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Research

The Use of Woodland Products to Cope with Climate Variability in Communal Areas in Zimbabwe

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ABSTRACT. Common lands provide smallholder farmers in Africa with firewood, timber, and feed for livestock, and they are used to complement human diets through the collection of edible nontimber forest products (NTFPs). Farmers have developed coping mechanisms, which they deploy at times of climatic shocks. We aimed to analyze the importance of NTFPs in times of drought and to identify options that could increase the capacity to adapt to climate change. We used participatory techniques, livelihood analysis, observations, and measurements to quantify the use of NTFPs. Communities recognized NTFPs as a mechanism to cope with crop failure. We estimated that indigenous fruits contributed to approximately 20% of the energy intake of wealthier farmers and to approximately 40% of the energy intake of poor farmers in years of inadequate rainfall. Farmers needed to invest a considerable share of their time to collect wild fruits from deforested areas. They recognized that the effectiveness of NTFPs as an adaptation option had become threatened by severe deforestation and by illegal harvesting of fruits by urban traders. Farmers indicated the need to plan future land use to (1) intensify crop production, (2) cultivate trees for firewood, (3) keep orchards of indigenous fruit trees, and (4) improve the quality of grazing lands. Farmers were willing to cultivate trees and to organize communal conservation of indigenous fruits trees. Through participatory exercises, farmers elaborated maps, which were used during land use discussions. The process led to prioritization of pressing land use problems and identification of the support needed: fast-growing trees for firewood, inputs for crop production, knowledge on the cultivation of indigenous fruit trees, and clear regulations and compliance with rules for extraction of NTFPs. Important issues that remain to be addressed are best practices for regeneration and conservation, access rules and implementation, and the understanding and management of competing claims on the common lands. Well-managed communal resources can provide a strong tool to maintain and increase the rural communities' ability to cope with an increasingly variable climate.

Key Words: *adaptation strategies; livelihood analysis; NTFP; resource conservation*

INTRODUCTION

Common lands provide smallholder farmers in Africa with feed for livestock, firewood, and timber for construction and are used to complement human diets through the collection of wild foods (Shackleton and Shackleton 2004). Products from common lands vary between environments, whereas extraction rates are closely related to social differentiation within communities, the state of the resource, and the household situation (Cavendish 2000). Purely economic valuations indicate that the direct monetary value of goods extracted from rain forests would not justify the preservation of the forest unless local people would receive incentives (Godoy et al. 2000). However, the valuation of forests is a dynamic concept among and within communities (Kepe 2008). Rural communities value the contribution of nontimber forest products (NTFPs) to human and livestock diets beyond their calculated market values (Nunes and Van den Bergh 2001, Shackleton et al. 2001, Kepe 2008), justifying selective conservation and management.

Economic valuation has dominated research on the benefits of natural resources to people, mainly using a comparison of different products through trade. However, only looking at valuation does not do justice to the multidimensional role of NTFPs in farmers' livelihoods (Ashley 2000, Shackleton and Gumbo 2010). Therefore, studies often miss the realized value of natural vegetation in terms of materials consumed, exchanged, or enjoyed (Kepe 2008). Several studies in southern Africa have concentrated on the abundance or utilization of NTFPs (e.g., Campbell 1987, Gomez 1988, McGregor 1995, Campbell et al. 1997, Mithöfer and Waibel 2003).

Climate change, defined as "any change in climate over time, whether attributable to natural variability or as a result of human activity" (IPCC 2001:984), may lead to changes in climate variability, defined as "variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events" (IPCC 2001:985). A decrease in rainfall, and hence a higher frequency and severity of droughts, may be one of the most influential results of climate change in southern Africa (Hulme et al. 2001). In Africa, many traditional mechanisms to cope with drought have been diminished because of social and economic change: knowledge of famine foods, as well as of food conservation techniques, is progressively disappearing (Fleuret 1986). Labor and food exchanges are not encouraged

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by the development of cash markets, e.g., migratory and casual labor, sale of livestock, firewood, beer making, handicrafts, and extraction of honey. According to Fleuret (1986), access to off-farm income allows smallholder farmers to cope with drought. Often, households switch to off- or nonfarm income to survive, but responses vary greatly among households, sometimes leading to loss of assets and increased poverty (Fafchamps 1998, Hoddinott 2006). The poor are especially vulnerable and run the risk of ending in a poverty trap when exposed to the consequences of climatic shocks (Carter et al. 2007).

Whereas nonmarket-based drought response mechanisms may play an important role in enhancing adaptation, a combination of traditional and nontraditional responses may present robust options for management of food shortages against climatic shocks. Globally, 80% of total energy intake is derived from eight cereals and four tubers, which may increase the risk of starvation in drought-prone or conflict areas (Grivetti and Ogle 2000), particularly in areas where markets function poorly and trade cannot compensate for food deficits (Tschirley and Jayne 2010). Dietary changes are a conscious response to food shortages caused by drought (Fleuret 1986). NTFPs can serve as safety nets at times of shortage (Zinyama et al. 1990, Guinand and Lemessa 2001, Shackleton and Shackleton 2004, Paumgarten 2005, Muller and Almedom 2008). Some studies indicate that wild food sources contribute to increased dietary diversity, which has been associated with good nutritional status (Fleuret and Fleuret 1980, Hatløy et al. 2000, Johns and Sthapit 2004).

We analyzed the importance of NTFPs during times of drought to identify options that could increase farmers' capacity for adaptation, defined as "the adjustment in natural or human systems to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (IPCC 2001:982). We investigated the users and utilization of NTFPs at the household and community levels with a focus on the social and the ecological context. Our overall aim was to understand actual consumption and constraints determining the role of NTFPs in coping with climate variability.

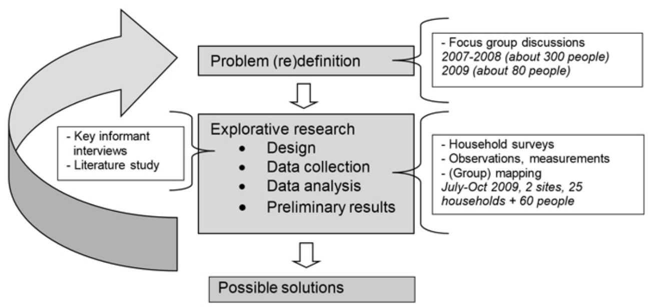
METHODS

Four phases can be discerned within the project: research initiation, problem definition, field research, and feedback (Fig. 1). Each phase is discussed in detail subsequently.

Project initiation

Wedza district in Zimbabwe was selected for the study for four major reasons: (1) Climatic projections indicate a reduction in rainfall and climate-induced decline in crop production. (2) Wedza covers Zimbabwe's Natural Regions (NRs) II to IV, ranging from 750-1000 mm/yr of rainfall in NR II to 450-650 mm/yr in NR IV. (3) Communities in the region are primarily of the Shona ethnic group but are diverse in resource endowment, infrastructure, and access to markets. (4) The study area typifies more than two-thirds of Zimbabwe's smallholder areas, where drought severely affects food security. Woodlands, grazing lands, and water resources are communally owned and underpin productivity of the dominant crop-livestock systems.

Fig. 1. Diagram depicting the methodology used in this research. In the problem (re)definition phase, the research objectives were determined. In the research phase, a field study was carried out to gather the relevant information, which was processed to generate quantitative and qualitative results. In this phase, 25 households were interviewed and approximately 60 farmers and local leaders participated in the mapping exercise. The outcomes were discussed with a panel of farmers to assess validity and to generate options for improved adaptation and/or to redefine problems.



Within Wedza district, two wards were selected in different climatic zones: Dendenyore in NR IIb, with rainfall of 750-1000 mm/yr; and Ushe in NR III, receiving 650-800 mm/yr (Vincent and Thomas 1961). Because of the differences in agroecology, and hence size of the resource base between Dendenyore and Ushe, the communities were expected to employ different coping strategies. Whereas communities in Dendenyore operated in a relatively high-potential cropping environment and had access to diverse woodlands and wetland resources, farmers in the more arid and deforested Ushe ward were more limited and often relied on nearby mountains to access forest products. There was therefore a need at the start of the project to understand how the attitudes and behaviors of the two groups of communities changed in response to emerging experiences and perceptions of climate variability, particularly rainfall.

Problem definition phase: focus group workshops

The research team had been working under the auspices of the Soil Fertility Consortium for Southern Africa (SOFECSA) in Wedza district since 2007 on perceptions of the communities to climate change, seeking to identify adaptation options to reduce vulnerability (Mapfumo et al. 2008). Following mobilization of communities through local leaders, extension officers, district authorities, and SOFECSA innovation

Table 1. Household characteristics, land owned, land cultivated, and livestock ownership for the two study sites. Numbers in brackets show the range; nd = no data.

Resource group	n (#)	Household size (heads)	Farm size (ha)	Land cropped to maize (ha)	Maize production (t)	Livestock (cows, goats, donkeys) (heads)
Ushe						
1	5	5 (3–8)	3.3 (2.5–5.0)	nd	2.2 (1.2–3.5)	13 (7–19)
2	6	5 (2–7)	2.1 (1.0–4.0)	nd	0.8 (0.1–1.5)	2.5 (0–4)
3	3	4 (4–5)	1.3 (0.6–2.0)	nd	0.5 (0.4–0.7)	0.7 (0–2)
Dendenyore						
1	4	5 (2–6)	3.1 (2.3–3.8)	1.4 (0.7–2.0)	1.3 (0.8–1.8)	6.5 (4–11)
2	2	6 (5–6)	2.6 (2.0–3.2)	1.8 (0.6–3.8)	0.7 (0.6–0.7)	3.0 (3–3)
3	5	4 (3–6)	1.7 (0.8–2.0)	0.6 (0.2–1.1)	0.8 (0.3–1.0)	0.6 (0–2)

platforms, participatory diagnostic tools were used during 2007 to identify major causes of vulnerability to climate change among households. There was evidence of farmers' awareness of climate change. Participants had observed changes in rainfall and temperature, such as prolonged dry spells and unusual temperature patterns. There was varied understanding about medium- to long-term changes. A series of participatory workshops was conducted with communities, in which desired processes of change were conceptualized through focus group discussions. Two main outcomes of these workshops were (1) identification of the importance of NTFPs as an option for coping with drought and (2) prioritization of integrated soil fertility management as an adaptation option. Learning centers were established as field-based knowledge-sharing platforms, primarily to enhance colearning for improved soil fertility management but also to enhance understanding of the role of NTFPs in food security. The learning centers allowed farmers to experiment with different crop types and different crop varieties, including traditionally known drought-tolerant crops, or hunger crops, such as finger millet, sorghum, and cowpea. This opened up discussions on relationships between cropping activities and natural resource management in the context of safety nets, deepening the debate on land use options.

