on the male members of the community, whereas management and conservation strategies regarding collection of NTFPs should be mainly targeted to women, as they are usually the most active participants in the collection of these products.

4.2.5. Influence of residence status on forest resource use

The majority of respondents from both Manyinga (67.4%) and Zambezi (93.75%) are local inhabitants. This shows that there is a low influx of people into the study area. Similarly, a study in West Africa found that more households in Nigeria (83%) and Cameroon (63%) were headed by non-migrants. The low immigration rates in the selected sites of this study could be due to the reason that the villages where the study was conducted are not easily accessible, have fewer livelihood alternatives, and therefore not very appealing to migrants. These findings concur with earlier reports which indicated that the *Cryptosepalum* forest is generally inaccessible. Research shows that the absence of conflicts in an area or region also contributes to low migration [76]. Our study region in particular and Zambia in general has not experienced major tribal conflicts, hence the low movement of people into the study sites. Findings of this study are, however, different from those in forest communities around Miombo woodlands of the Copperbelt Province of Zambia where high levels of migration and population density were observed [14]. The selected sites of this study are rural and far from both civilization and potential markets for forest products, unlike the Miombo woodlands of the Copperbelt, which are located near urban areas, and are thus attractive to rural migration. High immigration rates in forest communities have also been observed in other parts of the tropics [77,78].

This study established that there were more migrants in Manyinga (32.6%) than in Zambezi (6.25%). The reasons for migration included an invitation by family members, availability of farmland and abundance of rainfall. It was established that most of those who migrated to the area were informed by relatives or close associations. These findings corroborate reports elsewhere, which indicate that soil fertility, family invitations, low population density and absence of conflict make people migrate [76]. In addition, more remote settlements have more forest products than those living in town centres [77]. The potential reason for the higher number of Migrants in Manyinga than Zambezi district is the ongoing timber harvesting activities in the Manyinga district, which are likely to attract foreign people to the area.

The study established a significant relationship between residence status and using poles for construction, roots/tubers and grass for thatching. This finding is concurrent with reports by other researchers that residents who have lived in an area for longer are more likely to exploit more forest resources than residents who have lived in a locality for a shorter period [21,26]. Results of this study revealed that indigenous people were more involved in use of roots/tubers compared to the migrants, whereas the migrants were more involved in use of poles for construction and grass for thatching compared to the original inhabitants. The reason behind most migrants being involved in the collection of poles for construction and grass for thatching is the associated need to construct housing units for the new residents of the area. Migrants are believed to cut trees to build new houses [76]. On the contrary, the local inhabitants were more involved in using and collecting roots/tubers than the migrants in this study. This could be due to the local inhabitants' familiarity with the complexities of their environment (i.e. areas were to find roots and tubers for use) [79]. Research shows that people with experience in collecting forest products collect more forest products, whereas migrants may not have an awareness of where certain forest products may be available. In some studies, however, the length of residency did not show a positive relationship with collection of forest products [21]. A study conducted in Ghana to assess the impact of migrants on forests and land degradation did not find any evidence linking migrants to resource degradation when compared with native residents [80].

4.2.6. Perceptions on forest product abundance

With the exception of timber, charcoal and wild animals, most other forest products were perceived as abundant in both Manyinga (9 out 14 forest products) and Zambezi (10 out 14 forest products). Unlike Manyinga, thatching grass was also perceived to be in abundance in Zambezi district. Findings of this study are contrary to a study on the tropics which revealed that 90% of villagers observed a decline in the availability of forest products as a result of an increase in resource use owing to population increase [78].

In this study, despite Zambezi recording 10 perceived abundant forest products compared to 9 in Manyinga, statistical analyses revealed that 7 forest products were significantly more in Manyinga than in Zambezi. These results could be due to community access restrictions to Manyinga residents to forest areas around the Lusongwa forest reserve, which has potentially resulted in less exploitation of forest products compared to the Zambezi site, which is entirely open access. Researchers have shown that governing institutions such as land tenure systems influence use of forest products, with open access regimes promoting more exploitation of forest resources [9,69,70]. Interestingly, more than 96% of the households in Zambezi perceived timber to be 'no longer abundant' in the area. It was established during focus group discussions that timber harvesting activities had reduced in the area, because the timber had been depleted. A sentiment from one of the respondents from Zambezi below confirmed previous timber harvesting practices in the area:

> "It's too late to involve timber concession holders in helping us build a secondary school in the community, because the timber is finished now".

