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Sandveld Agriculture in Botswana

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In a discussion of arable agriculture in the Kalahari Desert area of Botswana, the Director of Agricultural Research made the following important observation:

> A description of present agriculture can at the moment only be partial and imprecise. As with the environment, data are scarce and observations covering the data are lacking in continuity over seasons, years, and areas. Yield levels, for instance, are not known with any degree of certainty (Öland 1980a:4).

Relatively little in-depth research has been carried out on arable crop production in the Kalahari, in part because there is a widespread belief that the Kalahari ecosystem is, at best, marginal in terms of agriculture, and therefore few people engage in it. Recent surveys in a number of Kalahari villages, however, have revealed that up to 90% of the households in those places plant crops. Admittedly, crop yields are often low and crop failures are not infrequent given the rainfall, which is both low and highly variable in space and time. Nevertheless, many of the people in the sandveld region of Botswana expend the effort to plant and tend crops, and sometimes these efforts are rewarded with the addition of cereals, pulses, melons and even vegetables and fruits to their diet.

The purpose of this paper is to review briefly the existing knowledge of sandveld agriculture in Botswana. After a discussion of the Kalahari ecosystem, an attempt will be made to describe the existing crop production practices. It will be shown that in spite of the fact that returns to labor in planting and cultivation are often low, many households persist in their agricultural activities. It will also be shown that even the highly mobile hunter-gatherer populations of the Kalahari engage in crop production, particularly in rainy years. Some of the major constraints to crop production in the sandveld will be outlined, and a series of recommendations as to how the Government of Botswana might overcome some of these constraints will be presented. Given the fact that the agricultural sector is the mainstay of the economy of Botswana, efforts should be made to increase agricultural production not only in the eastern hardveld areas of the country, but also in the sandveld and along the margins of the Okavango Delta.

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The Kalahari Ecosystem

The Kalahari Desert, often called the sandveld, covers much of the country of Botswana. Estimates range between 80 and 85 per cent of the total surface area. The Kalahari is a relatively flat or gently undulating plain which averages about 1000-1100 meters above sea level. It is part of a much larger psysiographic basin which stretches from the Orange River in South Africa to Angola. For an area called a desert it is heavily vegetated, causing some researchers to describe it instead as a "thirstland" since a characteristic feature is that it lacks surface water. The Kalahari is dissected by fossil river valleys, evidence of a much wetter climate in the past, and there are the remains of ancient beach ridges, part of a gigantic Pleistocene lake which covered much of north-central Botswana. The eastern boundary of the raised Kalahari plateau is characterized, in some places, by a pronounced scarp, to the east of which is the hardveld region, an area dominated by tropical ferruginous soils (Figure 1). There are three main drainage regions in Botswana: the Makgadikgadi basin in north-central Botswana, the Nossop-Molopo River system in south western Botswana, and the

Limpopo drainage in the east. The Makgadikgadi basin and the Nossop-Molopo drainage are separated by the Bakalahari Schwelle, a low ridge which runs in a north west — south easterly direction from Ghanzi to Kanye. The sands, vegetation and general physiography of the Kalahari tend to differ to the north and south of the Schwelle.

The climate of the Kalahari is semi-arid, with rainfall varying from about 250 mm per year in the south west and up to 700 mm per year in the north east. The coefficient of variation is high, and evaporation rates often exceed rainfall. Kalahari soils are mainly sandy; these sands are highly porous and have a relatively high moisture