Research phase

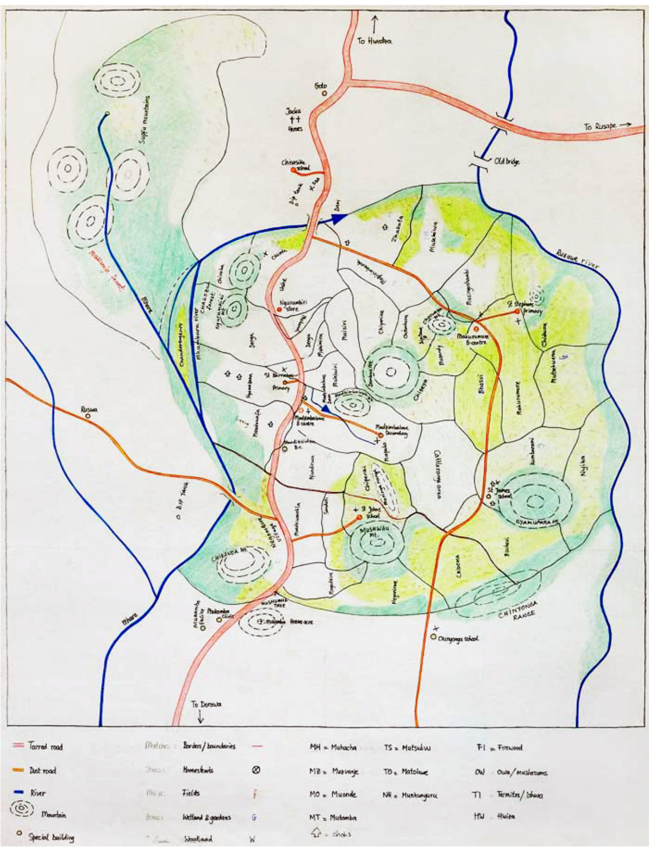
We conducted an explorative study of NTFP use patterns from July to October 2009. Together with local extension workers, we selected 14 households divided over 8 villages in Ushe ward and 11 households divided over 5 villages in Dendenyore ward for in-depth interviews. Time constraints, i.e., duration of the dry season, availability of translators, and distances to travel, limited the number of households we could interview. Household selection was based on location and social differentiation: households were selected from villages in different areas of the ward, i.e., 1 to 3 per village, and from 3 resource groups (RGs), i.e., resource endowed, intermediate, and resource constrained (Table 1). Resource-endowed households owned at least 3 cattle or donkeys, whereas resource-constrained farmers owned none. Intermediate farmers owned 1 to 2 cattle or donkeys, or additional assets, i.e., one farmer owned 4 ha of fenced cropping land, and another co-owned 5 cattle. The extension personnel and local leaders facilitated introduction of the research to the household members.

Household survey

Information from the literature and from key informants was used to design semistructured interviews. Each household was visited one to four times, depending on the progress of the interview and the available time per visit, between July and October 2009 for completion of the interview. The interview was designed to cover a designated year of normal rainfall, the 2008-2009 growing season, and a year of poor rainfall. Most farmers recognized the 2007-2008 growing season as a severe drought, comparable to the drought of 1991-1992. In the first visit, farmers were asked questions regarding farm production and food consumption. A farm map was drawn with the respondents including all farm plots and their use. A list of farm products was compiled, and for each product, farmers were asked to quantify production and use, i.e., home consumption, sold/bartered, stored, payment for labor, seed, feed, or given away, for the previous season. Farmers named the types of food they regularly bought and estimated quantities. They were asked to compile a list of food products consumed in the week before the interview and to estimate consumed quantities.

In the subsequent visits, farmers named food and nonfood NTFPs that they collected and selected 5 to 10 products that were most important to them, thus termed key NTFPs. This was done for the designated normal and poor rainfall years. Farmers ranked key NTFPs, based on their importance in both types of years. Three different types of quantitative questions regarding the key NTFPs were asked: (1) How much did you consume? (2) How much did you collect? (3) How much time did you invest in collection? Individual collection maps were drawn in which farmers indicated collection areas in years of normal and poor rainfall. Farmers indicated who collected the product and estimated the time required to walk to the collection place(s) of the product, one way, for an indication of the distance.

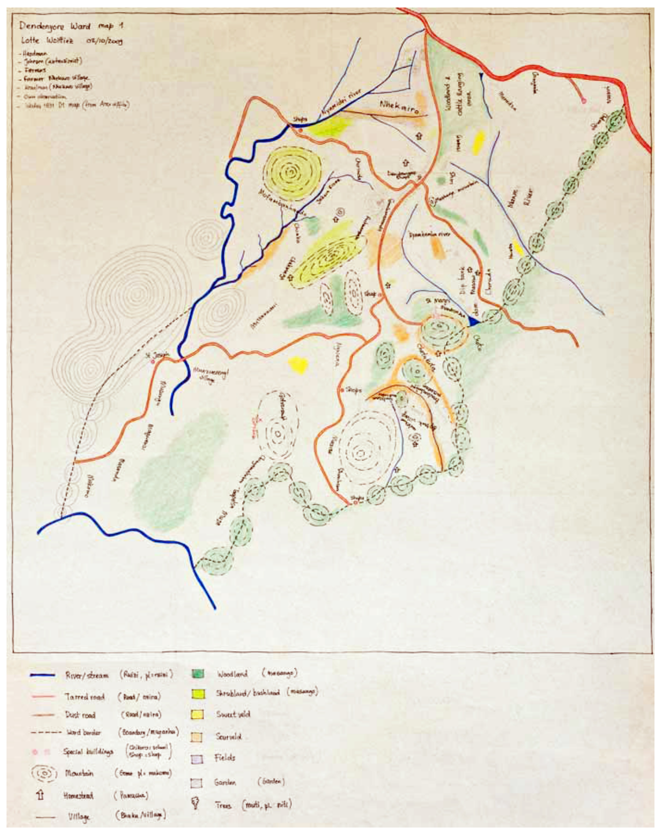
Fig. 2. Land use map of Ushe ward constructed in a group-mapping exercise. Dark green: woodland; light green: bushland; white/grey: field; orange/red: road; blue: river/stream; circle: mountain.



Group mapping

A group-mapping exercise was carried out in each ward to assess the knowledge of the size and state of the natural areas. Existing maps at the scale 1:50,000 (Department of the Surveyor General 1972*a*, *b*) were used to create a framework of ward borders, roads, rivers, and mountains for both study sites. Suggestions from key informants and field observations were used to add landmarks and to correct the "framework maps." These maps were copied on A0-size paper, which is 16 times the size of standard letterhead, for further use. Group-mapping exercises for the construction of land use maps were facilitated by local leaders and extension personnel. In Ushe ward, a group-mapping exercise was conducted during a meeting of village heads where 20 of the 29 village heads were present. A framework map of Ushe was filled in using stones, maize kernels, sunflower seeds, and beans to indicate villages and natural areas. Participants shaded the indicated areas with colored pencils, and the headman added village borders, dip tanks, and churches (Fig. 2). In Dendenyore ward, 30 farmers volunteered to participate in a group-mapping exercise and were divided into a men's group and a women's group. Each group was provided with a framework map and colored pencils to indicate the different land use areas. A third map was constructed using suggestions from informants, including extension officers, farmers, village heads, and passersby, and field observations made by researchers during farm visits (Fig. 3).

Fig. 3. Land use map of Dendenyore ward constructed using key informant contributions and author observations. Dark green: woodland; light green: bushland; yellow: sweet grassland/veld; orange: sour grassland/veld; white/grey: field; red: road; blue: river/stream; circle: mountain.



Data analysis

For the ranking exercise, the households were divided into the previously mentioned three RGs, namely, resource endowed, intermediate, and resource constrained. The results of the ranking were translated into valuations by attaching rank-dependent values to the key products. If farmers had ranked a product group, e.g., "mushrooms," instead of a single species, then the highest ranking species of that group was awarded the value. The sum of values per product per RG was divided over the sum of all values to obtain the weighted value (Appendix 1, Eqs. A1-A3). Nonfood products had only been included in the ranking exercise in Dendenyore, and therefore, their weighted value was calculated based on the sum of all values for Dendenyore. A correction factor allowed cross-comparison of the data (Appendix 1, Eqs. A4 and A5). Finally, the numbers were multiplied by 100.

Local units were translated into kilograms using measurements and conversion factors from the literature (Appendix 2). Data on farm production for consumption, purchased or bartered products, and donated products was translated into consumption per product per household per year. NTFP consumption per household was calculated for each key product, using either collected or consumed quantities, whichever was lowest; there was no significant difference between quantities collected and consumed for any product. Average household consumption was calculated over all households that indicated the product as a key product, and differences in consumption between years of normal and poor rainfall were calculated using a paired-sample t test. The total household consumption, including produced and otherwise obtained products and NTFPs, was divided over the number of household members and multiplied by the energy content (MJ/kg; Leung 1968) to obtain energy consumption per capita per year. The products were divided over five categories: cereals and roots/tubers, including sunflower; legumes, including soya and groundnut; vegetables and melons; fruits and nuts; and animal products (FAO 2005), and data were averaged per category and per RG.

Spatial data collected during interviews, group-mapping exercises, and field visits were used to build land use maps. The maps were digitalized and edited with GNU Image Manipulation Program editing software. GPS coordinates of the interviewed households and certain landmarks were used to locate the study areas on satellite images from Google Earth, and the constructed land use maps were compared with the satellite images to assess the validity of the maps.

Feedback sessions with farmers

A community meeting was held at each of the two study sites, during which the results of the survey and mapping exercises were presented and discussed with the community, first in plenary and then with men's and women's groups separately. Farmers were invited to assess the validity of the findings and to discuss possible ways to translate the knowledge into strategies for improving the ability of the community to cope with drought. The day after the community meetings, the research team sought feedback from key informants on ways forward.