By comparing the levels of abundance of forest resources in Manyinga and Zambezi in this study, we deduce that governing institutions such as land tenure systems, that restrict or enable access to forest resources play a role in promoting sustainable use as well as conservation of forest resources, and that where these institutions lack, exploitation of forest resources is eminent. Findings of this study also reveal that land use systems such as selective logging, open up forest areas to other land uses such as shifting cultivation (like the case for the Zambezi site) which may eventually lead to forest degradation. A similar situation was reported in a study in Southwesetrn Ethiopia where forests due to extraction of timber and conversion of forest land into farms have contributed to a decline in the availability of forest products [81].

4.3. Land clearing and determinants of loss forest cover loss

This study revealed that more than half (66.67%) of the respondents cleared land in the previous 10-year period mainly for agricultural purposes. Statistically, households from Zambezi significantly cleared more land during this period compared to those from Manyinga. Again these findings reveal the ease of clearing land in an open access regime than in an area with access restrictions. The reasons advanced for clearing land include; increasing agricultural productivity (63.8%), loss of fertility of previous land (23.1%), and recently allocated farmland (13.1%). A study conducted in the Democratic Republic of Congo (DRC) also reported that villagers in Misotshi-Kabogo cleared land, particularly cutting and burning of trees, for agriculture purposes [76] Similar observations were also established by Handavu et al. [14] in their study on the Copperbelt Miombo woodlands of Zambia. These findings could be attributed to the fact that agriculture is a major source of income for majority of rural communities in Africa [82]. Thus clearing of land for agricultural purposes by the community members is inevitable.

All respondents in Manyinga and the majority (88.39%) of respondents from Zambezi in this study indicated a reduction in forest cover in the study sites. The main perceived reasons for forest cover loss include timber harvesting (95.79%) in Manyinga district, whereas agriculture (62.75%) and population increase (39.21%) were perceived as the main reasons for forest cover loss in Zambezi district. In addition, the output of the logistic regression model that contained five predictive variables (gender, education, household size, wealth status and residence status) revealed that timber harvesting, agricultural expansion, and population increase were statistically significant in influencing perceived changes in forest cover in the survey sites. Findings of this study are similar to those of southwestern Ethiopia were the cutting down of trees for timber and establishment of cropland were the main drivers of forest cover loss [81]. During the current study, significant timber harvesting practices were observed in the Manyinga site than in the Zambezi site. Consequently, timber harvesting was established as the most perceived cause of loss in forest cover in Manyinga district. We established that timber harvesting activities were ongoing in the *Cryptosepalum* forest due to the co-existence of the *Cryptosepalum exfoliatum* species and the *Guibortia coleosperma* (rosewood), which is a high timber forest species. Concession license holders follow the rosewood in the *Cryptosepalum* forest, but in the process cause disturbance to the *Cryptosepalum exfoliatum*, which is the dominant species of *Cryptosepalum* forest.

On the contrary, agricultural expansion in form of shifting cultivation and population increase were established as the two most perceived causes of forest cover loss in Zambezi District. It was established that significant timber harvesting practices existed in the past in the *Cryptosepalum* forest of Zambezi, and that most of the timber was depleted at the time of this study. Agricultural expansion and population increase have also been reported by other researchers within the region (e.g. Namibia [18], Botswana [83], Zambia [14], Ghana [84], Zimbabwe [83], and Malawi [28], as significant determinants of loss of forest cover. For example, in the Zambezi region of Namibia, agricultural expansion was reported as the most perceived cause of forest cover loss, followed by population increase [18]. After charcoal production, agricultural expansion was established as the second most perceived cause of loss of forest cover, in the Zambian Copperbelt Miombos, with the third most cause being population increase [14]. Unlike the current study, Handavu et al. [14] study highlighted charcoal production as the most dominant cause of loss of forest cover in the Miombo woodlands of the Copperbelt probably because the study was located in the villages which are close to urban areas of the Copperbelt, where there is market for charcoal. The lack of involvement in high charcoal production activities by the respondents to the current study is probably due to unavailability of nearby market for such products, as researchers have established that a ready market influences charcoal production [14,64]. In addition, unlike the Miombo woodlands, which are dominated by good charcoal producing tree species, our study area is mainly dominated by *Cryptosepalum exfoliatum* species, whose potential for charcoal production has not been exploited.