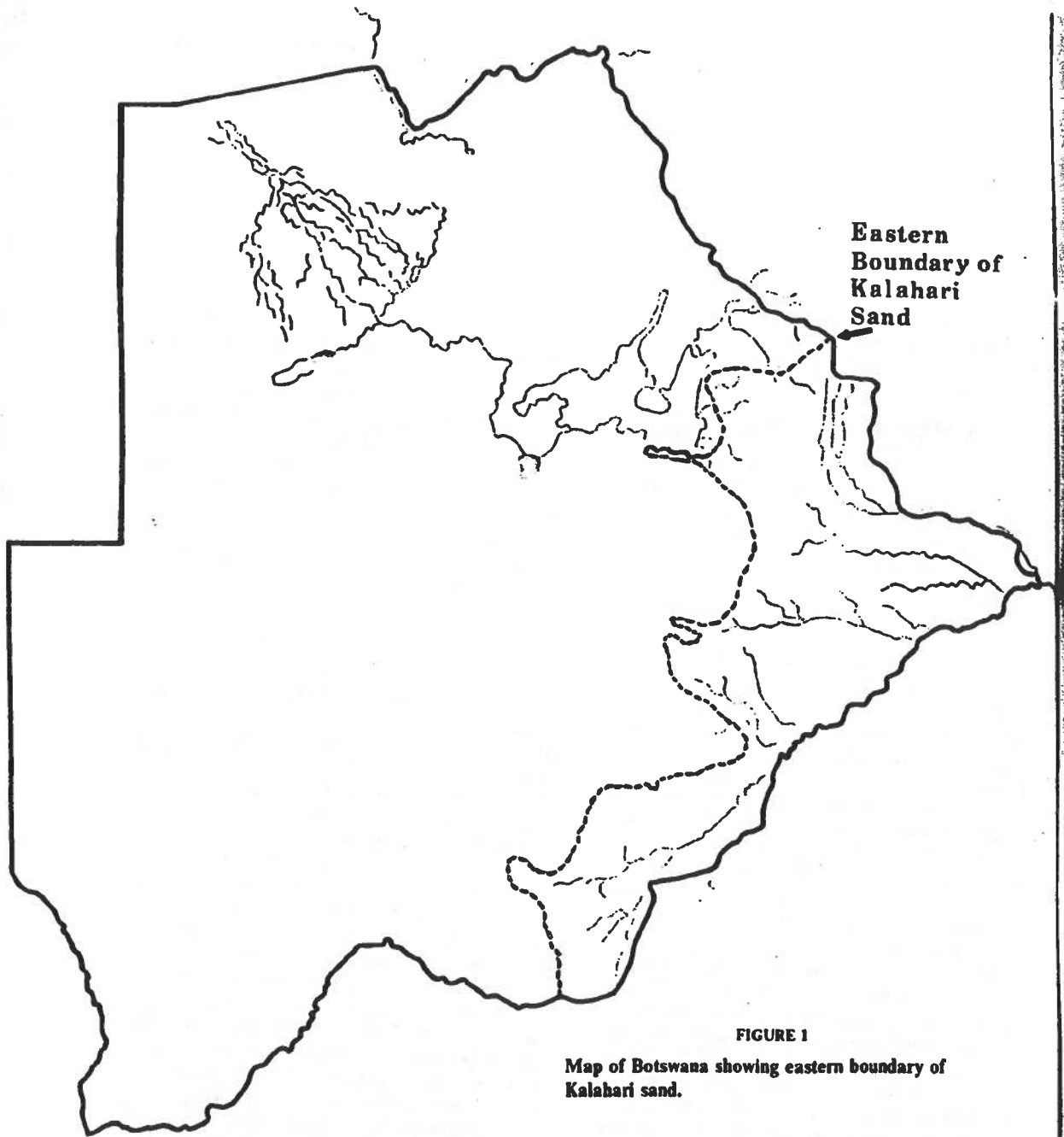


FIGURE 1

Map of Botswana showing eastern boundary of Kalahari sand.

retention capacity. The crucial limiting factor in the sandveld is water. Rainfall generally occurs between November and April, with the majority of the rain falling between January and March. Water remains in pans and depressions only for a short time, and there is little run-off. Rainfall is highly variable both in space and time. The water which infiltrates the sands is either retained or is lost directly through evaporation or indirectly through transpiration.

Soil moisture is a more crucial limiting factor to plant production in the Kalahari than is lack of soil nutrients. There is no question, however, that Kalahari sands are deficient in certain nutrients, particularly phosphates and nitrogen. In some areas there are low depressions where soil moisture collects, and nutrients are higher; these places can be found in the fossil river valleys which dissect the Kalahari, for example. Some areas have calcrete outcrops, where calcium carbonate ($CaCO_3$) has formed in the soils. These places, as well as pans, often have a higher water table than surrounding areas, and ground water can be tapped through the sinking of shallow wells. At the same time, high amounts of calcium may have adverse effects on certain crops. Sorghum, for instance, does not do well in areas of calcrete where the soil ph is likely to be correspondingly high.

It is important to have a sound working knowledge of the hydrogeology, physiography, and soils of the Kalahari if one is to make realistic recommendations about crop production. The Kalahari is not a vast, undifferentiated sandy plain covered with low tree and shrub savanna; rather, it is a mosaic of different soil and vegetation types which often vary greatly from place to place. These differences must be taken into account in planning agricultural development strategies in the sandveld.

Agricultural Strategies in Sandveld Areas

Relatively little attention has been paid to agricultural production in the sandveld. Government efforts have been restricted almost entirely to livestock production. Data on crop production in the Western Agricultural Region were not gathered until the 1979/80 cropping season. At present there are no Agricultural Demonstrators who specialize in crop production in either Ghanzi or Kgalagadi Districts. The only extension efforts in arable agriculture made thus far have been part of the Ministry of Local Government and Lands' Remote Area Development Programme, which has agricultural advisers in Ngamiland and Ghanzi. In spite of the lack of Government interest in sandveld crop production, many if not most of the households in the Kalahari engage, at least to a certain extent, in cultivation of cereals and other crops.

The majority of the households in the Kalahari employ a mixed economic strategy. While less than half of the households own livestock, many more are able to derive benefits from the presence of livestock, either through employment or informal sharing arrangements. It is interesting that in spite of the fact that livestock production plays such a crucial role in Botswana's economy, there are few good data upon which to base an assessment of the numbers and distribution of cattle in the country. One of the few attempts to make such an assessment is that of G.P. McGowan and Associates (1979), who provided the following estimates for the livestock population of the Kalahari in 1978:

TABLE 1

Livestock population of the Kalahari[1]

Region	1977 Total	1978 Total
Ngamiland	300 000	325 000
Rakops (Central)	40 000	44 000
Makoba West (Central)	100 00	109 000
Nata (Central)	60 000	65 000
Kweneng West	220 000	227 500
Ngwaketse West	210 000	217 000
Ghanzi	197 000	207 000
Kgalagadi North	40 000	41 500
Kgalagadi South	35 000	36 000
Molopo (Kgalagadi)	65 000	66 000
	1 073 000	1 288 000

[1] The data contained in this table were adapted from McGowan and Associates (1979, Volume 2, Appendix 1, Table 1). It should be noted that after five years of drought in the Kalahari the figures for livestock populations are probably somewhat less, though recent figures are lacking.

It is important to stress that livestock ownership in the Kalahari is highly skewed, much moreso than is the case either nationally or in the eastern hardveld portions of the country. In the Western Sandveld region of Central District, for example, out of a total of 666 households residing in the area, 590 or 88,8% owned no livestock, whereas among the absentee water source owners (n=61) 96,7% each owned over 100 head.[2] In Kalahari villages such as Kang, Kuli, or Kalkfontein, on the other hand, the distribution of ownership is somewhat less skewed, but the pattern is similar.

Rural households in the sandveld areas derive their subsistence from a combination of livestock production, arable agriculture, wage labour,

[2] A discussion of the Central District Western Sandveld region's livestock ownership and holding patterns can be found in Hitchcock (1978).

TABLE 2

Estimated percentages of Kalahari populations engaged in agricultural production

Location	Group	Size of a Population	Number Practising Agriculture	Percentage	Reference
Northwest Kalahari	!Kung	38	12	31,6	Gelburd (1978:79-82, Table 8)
Northwest Kalahari	!Kung	?	?	7.0	Wiessner (1977:85, Table 3)
Western Kalahari	Nharo, G/wi, etc.	4 512	?	Nearly 40	Childers (1976:62)
Southeast Kalahari	Tsassi, etc.	52	23	44,2	Caye and Koitsiwe (1976:26)
Southeast Kalahari (Kweneng)	Kua, etc.	136 hh's	66 hh's	48,5	Vierich (1979:41, Table 1)
Eastern Kalahari	Kūa, etc.	666 hh's	147 hh's	22,1	Hitchcock (1978:339)
Eastern Kalahari	Kūa, etc. foragers	118 hh's	8 hh's	6,8	
Nata River Region	Tyua	82 hh's	75 hh's	90,2	

a
Numbers given in this column are the totals of people from whom data were obtained; the designation "hh's" stands for households.

hunting, and gathering. Mine labour migration is high in some areas, such as the Kweneng and parts of Ngwaketse District. Employment on cattle posts belonging to others is a common means of obtaining a livelihood, for example, in the western part of Central District.