RESULTS

Study site and sample description

The study sites, Ushe and Dendenyore wards in Wedza district, in central-east Zimbabwe, have each an approximate surface area of 25 km² subdivided into about 30 villages. The natural vegetation is dry Miombo woodland, characterized by trees of the genera *Brachystegia* and *Julbernardia* and by an average rainfall of < 1000 mm/yr (Frost 1996). Over the period 1998-2007, Ushe received a higher than expected average annual rainfall of 854 ± 262 mm/yr, whereas Dendenyore received an average of 873 ± 254 mm/yr. In the years of study, 2007-2008 and 2008-2009, the following rainfall (from May to April) was extracted from satellite data: 896 mm and 542 mm, respectively, in Ushe, and 929 mm and 596 mm, respectively, in Dendenyore. Total rainfall was high in the 2007-2008 drought season, but distribution was very uneven (Fig. 4) with a long dry spell in February and March.

Fig. 4. Monthly rainfall in Ushe and Dendenyore during the 2007-2008 and the 2008-2009 growing seasons.

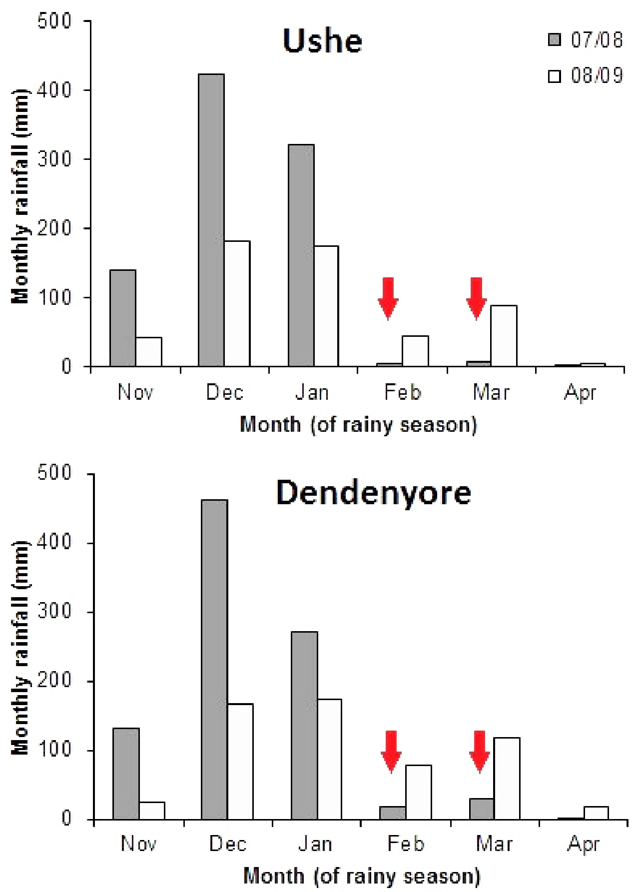


Table 2. Frequency with which products collected from woodlands were mentioned by interviewed households, disaggregated by resource group (RG). This list shows the products that were most frequently mentioned. For a complete list see Appendix 3.

Scientific name	English name	Type	No. of households by which the product was mentioned			
			RG 1 (n = 9)	RG 2 (n = 8)	RG 3 (n = 8)	All (n = 25)
Julbernardia globiflora, Brachystegia spiciformis	Firewood	nonfood	9	8	8	25
Amanita zambiana	Zambian slender caesar	mushroom	9	6	8	23
Parinari curatellifolia	Mobola plum	fruit	8	7	7	22
Uapaca kirkiana	Wild loquat	fruit	7	7	7	21
Julbernardia globiflora	Leaf litter	nonfood	8	5	7	20
Macrotermes spp.	Termite, alate	insect	8	5	5	18
Eucalyptus spp.	Poles	nonfood	6	6	6	18
Strychnos spinosa	Bitter monkey orange	fruit	5	6	6	17
Lippia javanica	Lemon bush	herb	4	6	5	15
Macrotermes spp.	Termite, soldier	insect	7	3	4	14
Corchorus oditorius	Bush okra	vegetable	6	3	5	14
Azanza garckeana	Snot apple	fruit	6	3	5	14
Eulepida masnona	Christmas beetle	insect	5	4	4	13
Silvicapra grimmia	Common duiker	animal	4	4	4	12
Vitex payos	Chocolate berry	fruit	5	5	2	12
Dovyalis caffra	Kol apple	fruit	7	3	2	12
Orthoptera spp.	Grasshopper	insect	4	2	5	11
Lepus capensis	Cape hare	animal	5	2	4	11
Hyparrhenia filipendula	Grass	nonfood	4	2	4	10†
Ficus sycamorus	Fig	fruit	2	4	4	10
Coimbrasia belina	Mopane worm	insect	2	3	5	10
Piliostigma thonningii	African biscuit	nonfood	4	4	0	8
Mus musculus	Mice	animal	4	1	3	8
Gynandropsis gynandra	African spider herb	vegetable	2	2	3	7
Amaranthus spp.	Poor's man spinach	vegetable	2	2	3	7
Coleus esculentus	Vlei tuber	tuber	3	1	2	6

†Only scored in Dendenyore ward, n = 11.

Because rainfall and other circumstances, e.g., location, culture, and demography, were very similar, the data from the different wards were mostly pooled together, apart from the analysis of the resource base. The households, divided over the two wards and three RGs, mainly differed in farm size and livestock heads (Table 1). Farmers of RG1 had larger farms and more livestock, and they produced significantly more maize than farmers of the other RGs.

Defining the problem with farmer groups

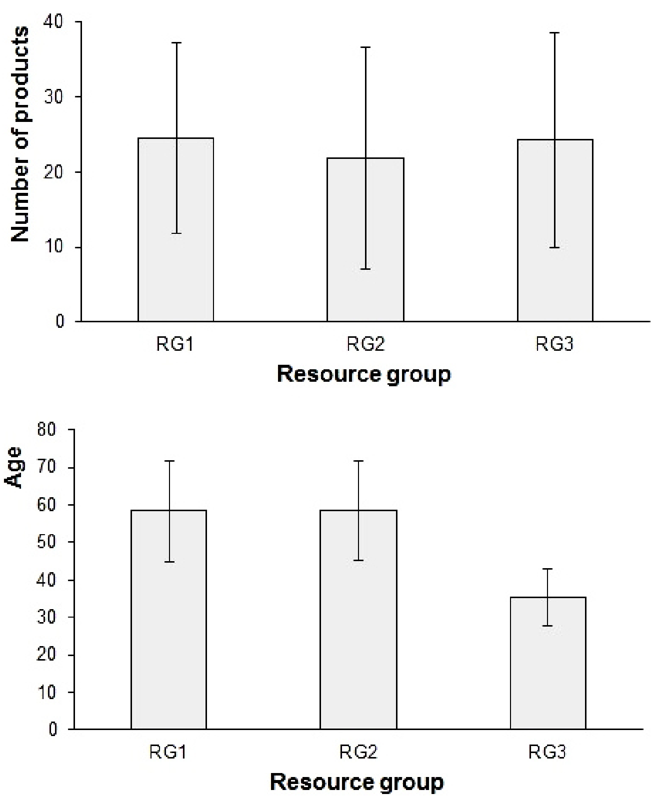
In the focus group workshops carried out in 2007, at the start of the research program, a total of approximately 300 farmers discussed adaptation to climate variability. The discussions resulted in a list of adaptation options and work plans for participatory experimentation. Among the list of options, farmers identified the use of communally owned natural resources as a coping strategy during times of drought, which they defined as low or poorly distributed rainfall that results in widespread crop failure. Most specifically, the consumption of wild fruits and grazing of cattle in veld and woodland areas were mentioned (Mapfumo et al. 2008). Establishment of the learning centers during the beginning of the study in 2007 enhanced farmer-to-farmer interactions and helped to mobilize the community to participate in diagnostic processes. This led to increased awareness and participatory analysis of farmers' perceptions on climate change and variability.

NTFPs as a coping mechanism in times of drought

Diversity of products collected from woodlands

Farmers collected more than 115 edible NTFP species and approximately 30 woody species and grass (Appendix 3). The 10 most frequently mentioned NTFPs included nonfood products such as firewood, leaf litter, and poles, and food products such as wild fruits, mushrooms, and insects (Table 2). All households collected firewood because none of them had an electricity connection or alternative energy sources. The preferred firewood species were *Julbernardia globiflora* and *Brachystegia spiciformis* because of their high energy output and being generally odorless when burning. Ninety-two percent of the households collected the mushroom *Amanita zambiana*, described as a good relish. More than 80% of the households indicated that they collected the wild fruits *Parinari curatellifolia*, or “hacha” in Shona, and *Uapaca kirkiana*, or “mazhanje” in Shona. Most households grazed their livestock in common land. Knowledge on and range of collection of NTFPs was not related to wealth status (RG) or age (Fig. 5).

Fig. 5. Number of edible nontimber forest products species mentioned per household per resource group (RG), and average age of the respondents. Bars show the standard error of mean.



Valuation of NTFPs
In the valuation exercises, approximately 50 NTFPs were mentioned at least once. The results (Appendix 1, Table A1.1) showed that the frequency of collection of a product was not a good indicator of the importance attached. In normal years, firewood was the highest valued product, followed by *U. kirkiana*, poles, termites, and thatch grass. These results were only partially reflected in the collected quantities (Table 3).

The wealthier farmers (RG1) valued the wild fruit category highest, i.e., 30% of the total; however, for the poorer farmers (RG3), nonfood products were most important, i.e., 33% of the total, although wild fruits, vegetables, and herbs were also highly valued.

In years of poor rainfall, wild fruits were the highest valued NTFP over all RGs, with a total value of 50%. Valuation of the nonfood products dropped to 19%. *P. curatellifolia* became the highest valued product, with a relative value that went from 2% in normal years to 26% in years of poor rainfall. Firewood was valued at only 9% (Appendix 1, Table A1.1).

The value of grass increased, probably because there were few other feeds for livestock. Mushrooms were considered less important because of their limited availability in times of drought. Several farmers mentioned that they did not hunt in years of drought because of low availability and competition with other households.

Quantities of collected and consumed NTFPs
Firewood was the most collected NTFP in the study area, with an average of 4511 kg/yr per household. In normal years, *U. kirkiana* was the most consumed edible NTFP, with an average of 239 kg/yr per household (Table 3a). The second most consumed edible NTFP was *P. curatellifolia*, followed closely by *Strychnos spinosa*. The fourth was the mushroom *A. zambiana* (Table 3a).