5. Conclusion

This study adds to the body of knowledge on the essential role of forest ecosystems in supporting rural livelihoods in sub-Saharan Africa. The study has established that communities living around the *Cryptosepalum* forest of Manyinga and Zambezi districts depend on various (14) forest products for livelihood sustenance. It was found that for heating purposes, the main source of energy used by most respondents in both study sites was firewood. Other forest products such as medicine, mushrooms, fruits, and wild vegetables are also obtained to meet household basic needs and food requirement. Generally, pooled resulted from the logistic regression model reveal that social and economic factors like gender, education level, size of a household, wealth status, as well as residence status have influence on use of forest resources, with some influencing the use of a particular forest product more than the other. The study established that timber harvesting is the main determinant of forest cover loss in Manyinga. In contrast, agricultural expansion and population increase were established as the main reasons for forest cover loss in Zambezi. The study has revealed that despite Manyinga having significantly more abundant forest resources than Zambezi, there is more involvement in collecting and utilising products from forests by community members in Zambezi than in Manyinga district. From these findings, it can be deduced that governing institutions, such as land tenure systems, that restrict or enable access to forest resources can play a role in promoting sustainable use as well as conservation of forest resources, and that where these institutions lack, exploitation of forest resources is eminent. The findings of the study also revealed that land use systems such as selective logging, open up forest areas to alternative land uses, e.g. shifting cultivation, which may eventually lead to forest degradation.

The study further adds to the body of knowledge on the influence of social and economic factors on the use of forest resources in African forest ecosystems, hence the importance of integrating these factors in forest conservation policies and strategies. The findings shade more light on the major determinants of loss of forest cover in the *Cryptosepalum* forest of sub-Saharan Africa, and create a basis for developing management strategies and interventions that promote sustainable resource use and forest conservation. The key factors influencing forest dependency in each district can be considered and factored into local planning and management of the *Cryptosepalum* forest for conservation objectives. For example, in Manyinga, emphasis has to be put on monitoring and managing timber harvesting activities, ensuring that local people benefit from the proceeds of the practice by engaging them in the activities and/or offering corporate social responsibility (CSR) through building roads, schools, health centres, and markets for trading. Whereas in Zambezi emphasis needs to be put on sustainable farming practices, and provision of farming inputs. In both districts, there is need to diversify income sources for the local people, providing access to higher education to expand people's livelihood portfolios. This will help reduce forest disturbance, thereby protecting the unique and endemic forest resources of the *Cryptosepalum* forest.

The three main policy implications from the findings of this study are that: 1) the *Cryptosepalum* forest is an important source of livelihood for rural communities around it. Thus to promote its continued existence and provision of forest products and services, it is recommended that the on-going forest disturbance activities (i.e. timber harvesting and shifting cultivation practices) are monitored and well managed; 2) socio-economic drivers of forest resource use differ with differing communities, and their surrounding needs and activities. Therefore, the development of policies and strategies to manage forest resource use should be target specific and guided by a particular local community's needs and socio-economic characteristics; 3) protection of a forest via zoning can restrict local community use and access, however, uncontrolled timber harvesting practices in such forests is likely to open up the forest to more degrading land uses such as shifting cultivation. Therefore, strict monitoring and control of timber harvesting practices as well as enforcing the law on any potential illegalities is highly recommended.

Important to note, however, is that the assessment of determinants of forest cover loss in this study was based on interview data captured during the household surveys. Actual field studies/assessments of forest disturbance activities in the *Cryptosepalum* forest would be useful in complementing the findings of this study. Future research should therefore be directed towards assessing the impact of timber havesting, shifting cultivation and/or other disturbance activities on forest composition and structure, so as to establish how continued practices will affect future forest functioning and provision of products and services. This study was also limited to the influence of only five socio-economic variables (gender, household size, level of education, wealth and residence status) on forest resource use, with other potential variables such as distance from the forest, age, and occupation of household head being left out of the study. Age of the household head was particularly left out of the analysis because of missing information, as most respondents to the study were either not willing to state their age or where not sure of their exact age. Similarly, occupation of the household head was not considered in the study because most respondents were uneducated, unemployed and not engaged in any economic activities. However, future studies can look into the potential influence of distance from the forest on forest resource extraction and utilisation. Future studies should also assess local communities willingness to adopt and implement agroforestry and/or other conservation agricultural practices as alternatives to shifting cultivation.

6. Data availability statement

The data that support the findings of this study are available on request from the corresponding author.

CRediT authorship contribution statement

Mwale Chishaleshale: Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Paxie Wanangwa Chirwa:** Writing – review & editing, Supervision. **Jules Christian Zekeng:** Writing – review & editing, Supervision. **Stephen Syampungani:** Writing – review & editing, Supervision, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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