Estimates of the numbers of households participating in crop production in the sandveld vary from as few as 7% (Wiessner 1977:85) to as high as 90% (Solway 1980:23). Some estimated percentages of Kalahari populations engaged in crop production are provided in Table 2. It is interesting to note that many of the groups doing agriculture have been described in the anthropological literature as "hunter-gatherers". It has been found that even mobile groups will plant crops of melons, maize, beans, or sorghum, then will continue to move, returning to the fields when the crops are ripe. Nearly all of the hunter-gatherer populations in the Kalahari derive a portion of their subsistence from domestic foods (Hitchcock & Ebert, 1984).

An examination of crop production in various Kalahari villages reveals some interesting patterns that make sandveld agriculture somewhat different from agriculture practised in the eastern part of Botswana.

Rather than having separate residences, fields, and cattle posts, many sandveld households cultivate fields and gardens close to their homes, while at the same time cattle are kept close by. As a result, crop damage due to marauding livestock is a serious problem. Most of the fields in Kang, for example, are fenced so as to prevent cattle from destroying the crops. Nevertheless, crop damage still occurs, and Susan Wynne (personal communication) found that fines for cattle damaging people's

crops are rarely levied, at least in the Letlhakeng area of Kweneng. Some areas, such as the Khwee region of western Central District, have relatively few cattle, so fields are left unfenced, but crops are still destroyed by wild animals. Wildebeest are a serious menace in the Ncojane Farms area of western Botswana.

Agricultural methods tend to be somewhat more varied in the sandveld than they are in the eastern hardveld of Botswana, where ploughing is usually done with the aid of single furrow ploughs drawn by draught oxen. The three major implements used in sandveld crop production are the digging stick, the hoe, and the plough. Tractors are rare, although they are sometimes used, as they were at Kang in 1978/79 and in the sandveld west of Mosolotsane in Central District in 1978. In the ALDEP[3] Survey, it was found that 11% of the households in Kalkfontein in Ghanzi District had no ploughs, while 40% of the households in Kang (Kgalagadi District) did not own a plough. Double row ploughs, planters, and cultivators are extremely rare in the sandveld.

It is difficult to say whether or not the lack of implements and draught power is a serious constraint to sandveld agriculture. Whereas Solway (1980), found that virtually all of the households in Dutlwe in Western Kweneng District ploughed their lands with the aid of draught power, this was the case for only 42,2% of the households engaged in crop production in the western Central District (Hitchcock 1978:344). In this region, 32% of the households used digging sticks, and 24,5% used hoes. Digging sticks and hoes are also used commonly in the Central Kalahari Game Reserve and in the area west of Hukuntsi in south western Botswana. Draught power is provided not only by oxen in the sandveld but also by cows, donkeys, and sometimes horses. According to the ALDEP survey, 75% of the farmers in Ghanzi District use donkeys for draught power. In the western part of Central District, 24 out of 56 ploughing teams recorded (48,2%) consisted of donkeys. In discussing ploughing with people in the sandveld, one learns that they would prefer to use oxen if they had access to them. Hiring of oxen is rare in the sandveld; most people obtain them through borrowing or sharing arrangements. It is significant that lack of access to oxen does not prevent people from planting crops, since they can use donkeys or they can resort to alternative implements.

Field sizes in the sandveld are generally relatively small, ranging from about 100 m^2 to several hectares in area. Table 3 provides data on field sizes of some Basarwa populations in the Kalahari. It is interesting to use these data as a starting point because it is often assumed that the field sizes of Basarwa populations are generally smaller than those of other groups. In a survey of 49 households in Hukuntsi and Tshane in 1978, it was found that the average field size was less than a hectare (Goodman Khumalo, personal communication). Lee (1979:409) points out that the typical field in the Dobe region of western Ngamiland is oval in shape and ranges from 0,25 to 1 hectare in size. Fields on freehold and leasehold farms in the sandveld also

TABLE 3

Comparative data on agricultural field sizes of food producing populations in the Kalahari Desert, Botswana

Location	Group	Size (ha)	Number of Fields	Reference
I. SW Kalahari				
a. N!haite/Hukuntsi	!Xõ	0,2-1.0	7	Thoma (1978)
b. Pepane/Lehututu	!Xõ	0,2-0.6	10	Thoma (1978)
c. Monong	!Xõ	0,5-0.6	2	Thoma (1978)
d. Ngwatle	!Xõ	0,3-0.4	2	Thoma (1978)
e. Kwakai	!Xõ	0,2-0.3	2	Thoma (1978)
f. Tshotswa	!Xõ	4,5	1 communal	Thoma (1978)
SUBTOTAL		average = 0,52	24	
II. SE Kalahari				
a. Thotayamarula	Kūa	5,9	1	Vierich (personal communication)
b. Mazane	Kūa	0,6-8.4	3	Vierich (personal communication
SUBTOTAL		average = 3,2	4	

(Continued)

Location	Group	Size (ha)	Number of Fields	Reference
III. Southern Kalahari				
a. Molopo Farms	Balala	average - 0.027	30	Lawry (1978:23)
IV. NW Kalahari				
a. Dobe, etc.	!Kung	0,532 ha	64	Matlhare (1978)
V. NE Kalahari				
a. Nata River region	Tyua	average 1.146	12	Cashdan and Chasko (1977:28)
VI. Eastern Kalahari				
a. Western Sandveld region	Kūa, etc.	0.01-1.1 average 0.14	18	Hitchcock (1978: 350)
TOTAL		average 0.6	197	

tend to be small; on the Molopo Farms in Kgalagadi District, for example, Lawry (1978) found that the average size of 30 plots was 250 square meters. Fields in river valley areas, such as those in north eastern Kweneng, tend to be larger than in other parts of the sandveld, averaging between 2 to 5 hectares in size (Helga Vierich, personal communication). Field sizes tend to vary, then, depending on soil type, labour availability, and type of cultivation method. Larger fields tend to be ploughed with the aid of draught animals, while smaller fields tend to be cultivated with the aid of digging sticks and hoes.