In years of poor rainfall, the average consumption of *P. curatellifolia* increased from 62 kg/yr per household to 489 kg/yr per household, and the consumption of *U. kirkiana* increased from 239 to 609 kg/yr per household ($p < 0.05$; Fig. 6). Consumption of most edible NTFPs appeared to increase (but $p > 0.05$) in years of poor rainfall except for *A. zambiana* and termites (Table 3b), and total consumption of wild food exceeded consumption of cultivated food. Average maize yields fell significantly to < 500 kg/yr per household, and of the other crops, only irrigated vegetables yielded similarly to years of normal rainfall. Some farmers stated that their meals would consist of mostly leafy vegetables because of the shortage of grain. Regarding the consumption of nonfood NTFPs, the farmers indicated that there was no difference between years of normal and poor rainfall.

Labor investment in the collection of *U. kirkiana* and *P. curatellifolia* rose from 124 and 17 h/yr per household in years of normal rainfall to 377 and 236 h/yr per household in years of poor rainfall ($p < 0.05$). There was no significant difference in labor investment between RGs. For other NTFPs, labor investment did not change significantly in years of poor rainfall. On average, households spent approximately 500 h/yr on firewood collection (data not shown).

Contribution to the diet
In years of normal rainfall, on-farm produce contributed 70-90% of the total food energy available to the household

Table 3. Mean consumed quantities of 17 key nontimber forest products for three resource groups (RG) in years of a) normal and b) poor rainfall. The asterisk* indicates a significant difference (a < 0.05) between the years (paired-sample t-test).

a) Normal rainfall

Product	Consumption (kg per household per year) ± SE											
	RG 1		*n*	RG 2		*n*	RG 3		*n*	TOTAL		*n*
Firewood	4736	± 886	*9*	2938	± 279	*8*	5829	± 1192	*8*	4511	± 539	*25*
Poles for construction	388	± 13	*2*	788	± 356	*5*	425	± 124	*3*	599	± 182	*10*
Leaf litter	294	± 42	*4*	328	± 172	*3*	839	± 276	*6*	553	± 147	*13*
Uapaca kirkiana	146	± 49	*7*	258	± 164	*5*	332	± 161	*6*	239	± 71	*18*
Parinari curatellifolia	149	± 137	*8*	16	± 13	*6*	2.8	± 2.8	*7*	62*	± 52	*21*
Strychnos spinosa	39		*1*	53	± 13	*3*	73		*1*	54	± 8.9	*5*
Amanita zambiana	65	± 24	*4*	19	± 6.5	*4*	20	± 10	*3*	36	± 11	*11*
Thatch grass	33	± 4.4	*3*	60	± 25	*2*	10	± 10	*2*	34	± 9.8	*7*
Corchorus oditorius	39	± 39	*2*	-		*0*	2.3		*1*	27	± 25	*3*
Cape hare	35	± 20	*2*	-		*0*	12	± 0.0	*2*	23	± 11	*4*
Termites, alate	14	± 6.1	*6*	52	± 52	*2*	6.3		*1*	21	± 11	*9*
Vitex payos	4.0	± 2.1	*2*	23	± 19	*3*	-		*0*	15	± 11	*5*
Azanza garckeana	0.06		*1*	16	± 16	*2*	0.5		*1*	8.3	± 8.0	*4*
Coleus esculentus	-		*0*	-		*0*	6.1	± 1.8	*2*	6.1	± 1.8	*2*
Grasshoppers	2.7	± 1.6	*2*	3.6		*1*	3.0	± 1.5	*3*	3.0	± 0.8	*6*
Birds	-		*0*	2.3		*1*	2.3		*1*	2.3	± 0.0	*2*
Dicoma anomala	-		*0*	0.002		*1*	0	± 0.0	*2*	0.0	± 0.0	*3*

b) Poor rainfall

Product	Consumption (kg per household per year) ± SE											
	RG 1		*n*	RG 2		*n*	RG 3		*n*	TOTAL		*n*
Firewood †	4736	± 886	*9*	2938	± 279	*8*	5829	± 1192	*8*	4511	± 539	*25*
Poles for construction †	388	± 13	*2*	788	± 356	*5*	425	± 124	*3*	599	± 182	*10*
Leaf litter †	294	± 42	*4*	610	± 172	*4*	716	± 276	*5*	553	± 147	*13*
Uapaca kirkiana	377	± 106	*7*	455	± 157	*5*	1008	± 490	*6*	609	± 177	*18*
Parinari curatellifolia	434	± 159	*8*	560	± 162	*7*	481	± 168	*7*	489*	± 90	*22*
Strychnos spinosa	243		*1*	97	± 31	*3*	592	± 228	*2*	286	± 116	*6*
Amanita zambiana	24	± 16	*4*	18	± 7.5	*4*	42	± 39	*3*	27	± 11	*11*
Thatch grass †	33	± 4.4	*3*	60	± 26	*2*	10	± 9.9	*2*	34	± 9.8	*7*
Corchorus oditorius	78	± 78	*2*			*0*			*0*	78	± 78	*2*
Cape hare	31	± 23	*2*			*0*	62	± 9.9	*2*	46	± 14	*4*
Termites, alate	2.2	± 1.3	*6*	62	± 59	*2*	2.7		*1*	15	± 13	*9*
Vitex payos	1.0	± 0.1	*2*	64	± 43	*3*			*0*	39	± 28	*5*
Azanza garckeana	2.7		*1*	19	± 13	*2*	3.0		*1*	11	± 7.0	*4*
Coleus esculentus	-		*0*			*0*	239	± 64	*2*	239	± 64.3	*2*
Grasshoppers	0.5	± 0.6	*2*	25		*1*	0.2	± 0.2	*2*	5.4	± 4.9	*5*
Birds	-		*0*	2.3		*1*	0.3		*1*	1.3	± 1.0	*2*
Dicoma anomala	-		*0*			*1*	0.3	± 0.3	*2*	0.2	± 0.2	*3*

†Based on farmers' remarks, collection of nonfood products was assumed to be equal in years of good and poor rainfall unless specifically stated otherwise. The differences in leaf litter collection are caused by two farmers.

(Fig. 7). This contribution dropped to only 20-30% in years of poor rainfall because of a significant reduction in maize production (data not shown). The energy contribution from purchased food increased from 6-10% in normal years to 24-32% in years of poor rainfall. Additionally, during the drought year of 2007-2008, donors provided food aid to some farmers in the form of maize, peas or beans, and porridge during a period of five months, which contributed on average 14-25% of the energy availability to households in that year (Table 4). Edible NTFPs contributed < 10% of the total available energy in normal years, but this increased at times of poor rainfall to up to 22% for RG1 and RG2 farmers, and up to 42% for the poor RG3 farmers (Fig. 7). The wild fruits *P. curatellifolia* and *U. kirkiana* together contributed more than 90% of the total energy from NTFPs, both in years of normal and poor rainfall.

Fig. 6. Consumption of *Uapaca kirkiana* and *Parinari curatellifolia* per resource group (RG) in times of normal and poor rainfall. Bars show the standard error of mean.

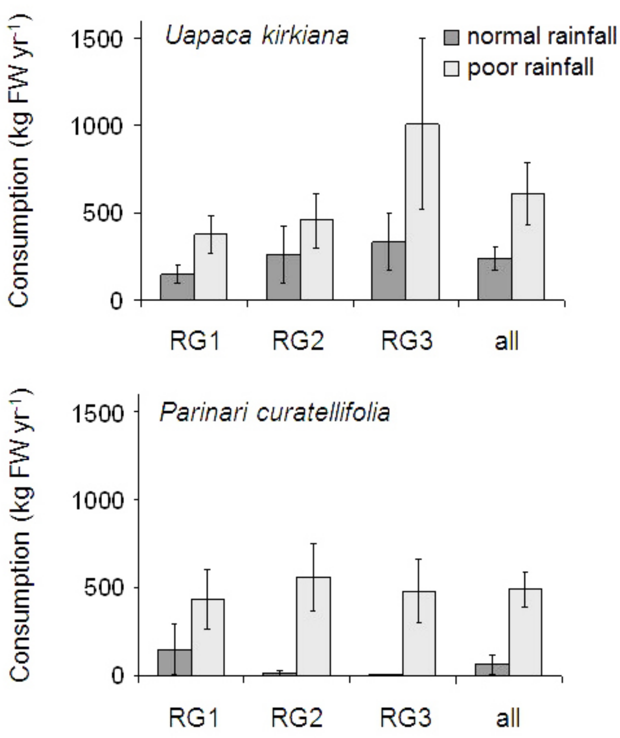
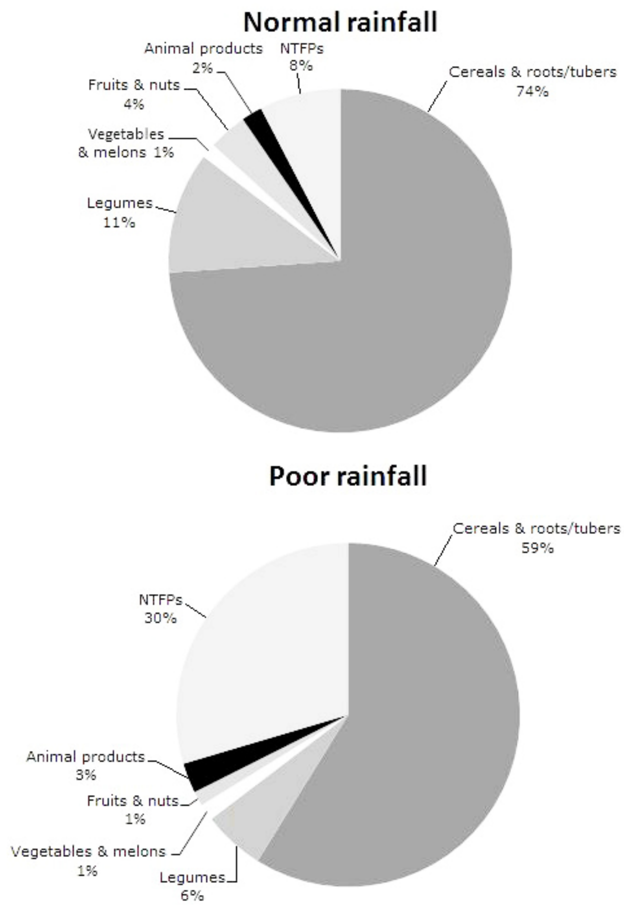


Fig. 7. Contribution of nontimber forest products to energy consumption in times of normal and poor rainfall, shown in percentage of the total intake per person per year (MJ).