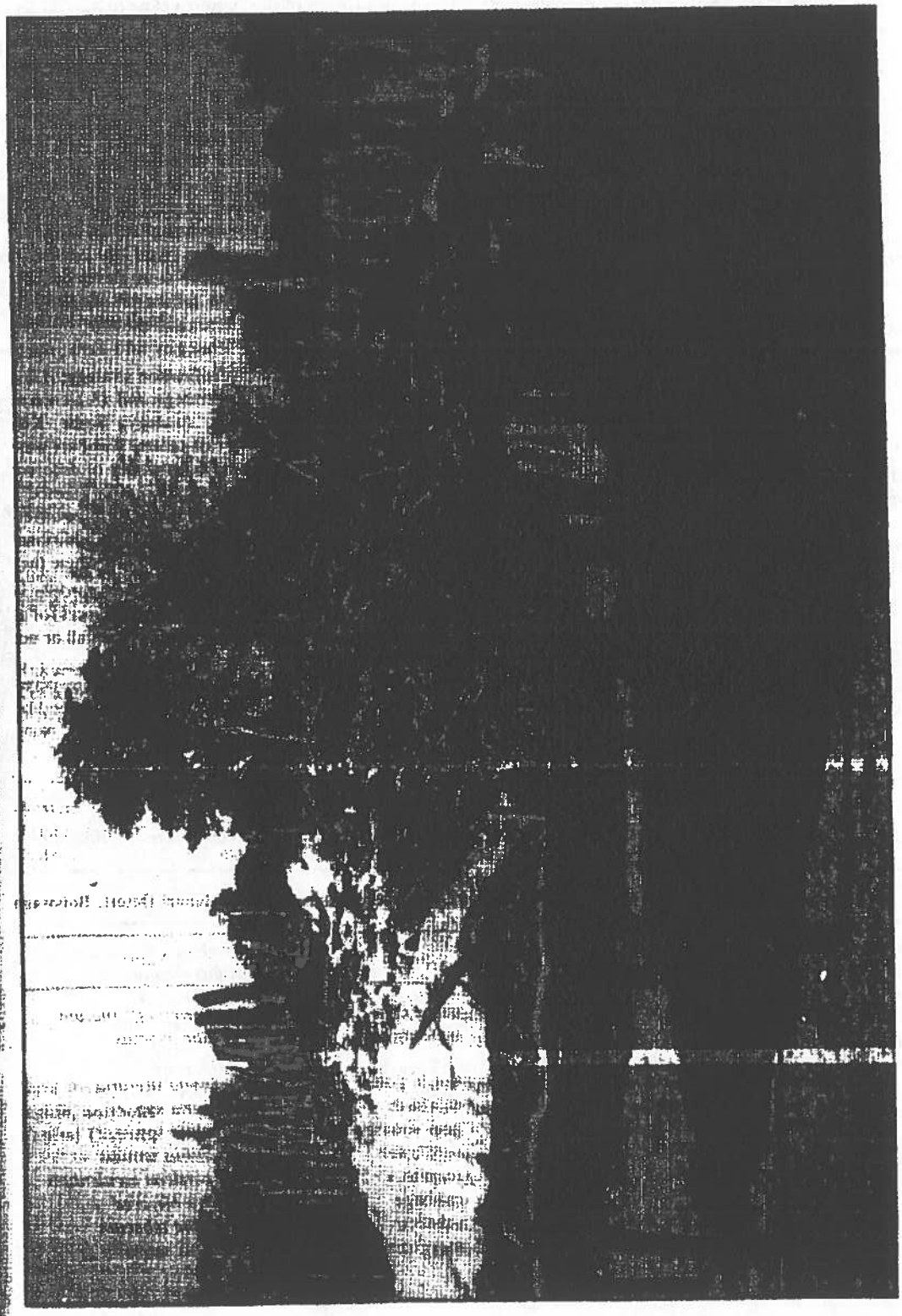
Timing of planting is critical in a moisture-stressed ecosystem. In order to maximize on the availability of soil moisture, one must plant as soon after a heavy rain as possible. It is interesting to note that by and large, agriculturalists in the sandveld tend to plant later than do those in hardveld areas. According to the ALDEP survey, only 38% of those who planted in Kang and Kalkfontein in 1978 did so before December. What this means is that over three fifths of those who planted did so in the period between December and March. The reasons for this late planting are not well-understood; it is possible that the amount of rainfall that is considered critical for planting by local farmers does not occur in the Kalahari until about January.

A major constraint in sandveld crop production is the availability of seed. The ALDEP survey showed that 85% of the farmers in Kalkfontein and 60% of those in Kang obtained seed from their own supplies. Because there are no lock-up stores nor agricultural demonstrators in western Botswana, people must rely on their own seed left over from the previous year. Given the fact that yields are low in the sandveld, people often eat their seed supply, leaving little if any seed for the next year's planting. An additional problem is the nature of the seed. Drought-tolerant crops have yet to be developed which are especially adapted to Kalahari conditions. Crop failures are common, but they would be less so if people had access to drought-tolerant seed.

A whole range of crops are planted in the sandveld. Table 4 gives a listing of the various domestic plants grown, along with their scientific names. It is important to note that cereals are an important crop in the sandveld, in spite of the fact that they are prone to destruction by birds, and other pests and are seriously affected by shortages of rainfall at critical times in the growth cycle. The most common plants grown in the sandveld are melons, beans, sorghum, and maize. In the western sandveld region of Central District, of the 45 households for which good yield data could be obtained, only 17 produced crops besides melons. In the Kalkfontein area of Ghanzi District, yields of sorghum and maize were half of those obtained nationally, however, beans turned out to be twice as productive. It should be pointed out, too, that many households in the sandveld grow two bean

Figure 2

Maize/Sorghum in a Serala (drying facility) at Maun/otai in the Northern Kalahari



crops per year. Figure 2 shows sorghum and maize in a drying facility in a north eastern Kalahari Basarwa compound.

Öland (1980a) has recommended that horticulture should receive first priority in research and extension efforts in the Kalahari. There is no question that a whole range of vegetables and fruits can be raised in the sandveld. Some people grow oranges *(Citrus sinensis)* and lemons *(Citrus limon)* in the vicinity of boreholes in the western part of Central District. Vegetables found growing near boreholes and wells include tomatoes, cabbages and lettuce. Green maize can also be grown in sandveld areas. Nevertheless, it is questionable whether first priority should be given to horticulture, which is engaged in by but a few Kalahari residents, or dryland crop production, which is practised by a large proportion of the sandveld population. On-farm research indicates that people would like to increase their cereal production. Melons are grown not only for food, but they are dried and stored for later use or sometimes serve as a substitute for water, as is the case in the Central Kalahari (Cashdan, 1977).

One of the biggest problems faced by arable producers in the Kalahari is the high frequency of crop failures. In general it can be argued that sandveld agriculture in Botswana is characterized by low production levels, as often the crops planted either fail to grow or produce only small amounts. There are relatively few data on sandveld agricultural yields in Botswana. Table 5 presents information on the yields of various crops in a number of different parts of the Kalahari sandveld. It can be seen that in general the yields are relatively low, and failure of crops is not uncommon. One way of reducing the risk of crop failure is to provide water for the crops from surface or underground sources; this was done by Gus Nilsson at his Sanitas garden in Hukuntsi, for example, and the yields were significantly greater than was the case among other remote area agriculturalists' fields. In some cases, as in the Western Sandveld of Central District, people have established gardens close to boreholes and wells and they water them regularly by hand. In the Central Kalahari Game Reserve, Basarwa groups have deepened wells in pans using shovels and picks, and some of the water is occasionally used for small gardens. In a few cases, hand pumps have been installed, as was done at the Remote Area Development Programme hostel in Hukuntsi.

Kalahari crop-producers tend to employ a number of different kinds of strategies in order to reduce the risk of crop failure or problems of destruction by insects, birds and animals. It is possible to divide these strategies into three major types: (1) a spatial diversification strategy; (2) a temporal diversification strategy; and (3) a crop or product diversification strategy. Some Kūa Basarwa groups in the east-central Kalahari were observed planting crops in a number of different places. At Khwee, for instance, Kūa planted a garden near each of their campsites at three different locations, and they established an additional garden near a borehole at Metsimonate where they spent the dry season in 1978. Having gardens in several different places increases the chances for at least one of them receiving sufficient rainfall or not being preyed upon by competitors.

A temporal diversification strategy involved planting crops at a number of times, depending upon rainfall, some early on during the rainy season, and others later. !Xō groups of the southwestern Kalahari, for example, stagger the

TABLE 4

Domesticated plants grown by foraging and food-producing populations in the Kalahari Desert, Botswana

Common Name	Scientific Name	Common Name	Scientific Name
sorghum	*Sorghum bicolor*	sugar cane	*Saccharum officinarum*
corn (maize)	*Zea mays*	watermelon	*Citrullus lanatus*
millet	*Pennisetum americanum*	sweet melon	*Cucumis melon*
finger millet	*Eleusine coracana*	bottle gourd	*Lagenaria siceraria*
cowpea	*Vigna unguiculate*	calabash	*Lagenaria* spp.
groundnut	*Arachis hypogaea*	gem squash	*Cucurbita* spp
pumpkin	*Cucurbita maxima*	sunflower	*Helianthus annuus*
teppary bean	*Phaseolus acutifolius*	tomato	*Lycopersicon esculentum*
mung bean	*Phaseolus aurens*	cabbage	*Brassica oleracea*
sweet reed	*Sorghum bicolor*	tobacco	*Nicotiana tabacum*
castor	*Ricinus communis*	marijuana (hemp)	*Cannabis sativa*

TABLE 5
Data on crop yields for a sample of sandveld households in Botswana

Area	Type of Crop	Yields	Remarks
Kweneng District Sandveld	sorghum	360 kg	yields vary enormously over time and from place to place (Vierich 1979:27)
	beans	"a few bucketsful"	
	maize	"a few bucketsful"	
	millet	"a few bucketsful"	
Dutlwe, western Kweneng District	sorghum	up to 20 bags	average yield - varies tremendously (solway 1980:25)
Dobe-/ai/ai area, western Ngamiland	sorghum	0,25-1 bag/ha	bag = 100 kg; data is for 1977/78 cropping season; 1978/79 season harvest failed completely (see Matlhare, 1978:19)
	maize	0,25-3 bags/ha	
	cowpeas	0,25-2 bags/ha	
	melons	(no figures given)	
	tobacco	(no figures given)	
Kalkfontein, Ghanzi District	sorghum	0.76 bags/acre	ALDEP Survey data (Odell, 1980)
	maize	0.80 bags/acre	
	beans	2,04 bags/acre	
Kang, Northern Kgalagadi District	sorghum	0,9 bags/acre	ALDEP Survey data (Odell, 1980)
	maize	0,6 bags/acre	
	beans	0,6 bags/acre	
Hukuntsi, Northern Kgalagadi District	sorghum	failed	Sanitas, Ltd. data for 1979/80; recorded in Oland (1980a:5)
	cowpea	1000 kg/ha	
	sweet maize	failed	
	hybrid maize	1900 kg/ha	
	China pea	900 kg/ha	
Western Sandveld Region, Central District	melons	15-300	data drawn from Hitchcock (1978: 351, Table 12.7)
	sorghum	1 bucket-8 bags	
	maize	0,3 bucket - 1,5 bags	
	millet	0,5 bucket - 3,0 bags	
	beans	1 bucket - 4 bags	
	watermelons	20-90	
	pumpkins	10-55	
	cowpeas	0,5 bucket - 0,5 bag	
	groundnuts	3 buckets	
	sweet reed	"many"	
Nata River region, northern Central District	maize	average is 3,7 bags per household (Sarwa) and 9,7 bags (non-Sarwa); individual yields breakdown given only for combination of sorghum, maize, and millet	bags = 200 kg; data drawn from Cashdan and Chasko (1977: 22-27, and Tables 4,1 and 4,2)
	sorghum		
	millet		
	melons		
	pumpkins		
	watermelons		
	beans		
	groundnuts		
	cowpeas		

times of their planting, cultivating patches of about 100 square meters in size for five or six weeks (Axel Thoma, personal communication). This strategy increases the chances of at least one patch receiving sufficient rainfall at the appropriate time.