Use of and access to natural resources

In Ushe ward, the majority of the NTFPs were collected from woodlands, but some products, such as certain insects, mushrooms species, fruits, and thatch grass, were preferentially collected from cropland. Additionally, several farmers had to collect firewood from fields because there was no bushland or woodland nearby. Other farmers, especially in western Ushe, mentioned that they walked about 10 km to collect wood because the nearby woodlands were stripped of all the dead wood. In years of poor rainfall, people from Ushe, usually the children, walked about 20 km toward the eastern border of Dendenyore ward to collect *U. kirkiana*.

In Dendenyore, all farmers in the sample collected wood close to their homesteads and walked to the woodlands in the eastern part of the ward to collect *U. kirkiana* and *P. curatellifolia*. For livestock grazing, the areas along the many streams were intensively used. Farmers in Dendenyore collected only specific NTFPs such as grasshoppers, termites, and certain wild vegetables from cropland.

In several group-mapping exercises, farmers and key informants constructed land use maps at the ward level. On a Google Earth satellite image of Ushe, 18 major natural areas were visually identified. Sixteen of these can also be found on the group map of Ushe (Fig. 2). The size of 5 areas was greatly exaggerated in the farmers' perception, and the size of 1 area was underestimated. Bushlands, i.e., light green areas, were defined as degraded woodlands in which the canopy was widely open, there was high bush encroachment, and most of the trees were immature. The group map of Ushe generally showed an underestimation of the degree of degradation of the woodlands.

On a Google Earth satellite image of Dendenyore, 22 major natural areas were visually identified. On the map constructed by key informants in Dendenyore (Fig. 3), 16 of these natural areas could be recognized, and out of these, the size of 6 areas was greatly underestimated, and none was exaggerated. The satellite images showed that in the center and the northeast of the ward, fields were scattered throughout, fragmenting the

Table 4. Mean contribution of different sources to the food energy availability for three resource groups (RG) in years of a) normal rainfall and b) poor rainfall. The cereals & roots/tubers category includes sunflower, the legumes category includes soya and groundnut, and the vegetables & melons category includes mushrooms. NTFP = nontimber forest products.

a) Normal rainfall

Food type	RG	n	Sources of food				Total available
			Produced	Purchased	Donated	Collected (NTFP)	
	#	#	MJ (capita/year) ± SE				MJ (capita/year) ± SE
Cereals & roots/tubers	1	8	3753 ± 525	286 ± 89	0	0	3965 ± 513
	2	4	2504 ± 283	399 ± 166	0	0	3092 ± 361
	3	6	2950 ± 830	284 ± 55	0	1 ± 1	3137 ± 843
Legumes	1	8	752 ± 214	18 ± 18	0	0	769 ± 213
	2	4	432 ± 108	0	0	0	432 ± 108
	3	6	373 ± 87	0	0	0	373 ± 87
Vegetables & melons	1	8	90 ± 45	0	0	2 ± 2	99 ± 44
	2	4	48 ± 6	0	0	0	53 ± 7
	3	6	56 ± 19	5 ± 5	0	3 ± 3	64 ± 15
Fruits & nuts	1	8	322 ± 159	0	0	328 ± 180	574 ± 220
	2	4	105 ± 28	0	0	239 ± 224	345 ± 243
	3	6	71 ± 44	0	0	277 ± 135	348 ± 151
Animal products	1	8	119 ± 42	16 ± 11	0	39 ± 21	170 ± 44
	2	4	73 ± 25	11 ± 11	0	131 ± 128	182 ± 77
	3	6	23 ± 10	17 ± 11	0	15 ± 7	52 ± 25

b) Poor rainfall

Food type	RG	n	Sources of food				Total available
			Produced	Purchased	Donated	Collected (NTFP)	
	#	#	MJ (capita/year) ± SE				MJ (capita/year) ± SE
Cereals & roots/tubers	1	7	461 ± 296	788 ± 471	418 ± 190	0	1938 ± 415
	2	4	517 ± 240	1068 ± 633	781 ± 385	0	2110 ± 482
	3	5	664 ± 415	951 ± 433	482 ± 203	93 ± 68	2096 ± 833
Legumes	1	7	98 ± 46	97 ± 97	34 ± 16	0	228 ± 83
	2	4	171 ± 105	32 ± 32	69 ± 42	0	265 ± 79
	3	5	73 ± 32	0	55 ± 27	0	112 ± 20
Vegetables & melons	1	7	19 ± 14	16 ± 16	0	5 ± 5	40 ± 18
	2	4	21 ± 13	7 ± 7	0	0	31 ± 13
	3	5	100 ± 71	0	0	0	106 ± 70
Fruits & nuts	1	6	50 ± 46	0	0	659 ± 215	819 ± 201
	2	4	90 ± 53	0	0	638 ± 299	728 ± 293
	3	5	4 ± 3	0	0	1511 ± 438	1515 ± 438
Animal products	1	7	50 ± 27	9 ± 9	0	15 ± 9	107 ± 32
	2	4	175 ± 128	0	0	124 ± 110	299 ± 125
	3	5	31 ± 19	0	0	48 ± 29	79 ± 45

natural areas into smaller stretches. Along the border and in the southern part, large continuous areas of woodland could be found.

All farmers indicated that cutting down fruit trees for firewood was not allowed, and most indicated that hunting and firewood collection in other wards was forbidden. Additionally, almost all farmers agreed that in times of drought, the entire ward and neighboring wards could be used for the collection of wild fruits. However, in the remaining cases, each farmer had a different idea about the formal rules for utilization of common resources. Only the headman and the village heads were well aware of the laws. The headman of Ushe indicated that enforcing the rules was problematic. Nevertheless, court was held every Friday to administer justice to those who were suspected of breaking traditional laws.

Feedback sessions with farmers

The research results were presented to farmers in two feedback meetings, one in each ward. Approximately 40 farmers attended each meeting. Farmers considered most findings to be realistic and correct but disagreed with the wealthier farmers consuming the highest amounts of *P. curatellifolia* in years of normal rainfall (Fig. 6). After the results were presented, farmers discussed their implications and how this knowledge could help them to prepare for years of poor rainfall. Farmers said that in years of normal rainfall, production should be maximized and storage methods should be improved so that the grain could be stored for times of food shortage. However, farmers indicated that this would not substitute for wild fruits in years of poor rainfall. They mentioned that "you cannot prepare for a bad season," indicating lack of access to reliable early warning information, and therefore "people should not play with 'hacha' and 'mazhanje,' *P. curatellifolia* and *U. kirkiana*, because they help the community during a bad year." To enhance the availability of wild fruits, farmers indicated that a mechanism was needed to avoid the cutting down of fruit trees. They suggested maintaining village orchards of wild fruit trees, especially *P. curatellifolia* and *U. kirkiana*.

Farmers listed several constraints that limited the efficacy of NTFPs as a coping mechanism: illegal selling of wild fruits in bad years, heterogeneous distribution of fruit trees within the ward, lack of experience with planting wild fruit trees, poor management of the communal resources, high human population pressure, overgrazing by livestock, and a lack of trust in authorities within the community. The feedback informed follow-up work to determine the size of the common pools of natural resources available to the communities, to estimate changes in patterns of the amounts of goods and services derived from these pools, and to determine how these have influenced livelihoods and impacted on gender roles. Alternative land use options that enhance adaptation have been prioritized for evaluation through the learning center approach.

DISCUSSION

Our findings demonstrate the important contribution of NTFPs, especially wild foods, to household food intake at times of drought. Through in-depth interviewing and group discussions, we were able to estimate the contribution of NTFPs to the diet in quantitative terms. Previous studies highlighted the role of NTFPs in Africa as a coping strategy during drought but lacked quantitative estimates of their importance (Guinand and Lemessa 2001, Mithöfer and Waibel 2003, Shackleton and Shackleton 2004, Paumgarten 2005, Muller and Almedom 2008, Fisher et al. 2010). Consumption of wild fruits increased significantly in dry years in the rural communities studied (Fig. 6). NTFPs provide people with several important dietary elements besides energy, such as microminerals, protein, i.e., insects, and vitamin C (Wehmeyer 1966, Fleuret and Fleuret 1980, Hatløy et al. 2000, Johns and Sthapit 2004). Our results emphasize the importance of forest and biodiversity conservation for utilitarian purposes such as the extraction of products (Swift et al. 2004) that provide a coping strategy following years of crop failure.

Together, farmers named more than 100 species of edible plants and animals that were collected from the land (Appendix 3), demonstrating deep knowledge of useful species in their environment (McGregor 1995). Fleuret (1986) suggested that knowledge about wild and famine foods is disappearing, but our results do not support this. There was no correlation between age or social differentiation and the number of species collected (Fig. 5). The observation that children were the major consumers of wild fruits indicates the continuing importance of NTFPs as a source of food (Campbell 1987, Mithöfer and Waibel 2003).

Farmers indicated that collection of NTFPs was related to personal preference as well as to availability, as previously observed (Campbell 1987). Farmers consciously selected the most suitable areas such as wetlands, fields, woodlands, or mountain slopes for the collection of specific NTFPs. They were knowledgeable about the natural areas available near their homestead (Figs. 2 and 3; Herlihy and Knapp 2003), and if these areas were not depleted, they were continuously visited for the collection of NTFPs. However, when an area was depleted, farmers chose either to collect the NTFP in a less-preferred area or to travel toward other areas, farther away from the homestead, with implications for labor available for other tasks. Farmers in Ushe ward sometimes collected firewood in and around fields because woodlands were too degraded. This required additional labor investment, and all farmers indicated labor as a constraint for their farming activities (Alwang and Siegel 1999). Labor constraints are especially pressing during the rainy season (Campbell et al. 1997) and less so with regard to the collection of edible NTFPs during the dry season. Farmers were known to collect NTFPs opportunistically (Campbell et al. 1997), but after the 2007-2008 drought, long journeys were undertaken specifically for the collection of *Parinari curatellifolia* and *Uapaca kirkiana*, mainly by children but also by adults (results not shown). Adult women and children, male and female, were mostly responsible for the collection of NTFPs, apart from hunting activities and the collection of poles, which was done by men (Campbell et al. 1997, Cavendish 2000).