A crop or product diversification strategy involves planting a number of different kinds of seeds in the hopes that at least some of them will grow. Drought-tolerant sorghum seeds, for example, are much in demand in the Kalahari, but often Basarwa and other groups will plant sorghum seeds obtained in trade from groups in the hardveld to the east. A combination of beans, sorghum, maize, melons, and vegetables are often planted by remote area groups. Some of these crops are more drought-resistant than others, and they have different soil moisture requirements. Planting a number of different crops together is known as intercropping, and it is seen fairly often in the Kalahari Desert.

It is interesting to note that foragers in the eastern Kalahari who grow crops, only occasionally tended to have fewer planting failures than did full-time plow agriculturalists who had a much longer period of involvement with food production. It is also significant that groups which are mobile still plant crops, returning after a while to places where they established their gardens in order to harvest the results. Thus, agriculture does not necessarily imply that gorups must be sedentary in order to practice it. In a few cases, groups in the eastern Kalahari utilized old residential campsites to plant their crops, and they returned to these old sites months later to harvest the melons and beans.

Agricultural techniques in the Kalahari can be divided into four major types: (1) digging stick agriculture, (2) hoe agriculture, (3) plow agriculture, and (4) tractor agriculture. The simplest kind of agriculture is that done with the aid of a digging stick, but in many ways hoe agriculture is very similar. Nearly all of the agriculture practised in the sandveld, with the exception of tractor agriculture, can be described as a kind of swidden system in which areas are cleared of grass, bush and trees, and the material is then burned. Crops are raised in two major settings: they are either grown close to the residences of people, or they are grown in fields, some of which are at significant distances away from people's homes. In Botswana the fields are knows as *masimo* lands, and they are segregated spatially from the village in many cases. Although frequently it is difficult to discern the difference between gardens and lands, some Kalahari residents differentiate between them on the basis of (1) location, (2) size, and (3) the type of method used (e.g., hoe *vs* plough). In general, gardens are found close to residential compounds; they are small; and they are cultivated with the aid of either a digging stick or a hoe. Most Kalahari foragers and part-time food producers tend to grow crops in gardens rather than fields. An advantage of having the gardens close to the people's homes is that potential competitors such as antelopes or baboons tend to stay away from places which are occupied.

The agricultural cycle in the sandveld can be described roughly, but it should be stressed that there is year to year and also regional variation in the timing of activities, depending on rainfall inputs, availability of seeds, implements, labour, and a number of other variables. In general, planting is done at the time of the first rains, which in the Kalahari may occur any time between October and December, but which are often late as compared to the eastern hardveld and northern portions of the country. Weeding is usually done only once, often in the mid-February to mid-March period. Crops which ripen early, such as green maize, sweet reed, and melons, may be harvested in late March of April. An important crop in the Kalahari, sorghum, begins to seed in April or May, and it is important for people to keep birds away from the fields at this stage. In some cases as many as 50 people were observed in the act of bird-scaring in fields in the east-central Kalahari in 1978. Harvesting of crops is carried out from June through July and sometimes into August, depending on field size, yield, and crop type. Following the harvest there is a period of processing of the crops, when they are threshed, winnowed, and bagged. Some of the crops are taken to residences where they are stored, but often the yields are so small in the Kalahari that the food is consumed relatively quickly.

The introduction of the plough in the Kalahari has led to an increase in field sizes and yields, and it has had important implications for the division of labour in agriculture. Among Tswana and some Bakgalagadi populations, hoe agriculture is done mainly by women, with men taking little part. Once the plough was introduced, however, men were the ones who handled the livestock which were used to draw the ploughs, so their involvement in the agricultural process increased significantly. Men would hold the plough itself while a young boy would walk beside the oxen cracking a whip over their heads. Women then did the planting and subsequent activities relating to agriculture, including weeding, bird-scaring, harvesting, and post-harvest processing.

Storage of agricultural produce in the sandveld is not as common as it is in the hardveld regions of the country, but sometimes significant amounts of crops were produced, and people processed them for storage and later consumption. Once agricultural crops are harvested they are brought from the fields to the compounds, sometimes in bags on the backs of donkeys or in wagons.

The crops are spread out on the ground to dry in some cases, or they are placed in *dirala*, specialized facilities used for the purpose of holding crops.

Some are placed in a kind of crib-type facility 1 meter high and 1.5 meters long. Occasionally maize cobs, with the corn still attached, are tied to upright poles out of the reach of chickens. Cow hides or tarpaulins are spread on top of the grain in the drying facilities in order to keep birds from eating the produce. Below the drying facilities are placed piles of melons and pumpkins. After a month or so of drying, the grains are threshed on specially prepared floors of cow dung and mud. Women swing 2 meter long mopane poles over their heads in order to beat the grain. The threshed material is then poured slowly out of baskets or bowls in order to allow the wind to carry off the chaff. After that, the processed grain is often mixed with burned donkey dung and ash and placed in bags. The burned material was said to be an effective means of preventing insects from destroying the stored material. Some of the sorghum is sprouted and is then turned into a beer known as *bojalwa*. Other grains are pounded into meal and used immediately for porridge. The stored material is later recovered from the storehouses or bags where it was placed and the grain sifted again to remove the ash and burned dung before being processed for preparation of porridge.