Valuation and consumption of NTFPs

In years of poor rainfall, wild fruits, especially *P. curatellifolia*, were the most highly valued NTFPs. In the feedback meeting, farmers agreed that in years of poor rainfall there was little food to be cooked, so firewood was less important. There was no clear differentiation of valuation outcomes related to social status, which may point to a relatively homogeneous household situation (Kepe 2008). For example, none of the households had electricity or owned agricultural machinery. Through role plays with several communities in Zimbabwe, Campbell et al. (1997) found a similar valuation pattern for normal years, with poles, grazing resources, firewood, and wild fruits as the most valued products.

Edible NTFPs were consumed in large quantities and formed an important contribution to the household diet, especially in drought years (Fig. 7). Wild fruit consumption was somewhat higher than observed in three villages in South Africa (Shackleton et al. 2002, Twine et al. 2003). However, the food reserves and food intake of the wealthier farmers in years of poor rainfall may have been underestimated because we were unable to quantify the extent to which households differed in their ability to store surplus production from one year to the next (Ncube et al. 2009). The quantities of firewood collected (4.5 t/yr per household) were similar to estimates made in Mutanda, Zimbabwe (5.5 t/yr per household; Grundy et al. 1993), and in Limpopo province, South Africa (4.5 t/yr per household; Twine et al. 2003). Quantification based on semistructured questionnaires is a powerful tool, although it may suffer from bias and potential for incorrect recall leading to under- or overestimation (Nemarandwe and Richards 2002). Farmers' estimates of both collected and consumed quantities of NTFPs and of the food consumption in the previous week were used to internally triangulate quantities, and this confirmed our results (data not shown). During feedback sessions, farmers confirmed results presented as pie charts and in local units.

The 2007-2008 season in Zimbabwe was exceptionally poor. A prolonged dry spell led to strong incidence of crop failure, and as a result of hyperinflation, cash was virtually worthless (IMF 2009). There was little food available on the market, and farmers had few alternatives to the consumption of wild fruits. Farmers confirmed that wild fruits were "how the people in Ushe community had survived during the 2007/2008 season." Farmers indicated that *P. curatellifolia* was more important in times of drought than *U. kirkiana*. *P. curatellifolia* is one of the most carbohydrate-rich indigenous fruits in the Miombo woodlands (Kalenga Saka and Msonthi 1994). Farmers explained that *P. curatellifolia* could be processed into porridge and a drink, as well as consumed directly (Kalaba et al. 2009), although the fruit of *U. kirkiana* was preferred for its taste. For poor households, wild fruits contributed > 40% to the total energy intake in a year of drought, compared with 22% for wealthy households. Such a high contribution to energy availability was not previously reported.

Knowledge of and access to common resources

Group mapping of natural resources can support both social purposes and research (Herlihy and Knapp 2003). Our group-mapping exercises served to assess and to increase the awareness of the size and state of the natural areas (Figs. 2 and 3). Participating farmers were able to localize natural areas on a framework map (Chambers 2006). In Ushe, where natural areas were scarce and degraded, we found that local people consistently overestimated the natural area available and underestimated the degree of degradation. In Dendenyore, where natural areas were relatively abundant and in a good state, we found that farmers underestimated the natural area available. This suggests a limited knowledge of faraway or little-used areas and emphasizes the importance of mapping areas of limited size (Martínez-Verduzco et al. 2012).

Access rules were unclear in both of the wards studied, although all farmers indicated that cutting fruit trees for firewood was not allowed (Campbell et al. 1997) and many indicated that hunting and firewood collection in other wards was forbidden. Although some rules were apparently known, enforcement varied because of the ineffectiveness of traditional authorities or conflict between traditional and formal authorities (Campbell et al. 1997). The headman of Ushe indicated that enforcement of rules was problematic. These findings suggest either a limited power of local authorities to enforce bylaws governing natural resource management or poor commitment to the rules and lack of ownership by community members.

NTFPs as a coping strategy

Farmer feedback highlighted six main issues: (1) Wild fruits were an important part of the diet, particularly in years of poor rainfall. (2) Cultivated food could not fully substitute for wild food (cf. Scott 1976). (3) Wild fruits were a coping strategy because staple maize grain could not be stored for long mainly as a result of postharvest losses and cash needs. (4) Marketing of wild fruits compromised their role as a safety net, especially when urban traders harvest illegally. (5) Deforestation reduced the effectiveness of using wild fruits to cope with drought and increased the time required for foraging. (6) Conflicts often arose as the result of the weakness of local institutions that governed the use of natural resources.

Farmers were invited to reflect on ways to use the knowledge generated. Several options were mentioned, such as increasing production of small grains, improving storage facilities, preventing the destruction of wild fruit trees, and planting wild trees in a village orchard. Indigenous fruit trees are known to be selectively retained when woodland is cleared (Campbell 1987). Planting of Miombo fruit trees (Akinnifesi et al. 2006, 2008) or assisted natural regeneration (Chazdon 2008) may be realistic options to ensure future supply of indigenous fruits in times of need.

CONCLUSIONS

NTFPs clearly play an important role in farmers' livelihoods, especially because of their contribution to diets in years of poor rainfall. In such years, NTFPs contributed up to 40% of the total energy availability of poorer households, with wild fruits as the most important foods collected. Similarities in the use patterns of NTFPs by communities in contrasting agroecologies during drought years indicated the extent to which the farming systems were rendered vulnerable with the decline of the common natural resource pools. Farmers collected a wide range of NTFPs and were very aware of the important role of these products in their everyday lives. In discussions with farmers, it was brought to light that NTFPs were an effective coping strategy. To adapt to climate change, farmers mentioned that crop production needed to be intensified and grain storage had to be improved. Additionally, communities should cultivate fast-growing trees for firewood and organize community conservation or cultivation of indigenous fruit trees. Farmers indicated that clear regulations and better compliance with regard to extraction of communal resources were required so that NTFPs could continue to be available for the community.

The key role that common property resources play in adaptation to predicted climatic changes demands greater attention from the policy and research communities. Many issues remain, such as best practices for conservation and regeneration of key species, access rules, and competing claims on common lands. Improved management and utilization of communal resources will provide a strong tool to help maintain and increase the rural communities' ability to cope with an increasingly variable climate.

Responses to this article can be read online at:
http://www.ecologyandsociety.org/issues/responses.php/5705

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APPENDIX 1: Calculations and results for the valuation exercise.

Farmers were asked to choose five NTFPs that they normally valued most, and to put those five products in order of importance. They were asked to do the same for a year of poor rainfall. The ranks were converted to values as follows: rank 1 = value 5; rank 2 = 4; rank 3 = 3; rank 4 = 2; rank 5 = 1. Some farmers chose 5 products without ranking them; these were given a value of 3, each. If farmers had ranked a product group (e.g. 'mushrooms') instead of a single species, the highest ranking product of that group was given that value.

The values (v) were used to calculate the relative importance of each product (Table 3). The sum of values (V) per product p per resource group r was divided over the sum of values that was given by farmers in each ward (V_w) to obtain a weighted value (WV, Eq. A1 – A3). This weighted value was corrected because the non-food products had only been included in the ranking exercise in Dendenyore, and therefore their relative value was calculated based on the sum of values for Dendenyore only (Vw^D). Multiplication with a correction factor (C) allowed cross-comparison of all values (Eq. A4, A5) and finally the numbers were multiplied by 100 (Table A.1.1).

Eq. A1. The value of a product ($V^r_{p,y}$) was calculated as:

$$V^r_{p,y} = \sum_{h=1}^{n} v^r_{p,h,y},$$

where V is the value of product p for resource group r in year y, and v is the value of product p for household h (h = 1, 2, ..., n) in year y. Year y is either good or bad.

Eq. A2. Total of all values awarded in a resource group within a ward was calculated as:

$$Vw^{w,r}_y = \sum_{h=1}^{m} \sum_{p=1}^{n} v^{w,r}_{p,h,y},$$

where Vw is the sum of the values of all products p (p = 1, 2, ..., n) for all households h (h = 1, 2, ..., n) in resource group r in ward w in year y. The wards w are Ushe (U) and Dendenyore (D).

Eq. A3. The weighted value of a product per resource group was calculated as:

$$\begin{cases} pt = F \Rightarrow WV^r_{p,y} = \dfrac{V^r_{p,y}}{\sum_{w=1}^{n} Vw^{w,r}_y} \\ pt = NF \Rightarrow WV^r_{p,y} = \dfrac{V^r_{p,y}}{Vw^{D,r}_y} \end{cases},$$

where *pt* is the product type, either food (*F*) or non-food (*NF*), and *WV* is the weighted value of product *p* for resource group *r* in year *y*. Vw^D is the sum of the values of all products *p* for all households *h* in resource group *r* in Dendenyore ward.

Eq. A4. The resource-group specific correction factor was calculated as:

$$C_y^r = \sum_{p=1}^{n} WV_{p,y}^r ,$$

where *C* is the correction factor for resource group *r* in year *y*.

Eq. A5. The relative value of a product per resource group was calculated as:

$$RV_{p,y}^r = \frac{WV_{p,y}^r}{C_y^r} * 100 ,$$

where *RV* is the relative value of product *p* for resource group *r* in year *y*.

Table A1.1: Farmer's valuation of NTFPs, based on a valuation exercise in which farmers selected the NTFPs that were most important to their household and ranked these. Values shown are relative values, and can be compared vertically, horizontally and between product groups. Total values in an entire column add up to 100.

Product name	Year of normal rainfall Value per product per RG				Year of poor rainfall Value per product per RG			
	RG 1	RG 2	RG 3	Total	RG 1	RG 2	RG 3	Total
Fruits								
Parinari curatellifolia	2	3	0	2	27	31	22	26
Uapaca kirkiana	10	7	14	10	8	20	10	12
Strychnos spinosa	2	2	3	2	2	5	2	3
Azanza garckeana	5	5	3	4	0	0	0	0
Vitex payos	1	4	0	2	5	4	0	3
Dovyalis caffra	3	0	0	1	0	0	0	0
Ficus sycamorus	0	0	4	1	3	0	0	1
Total fruits	30	22	23	26	47	65	42	50
Vegetables								
Corchorus oditorius	0	0	4	1	4	0	1	2
Gynandropsis gynandra	0	2	0	1	2	0	0	1
Amaranthus spp	0	0	3	1	0	0	0	0
Total vegetables	3	2	12	6	8	0	5	5
Herbs and medicines								
Lippia javanica	0	0	0	0	0	0	0	0
Dicoma anomala	0	2	7	3	0	0	2	1
Herbs total	1	6	9	5	1	4	3	2
Roots/tubers								
Coleus esculentus	0	0	0	0	0	0	7	2
Total roots/tubers	0	0	0	0	3	0	7	4
Mushrooms								
Amanita zambiana	2	4	4	3	4	4	0	3
Total mushrooms	8	10	9	9	6	10	3	6
Insects								
Termites, alate	13	1	0	6	2	0	2	2
Termites, soldier	3	0	0	1	2	4	0	2
Eulepida masnona	0	0	0	0	1	0	3	1
Grasshoppers	3	0	3	2	4	2	3	3
Coimbrasia belina	0	0	0	0	0	0	3	1
Total insects	19	1	3	9	8	6	11	9
Wild animals								
Common duiker	0	3	3	2	0	0	4	1
Cape hare	7	4	0	4	3	0	4	3
'Mice'	1	0	0	0	1	0	0	0
'Birds'	3	3	3	3	0	0	1	0
Wild pig	0	0	0	0	2	0	0	1
'Fish'	3	0	3	2	0	0	0	0
Total wild animals	14	11	9	12	6	0	9	6
Non-food								
Firewood	14	23	16	17	13	16	0	9
Leaf litter	0	0	0	0	0	0	11	4
Poles	0	16	7	7	0	0	0	0
Thatch	4	9	4	5	6	0	0	2
Grazing	6	0	0	2	1	0	8	4
Total non-food	26	48	33	34	21	16	19	19

APPENDIX 2: Assumptions and conversion factors.

Table A2.1: Conversion factors for farm products

CONVERSION FACTORS FOR FARM PRODUCTS			
Farm product	**Unit**	**Conversion**	**Source**
Maize	1 bag	50 kg DW	Respondents, key informants
Potatoes	1 litre	769 g DW	http://www.simetric.co.uk/si_materials.htm
Soybean	1 litre	721 g DW	http://www.simetric.co.uk/si_materials.htm
Groundnut (unshelled)	1 litre	272 g DW	http://www.simetric.co.uk/si_materials.htm
Beans	1 litre	801 g DW	http://www.simetric.co.uk/si_materials.htm
Wheat flour	1 litre	593 g	http://www.simetric.co.uk/si_materials.htm
Millet grain	1 litre	780 g DW	http://www.simetric.co.uk/si_materials.htm
Rice	1 litre	753 g DW	http://www.simetric.co.uk/si_materials.htm
Wheat grain	1 litre	790 g DW	http://www.simetric.co.uk/si_materials.htm
Bambara groundnut	1 litre	750 g DW	Estimate
Pumpkin	1 piece	1 kg FW	Estimate
Butternut	1 bucket	10 kg FW	Estimate
Kale/rape vegetables	1 bundle	0.5 kg FW	Estimate
Sugarcane	1 stalk	1 kg FW	Estimate
Bananas	1 bunch	5 kg FW	Estimate
Sunflower seed	1 bag	30 kg FW	http://www.whfoods.com/genpage.php?tname=foodspice&dbid=57
Tomatoes	5 litre	2.72 kg FW	http://wiki.answers.com/Q/How_much_does_one_gallon_of_tomatoes_weigh&altQ=How_much_does_a_gallon_of_tomatoes_weigh&isLookUp=1
Cucumber	1 bucket	12 kg FW	Estimate
Onion, carrot, orange, guava	1 bucket	10.88 kg FW	Estimate
Mango	1 bucket	12 kg FW	Estimate
Pawpaw	1 fruit	0.5 kg FW	Estimate
Grape	1 bunch	1 kg FW	Estimate
Apple	1 fruit	150 g FW	Estimate
Spring onion	1 piece	20 g FW	http://www.answers.com/topic/spring-onion-1
Cabbage	1 head	0.5 kg FW	Estimate
Chicken	1 chicken	1.5 kg meat	Mwalusanya et al. 2002
Cattle	1 cattle	144 kg meat	Moyo 1995
Turkey	1 turkey	4 kg meat	Estimate
Goat	1 goat	30 kg meat	Estimate

Table A2.2: Conversion factors for NTFPs

CONVERSION FACTORS FOR NTFPs			
NTFRP	**Quantity**	**Conversion**	**Source**
Firewood	1 bundle	25 kg DW	Biran et al. 2004
	1 cartload	340 kg DW	Benjaminsen 1997
Parinari curatellifolia	1 litre	0.6 kg FW	Measurement
	1 fruit	15 g FW	Measurement
Uapaca kirkiana	1 liter	0.6 kg FW	Measurement
	1 fruit	15 g FW	Measurement, http://www.worldagroforestry.org/downloads/publications/PDFs/pp05177.doc
Amanita zambiana	1 litre	250 g FW	http://www.veg-world.com/articles/cups.htm
Thatch grass	1 bundle	0.85 kg FW	Estimate
Termites	1 litre	208 g FW	Estimate

Poles	1 pole	10 kg DW	Estimate
	1 cartload	20 poles DW	Estimate
Cape hare	1 hare	3 kg FW	http://www.biodiversityexplorer.org/mammals/lagomorpha/lepus_saxatilis.htm
Strychnos spinosa	1 fruit	0.3 kg FW	Measurement
	1 litre	0.8 kg FW	Estimate
Grasshoppers	1 adult	2.5 g FW	Estimate, http://en.wikipedia.org/wiki/Migratory_locust
	1 litre	0.6 kg FW	Estimate, http://www.simetric.co.uk/si_materials.htm
Vitex payos	1 litre	0.6 kg FW	Estimate
Azanza garckeana	1 litre	0.5 kg FW	Estimate
Leaf litter	1 cubic m	210 kg DW	Estimate, http://www.simetric.co.uk/si_materials.htm
Cochorus oditorius	1 cup	75 g FW	Estimate

Table A2.3: Conversion factors local units to universal units

CONVERSION FACTORS LOCAL UNITS TO UNIVERSAL UNITS			
Local unit	**Quantity**	**Conversion**	**Source**
Scotch cart	1 cart	800 L	Measurement
Wheelbarrow	1 barrow	27.5 L	Measurement
Handful	1 handful	150 mL	Estimate
Plate	1 plate	0.7 L	Estimate
Deep plate	1 plate	1.5 L	Estimate
Cup	1 cup	250 mL	Estimate
Big cup	1 cup	500 mL	Estimate
Small dish	1 dish	3 L	Respondents' estimate
Dish	1 dish	5 L	Estimate
Bucket	1 bucket	20 L	Respondents' estimate
Bag	1 bag	69 L	http://www.simetric.co.uk/si_materials.htm
90 kg bag	1 bag	90 kg of maize	Respondents

APPENDIX 3: Complete list of NTFPs used in the research area.

Table A3.1: Wild fruits, species names and collection scores.

Latin name	English name	Shona name	Nr of times mentioned per RG			
			RG 1 *n=9*	RG 2 *n=8*	RG 3 *n=8*	All *n=25*
Parinari curatellifolia	Mobola plum	*Hacha*	8	7	7	22
Uapaca kirkiana	Wild loquat	*Mazhanje*	7	7	7	21
Strychnos spinosa	Bitter monkey-orange	*Matamba*	5	6	6	17
Azanza garckeana	Snot apple	*Matohwe*	6	3	5	14
Vitex payos	Chocolate berry	*Tsubvu*	5	5	2	12
Dovyalis caffra	Kol apple	*Nhunguru*	7	3	2	12
Ficus sycamorus	Fig	*Mawonde*	2	4	4	10
Vanqueriopsis lanciflora	Crooked false medlar	*Matufu*	4	3	2	9
Syzygium guineense		*Hute*	2	3	3	8
Lannea edulis		*Tsambatsi*	2	3	3	8
Ximenia caffra	Sour plum	*Tsvanzva*	3	3	2	8
Garcinia huilensis		*Matunduru*	2	2	2	6
Carissa edulis	Carissa	*Dzambiringwa*	1	1	3	5
Anona senegalensis	Custard apple	*Maroro*	2	2	0	4
		Tsokotsiana	1	1	2	4
Strychnos innocua	Monkey orange	*Makwakwa*	0	1	1	2
Carissa bispinosa	Carissa	*Munzambara*	1	0	1	2
Sclerocarya caffra	Marula	*Marula*	1	1	0	2
		Tsvirinzvi	0	1	0	1
Diospyros mespiliformis	Ebony	*Shuma*	1	0	0	1
Bridelia cathartica		*Mupambare*	1	0	0	1
Carica papaya	Pawpaw	*Mapopo*	0	1	0	1
Dovyalis caffra	Kei apple	*Tsvoritoto*	0	0	1	1
Ficus burkei	Wild fig	*Tsamvi*	0	0	1	1
Psidium guajava	Guava	*Guava*	0	0	1	1
Adansonia digitata	Baobab	*Mahuyu*	0	1	0	1
Opuntia vulgaris	Prickly pear	*Zvinanazi*	0	1	0	1
		Masadzambodza	0	1	0	1
Piliostigma thonningii	African biscuit	*Musekesa*	0	0	1	1
Ximenia caffra	Sour plum	*Nhengeni*	0	1	0	1
Mimusops zeyheri	Red milkwood	*Chechete*	0	1	0	1
Total fruits			**61**	**62**	**56**	**179**

Table A3.2: Wild vegetables, species names and collection scores.

Latin name	English name	Shona name	Nr of times mentioned per RG			
			RG 1 *n=9*	RG 2 *n=8*	RG 3 *n=8*	All *n=25*
Corchorus oditorius	Bush okra	*Derere*	6	3	5	14
Gynandropsis gynandra	African spider herb	*Nyeve*	2	2	3	7
Amaranthus spp.	Poor man's spinach	*Mhowa*	2	2	3	7
Senecio erubescens		*Chirewerewe*	4	2	1	7
Sesamum angustifolium	Sesame	*Samuwende*	2	2	1	5
Cleome monophylla	Spindle pod	*Mujakari*	1	2	1	4
Heteropogan contortus	Spear grass	*Mhuvuyu/mutsine*	1	1	2	4
		Mhonja	2	0	0	2
Solanum nigrum	Nightshade	*Musungusungu*	1	1	0	2
		Monenza	0	1	0	1
		Fototo	0	1	0	1
		Mundya	0	1	0	1
		Chipesu	0	1	0	1
Total vegetables			**21**	**19**	**16**	**56**

Table A3.3: Wild mushrooms, species names and collection scores.