There were a number of constraints on crop production which had to be dealt with. The problem of nutrient deficiencies in the soils is circumvented by sandveld agriculturalists in a number of ways. One method is to clear the area where the field is to be, then burn the debris in place, thus adding nutrients to the soil. Another way is to locate fields on abandoned kraals, being careful that these kraals have not been utilized recently, as nitrate levels might be too high and the crops would be affected. Still another method is to allow livestock to graze on the stubble of the fields after harvest; the cattle thus get a high-protein feed while at the same time providing manure which enriches the soil for next year's planting. It is important to note that manuring and use of fertilizers is low or non-existent in most parts of the sandveld. In Hukuntsi and Tshane, for example, only 10% of the households applied manure to their fields, and the percentages are even lower in Kang, Kalkfontein, western Ngamiland, and western Central District. Use of chemical fertilizers is extremely rare; these are usually applied only by the better-off farmers.

Shortage of labour is considered by some to be a serious problem in sandveld agriculture, while others note that farmers have a large pool of potential labourers to draw from. Labour requirements are high at particular times during the year, such as the period in February-March when birds are preying upon the crops, or harvest time. Children are often brought into the labour force, as are non-relatives. *Majako*, or agricultural labour in someone alse's fields done in exchange for a portion of the crop produced, is very common in the sandveld. In the north eastern Kweneng, for instance, *majako* labour provides a substantial portion of the crops available to local households in a large number of cases. In the Ncojane Farms Kjaer-Olsen (1979) noted that even though 50% of the households did not plant, many of the women assisted in the work in other people's fields. It should also be pointed out that a large amount of food is exchanged in the form of gifts or sharing at mealtimes.

Sandveld agriculturalists do face a number of serious constraints to successful crop production. Not only are there environmental hazards such as low and erratic rainfall and nutrient-deficient soils, but there are also technical constraints, such as lack of access to drought-tolerant seed. Extension personnel have yet to be placed in most of the sandveld. District and local officials in the Ghanzi and Kgalagadi districts, as well as those in the western portions of Ngamiland, Central, Kweneng, and Ngwaketse districts, see the lack of extension staff as a key constraint to arable agriculture in their regions. The majority of farmers in the sandveld tend to be poor, many of them owning less than 10 head of livestock. As a result, they either have to borrow oxen for draught power or they use donkeys; some farmers use digging sticks and hoes, the drawback to these implements being the amount of area that can be cultivated, thus making yields per household lower. Although draught power is not as important a constraint as it is in the eastern hardveld areas, it nevertheless does present problems to some farmers in the sandveld.

Discussion and Recommendations

Data on crop production in the sandveld regions of Botswana have revealed first of all that a substantial portion of the population engages in arable agriculture. Findings also show that people in the sandveld have a good working knowledge of their environment and the crops they are dealing with, and that they employ a number of different strategies to reduce risk. Rather than trying to change the existing strategies of sandveld crop producers, it might be useful to carry out further research on the kinds of farming systems already employed and the reasons for the choices that have been made. Extension advice could then build on the existing systems and thus potentially increase the degree of acceptance of new technologies.

Harvested yields are relatively low in the sandveld, but these could be substantially increased. Research on drought-tolerant varieties of crops could assist in providing crops which would withstand periods of limited rainfall. At the same time, it is important to ensure that this research is not carried out solely on isolated research stations. A significant observation has

been made by Öland with regard to the relevance of agricultural research to the needs of disadvantaged groups:

> "On the whole, a large number of less-well-off people are unlikely to benefit directly from progress following ongoing agricultural research ... An understanding in considerable detail of prevailing agriculture, resources available for change, and social and economic fabric is imperative for success. It is equally important that new technology be made available to the people concerned. (Öland 1980b:16)."

The target groups, therefore, should not be the large farmers but rather the small farmers who make up the bulk of the farming population. Development strategies and new technologies should focus directly on the problems of so-called marginal farmers. On-farm research should be conducted in order to determine what precisely the constraints are that these farmers are facing. Extension advice should build directly upon the research done on the farms, as well as upon data gathered during experiments carried out on a number of carefully selected research locations.

It has already been suggested that a small research station be established at Hukuntsi. This research station, which could be 5-10 hectares in size, would serve as one of several locations where different kinds of crops could be grown using various kinds of inputs and management techniques. It is recommended that additional research stations be included at the following places: (1) Kule-Ncojane, southern Ghanzi District, (2) Kang, northern Kgalagadi District, (3) XaiXai, western Ngamiland, (4) Mmaletswai, western Central District, (5) Dutlwe, western Kweneng, and (6) Sekoma, western Ngwaketse District. These areas represent a variety of ecological conditions in the sandveld. Some are villages, others are small settlements which are as yet undeveloped. Mmaletswai, located in the eastern Kalahari region of Central District, has been selected as a Communal Pocket within the second commercial development area under the Tribal Grazing Land Policy.

Given the emphasis of Botswana's Sixth National Development Plan on increasing incomes and employment in rural areas, it is recommended that development of arable agriculture in the sandveld be part of the country's overall rural development effort. Arable crops research has been conducted in Botswana for well over 30 years, almost entirely in the eastern hardveld portions of the country. Recently there has been an upsurge in interest in molapo farming in Ngamiland. As yet the only research conducted under true sandveld conditions is that of Sanitas, a private firm which had excellent results at Hukuntsi. It is important to note that almost all of the research has been done on research stations and has rarely involved on-farm investigations of local farming systems. However there has been a substantial input into a farming system in the eastern hardveld since the mid 1970s, with the introduction of farming system research teams at Pelotsetlha, Sebele, Mahalapye and Francistown, and on the sandveld and soils of Western Ngamiland at Gomare. There is a need for a shift in research emphasis towards the sandveld, which must include research into ongoing crop production systems.

The Arable Lands Development Policy in Botswana places great emphasis on a technology package which includes row planting. It is clear that very few Kalahari farmers plant in rows at present, and it is also apparent that broadcasting of seed may serve as a risk aversion mechanism. Additional research on traditional methods of planting, including broadcasting, the use of digging sticks and hoes, and inter-cropping is necessary.