Latin name	English name	Shona name	Nr of times mentioned per RG			
			RG 1 *n=9*	RG 2 *n=8*	RG 3 *n=8*	All *n=25*
Amanita zambiana	Zambian slender caesar	*Nhedzi*	9	6	8	23
Cantharellus		*Tsvuketsvuke*	9	4	6	19
Boletus edulis		*Tindindi*	6	2	6	14
Cantharellus		*Chihombiro*	4	3	4	11
Cantharellus densifolius		*Nzeve(ambuya)*	6	3	3	12
Termitomycete		*Huvhe*	5	1	2	8
		Uzutwe	1	2	3	6
		Ndebvudzasekuru	0	2	1	3
		Bunaretsoko	1	2	0	3
		Chinyokasheshe	1	1	0	2
		Dindijava	0	2	0	2
	"Mushrooms"	*Owa*	0	2	0	2
		Chiyambwe	0	0	1	1
		Tsihhuri	0	1	0	1
		Chiropachembwa	0	0	1	1
Total mushrooms			**42**	**31**	**35**	**108**

Table A3.4: Wild herbs and medicines, species names and collection scores.

Latin name	English name	Shona name	Nr of times mentioned per RG			
			RG 1 *n=9*	RG 2 *n=8*	RG 3 *n=8*	All *n=25*
Lippia javanica	Lemon bush	*Zumbani*	4	6	5	15
Temnocalyx obovatus	Makoni tea bush	*Makoni tea*	2	0	3	5
Aloe spp.	Aloe	*Gawagawa*	3	0	2	5
Dicoma anomala		*Chifumuro*	1	1	3	5
Erythrina abyssinica	Lucky-bean tree	*Mutiti*	2	0	1	3
Elephantorrhiza elephantina		*Muzezepasi*	2	0	1	3
		Moringa	1	0	1	2
Eucalyptus spp.		*Gum tree*	1	0	1	2
Terminalia sericea		*Mususu*	1	0	1	2
Sarcostemma viminale	Milk rope	*Nyokadombo*	2	0	0	2
		Muwengahonye	0	1	1	2
		Manyama	0	0	1	1
Securidaca longepedunculata	Violet tree	*Mufufu*	0	0	1	1
	Christmas tree	*Christmas tree*	0	0	1	1
	Guava	*Guava coffee*	0	0	1	1
Ficus sycamorus	Fig	*Muwonde leaves*	0	0	1	1
Cyperus angolensis	White-flowered sedge	*Chityorabadza*	0	0	1	1
Combretum apiculatum		*Mugodo*	1	0	0	1
		Gardenrule	0	1	0	1
Solanum incanum	Bitter apple	*Nhundurwa*	1	0	0	1
		Munzvanzva	1	0	0	1
		Mumhungu	1	0	0	1
		Mutarara	1	0	0	1
		Muroro	1	0	0	1
		Ndolani	0	1	0	1
Lantana camara		*Lantana camara*	0	1	0	1
		Musahute	0	1	0	1
Total herbs			**25**	**12**	**25**	**62**

Table A3.5: Wild roots/tubers, species names and collection scores.

Latin name	English name	Shona name	Nr of times mentioned per RG			
			RG 1 *n=9*	RG 2 *n=8*	RG 3 *n=8*	All *n=25*
Coleus esculentus	Vlei tuber	*Tsenza*	3	1	2	6
Eriosema pauciflorum		*Tsombori*	1	1	3	5
Babyana hypogaea		*Hwenya*	1	1	0	2
Commiphora marlothii	Paperbark	*Munyera*	0	1	0	1
		Muchanya	1	0	0	1
Total tubers			**6**	**4**	**5**	**15**

Table A3.6: Insects, species names and collection scores.

Latin name	English name	Shona name	Nr of times mentioned per RG			
			RG 1 *n=9*	RG 2 *n=8*	RG 3 *n=8*	All *n=25*
Macrotermes spp.	Termites, alate	*Ishwa*	8	5	5	18
Macrotermes spp.	Termites, soldier	*Majuru*	7	3	4	14
Eulepida masnona	Christmas beetle	*Mandere*	5	4	4	13
Orthoptera spp	Grasshoppers/locusts	*Whiza/mashu*	4	2	5	11
Coimbrasia belina	Mopane worm	*Madora*	2	3	5	10
Carebara vidua	Flying ants	*Tsambarafuta*	3	2	3	8
Bracytypus membranaceus		*Makurwe*	3	0	3	6
Cirina forda		*Harati*	2	0	1	3
Sternocera funebris		*Zvigakata*	1	0	1	2
Total insects			**35**	**19**	**31**	**85**

Table A3.7: Wild animals, species names and collection scores.

Latin name	English name	Shona name	Nr of times mentioned per RG			
			RG 1 *n=9*	RG 2 *n=8*	RG 3 *n=8*	All *n=25*
Sylvicapra grimmia	Common duiker	*Membwe*	4	4	4	12
Lepus capensis	Cape hare	*Tsuro*	5	2	4	11
	Mice	*Mbeva*	4	1	3	8
	Birds	*Shiri*	2	1	4	7
Procavia capensis	Rock rabbit	*Mbira*	2	3	1	6
Potomachoerus larvatus	Wild pig	*Nguruve*	2	2	2	6
	Fish	*Hove*	1	0	2	3
Paracynictis selousi	Selous mongoose	*Jerenyenje*	0	2	1	3
Hystrix africaeausralis	Porcupine	*Nungu*	0	1	1	2
Numida meleagris	Wild guineafowl	*Hanga*	0	1	1	2
Paraxerus cecapi	Tree squirrel	*Tsindi*	0	0	1	1
	Fowl	*Orwe*	0	0	1	1
Oreotragus oreotragus	Klipspringer	*Ngururu*	0	1	0	1
		Nhimba	0	1	0	1
		Chiwuta	0	1	0	1
Aepyceros melampus	Impala	*Impala*	0	0	1	1
Raphicerus campestris	Steenbok	*Mhene*	0	1	0	1
Total animals			**20**	**21**	**26**	**67**

Table A3.8: Livestock feed, species names and collection scores.

Latin name	English name	Shona name	Nr of times mentioned per RG			
			RG 1 *n=9*	RG 2 *n=8*	RG 3 *n=8*	All *n=25*
Piliostigma thonningii	African biscuit	*Musekesa*	4	4	0	8
Dichrostachys cinerea		*Mupangara*	3	1	1	5
		Tsokotsiana	0	0	1	1
		Muhunga	1	0	0	1
		Pfubvudza	1	0	0	1
		Star grass	1	0	0	1
		Green glass	1	0	0	1
Total feed			**11**	**5**	**2**	**18**

Table A3.9: Non-food products, species names and collection scores.

Latin name	English name	Shona name	Nr of times mentioned per RG			
			RG 1 *n=9*	RG 2 *n=8*	RG 3 *n=8*	All *n=25*
FIREWOOD	Firewood	*Huni*	9	8	8	25
Julbernardia globiflora		*Munhondo*	5	5	4	14
Brachystegia spiciformis		*Msasa*	6	4	4	14
Brachystegia glaucescens	Mountain acacia	*Muwunze*	3	4	2	9
Brachystegia boehmii		*Mupfuti*	2	6	1	9
Combretum apiculatum		*Mugodo*	0	2	1	3
Pericopsis angolensis		*Muwanga*	0	1	1	2
Piliostigma thonningii		*Musekesa/mutukutu*	0	1	1	2
		Mudjoke	1	0	1	2
Dovyalis caffra	Kol apple	*Munhunguru*	0	0	1	1
		Mudzunzowa	0	1	0	1
Azanza garckeana		*Mutohwe*	0	1	0	1
Eucalyptus spp	Gum tree	*Eucalyptus*	0	1	0	1
		Mushawa	0	1	0	1
Dichrostachys cinerea		*Mupangara*	0	0	1	1
		Mubuku	1	0	0	1
		Tsokotsiana	0	0	1	1
TERMITARIA	Termitaria	*Churu*	7	5	8	20
LEAF LITTER	Leaf litter	*Mutsakwani*	8	5	7	20
Julbernardia globiflora		*Munhondo*	0	1	1	2
Brachystegia boehmii		*Mupfuti*	0	1	1	2
Ficus burkei/ingens/natalensis	Wild fig	*Mutsamvi*	0	1	1	2
Brachystegia glaucescens	Mountain acacia	*Muwunze*	0	0	2	2
Sectia brachypetala		*Mutondochuru*	0	1	0	1
Ficus sycamorus	Fig	*Muwonde*	0	1	0	1
Piliostigma thonningii		*Musekesa*	0	1	0	1
Ziziphus mucronata		*Muchecheni*	0	1	0	1
Brachystegia spiciformis		*Msasa*	0	0	1	1
		Tsokotsiana	0	0	1	1
		Mukonachando	0	0	1	1

Table A3.9: Non-food products, continued

Latin name	English name	Shona name	Nr of times mentioned per RG			
			RG 1 *n=9*	RG 2 *n=8*	RG 3 *n=8*	All *n=25*
POLES	Poles	*Mapango*	6	6	6	18
Eucalyptus spp	Gum tree	*Eucalyptus*	1	1	1	3
Pericopsis angolensis		*Muwanga*	0	2	1	3
Terminalia sericea		*Mususu*	1	1	0	2
Burkea africana		*Mukarati*	0	2	0	2
Ormocarpum trichocarpum		*Mpotanzou*	1	0	0	1
		Mubuku	0	1	0	1
		Murwiti	0	0	1	1
THATCH	Thatch grass	*Huswa*	5	2	7	14
Hyparrhenia filipendula		*Madangaruswa*	1	0	0	1
		Nutu	0	0	1	1
GRAZING	Grazing		4	2	4	10*
ROPE	Rope from bark	*Makavi*	1	0	3	4
Brachystegia spiciformis		*Msasa*	1	0	0	1
BROOMS	Brooms		1	2	1	4
Myrothamnus flabellifolius		*Mufandichimuka*	1	0	0	1
Schotia brachypetala		*Mwawashuni*	0	0	1	1
STONES	Stones for building		0	0	1	1
SODIC SOIL	Sodic soil		1	0	0	1
BRICKS	Bricks		0	1	0	1
Total non-food			**42**	**31**	**45**	**118**

*** Grazing was scored only in Dendenyore Ward.**