Experiments with drought-tolerant crops, perhaps like the ones grown in the Sahel or other semi-arid areas, may prove very useful under Kalahari conditions. Plant breeding work is necessary in order to develop pest and disease resistance as well. Much has been made of high-yielding varieties, but high yields mean little if crops fail due to drought or pestilence.

Öland's suggestion that horticulture receive high priority in Kalahari agricultural development is well worth considering, but by no means should horticulture receive a higher priority than dryland crop production, since the majority of crop producers in the sandveld engage in the latter. Marginal farmers are much more likely to adopt a new variety of melon than they are new kinds of fruits and vegetables. There is no question, however, that from a nutritional standpoint horticulture needs to be expanded, since it would complement the existing diet. Gathering of wild fruits is not only common in the Kalahari, it could be said to be characteristic of populations residing there. As livestock numbers grow, however, wild fruits and other food plants are disappearing, and they must be replaced by home-grown varieties.

Extension assistance is needed badly in the sandveld. At present there are no Agricultural Demonstrators in either Ghanzi or Kgalagadi Districts who deal mainly with arable crops. Agricultural assistants have been appointed as part of the team involved in Remote Area Development, however, and it is recommended that additional personnel be made available to this programme. It is also recommended that the Remote Area Agricultural Assistants be given the opportunity to get further training.

One of the major constraints to crop production in the sandveld is lack of seed. It is recommended, therefore, that seeds be made available to various

villages in the Kalahari. Also, Remote Area Development Officers and other extension staff should be given seeds which can then be taken to remote areas. Seeds have been sold in the Central Kalahari Game Reserve, for example, and they have proved very popular. It is also recommended that these seeds be made available at subsidized prices.

Another constraint to crop production in some areas is lack of implements. It is recommended that single furrow ploughs be made available, again at subsidized prices, in Kalahari villages. Also, in remote areas, tools such as hoes, axes, and shovels would greatly facilitate field clearance and preparation, as well as planting. Areas where rural industrial enterprises could be established should be set aside. At these places people could engage in implement repair and manufacture, thus providing not only a much-needed service in the sandveld, but also a number of jobs.

It is important to remember that most rural households in Botswana are not autonomous units. Households have a variety of ties with other households, both through kinship and friendship, but also through economic arrangements. Households must be seen as single nodes within a complex web of interconnecting ties. On-farm research, therefore, must take cognizance of these links, and must gear research strategies accordingly.

The kinds of crops upon which research should be focussed include melons, beans, sorghum, maize, and cowpeas. The kinds of target crops should be based upon the present farming systems in the Kalahari. In addition, experimental work could be carried out on other crops which might prove useful as cash crops, such as groundnuts, oilseeds, and pulses. Work with crops, such as that by J.G. van Gass in the northern State Lands near Nata, should be investigated carefully in order to determine the causes of success and failure.

Different areas have different problems and potentials, and it is necessary to keep this fact in mind when designing agricultural development strategies for the sandveld. What grows well on black cotton soil may not do so well on sand underlain by calcrete. Sorghum, for example, does well in *seloko* areas but not calcrete areas. This means, for example, that Mmaletswai should perhaps have less of an emphasis on sorghum and more on alternative crops.

Extension advice should be geared toward the needs of subsistence farmers and not just large-scale farmers. Given population increase in the Kalahari more and more people are turning toward arable production. Areas that were once cattle post regions now have lands areas within them. Many of these farmers have only recently begun to produce crops to any significant degree. These farmers will need basic advice on crops, planting methods, implements, inputs, and weeding and harvesting techniques. They will also need advice on how best to store the harvest, and how to properly select the seed for next year's planting. They will also need to be given advice on the procedures for filing applications for ploughing land with the sub-Land Board, and since many sandveld residents have not been to school, they will need assistance in filling out the forms. The Agricultural Demonstrators and Agricultural Assistants who work in the Kalahari will have to be highly flexible and prepared to deal with a variety of problems, only some of which have to do directly with agriculture.

A suggested programme for research and development of sandveld agriculture might incorporate the following elements: (1) selection of a target area, (2) the conducting of an investigation of local farmers in the area, combined with an evaluation of existing data; (3) the feeding back of the research data into the development of a technological package geared to the local conditions; (4) the testing of the technology packages in the local area; (5) refinement of the technology package and re-testing; and, finally (6) implementation of the package on a larger scale. The key to such an approach is the continuous and full involvement of local farmers. Also, extension personnel must be tied in to the research and development strategy in such a way that they are as much a part of it as are the local farmers. Emphasis should be placed on identifying the key constraints in the cropping system. These constraints might be overcome through new kinds of inputs, such as drought-tolerant seeds, or through changing the timing of planting. Whatever modifications to the existing system are suggested, these must be tested first before they are recommended to the farmer.

Besides local on-farm research there must be a system of experimental research stations located in areas that are ecologically representative of the conditions where new technology packages might be applied. Careful study of soil, rainfall, and other environmental conditions will have to be carried out in conjunction with the ongoing experimental work. Detailed records should be kept of the findings, and these data should be made available to the local farmers in an easy-to-understand format.

Finally, it must be kept in mind that in Botswana, small farmers are engaged not only in arable production but also in livestock and smallstock production, hunting, gathering, and various kinds of off-farm employment. The relationship among all of these activities must be considered explicitly. The linkage between arable and livestock production, for example, is critical in Botswana. Research and development strategies must therefore be geared toward examining these linkages and overcoming the various obstacles to increased production. Only in this way can Botswana's goals of increased production and a better distribution of income and

employment be achieved.

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NOTES

1 The data contained in this table were adapted from McGowan and Associates (1979, Volume 2, Annex 2, Appendix 1, Table 1). It should be noted that after five years of drought in the Kalahari the figures for livestock populations are probably somewhat less, though recent figures are lacking.

2 A discussion of the Central District Western Sandveld region's livestock ownership and holding patterns can be found in Hitchcock (1978).

3 ALDEP — Arable Lands Development Programme.

4 TGLP — Tribal Grazing Lands Policy.

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