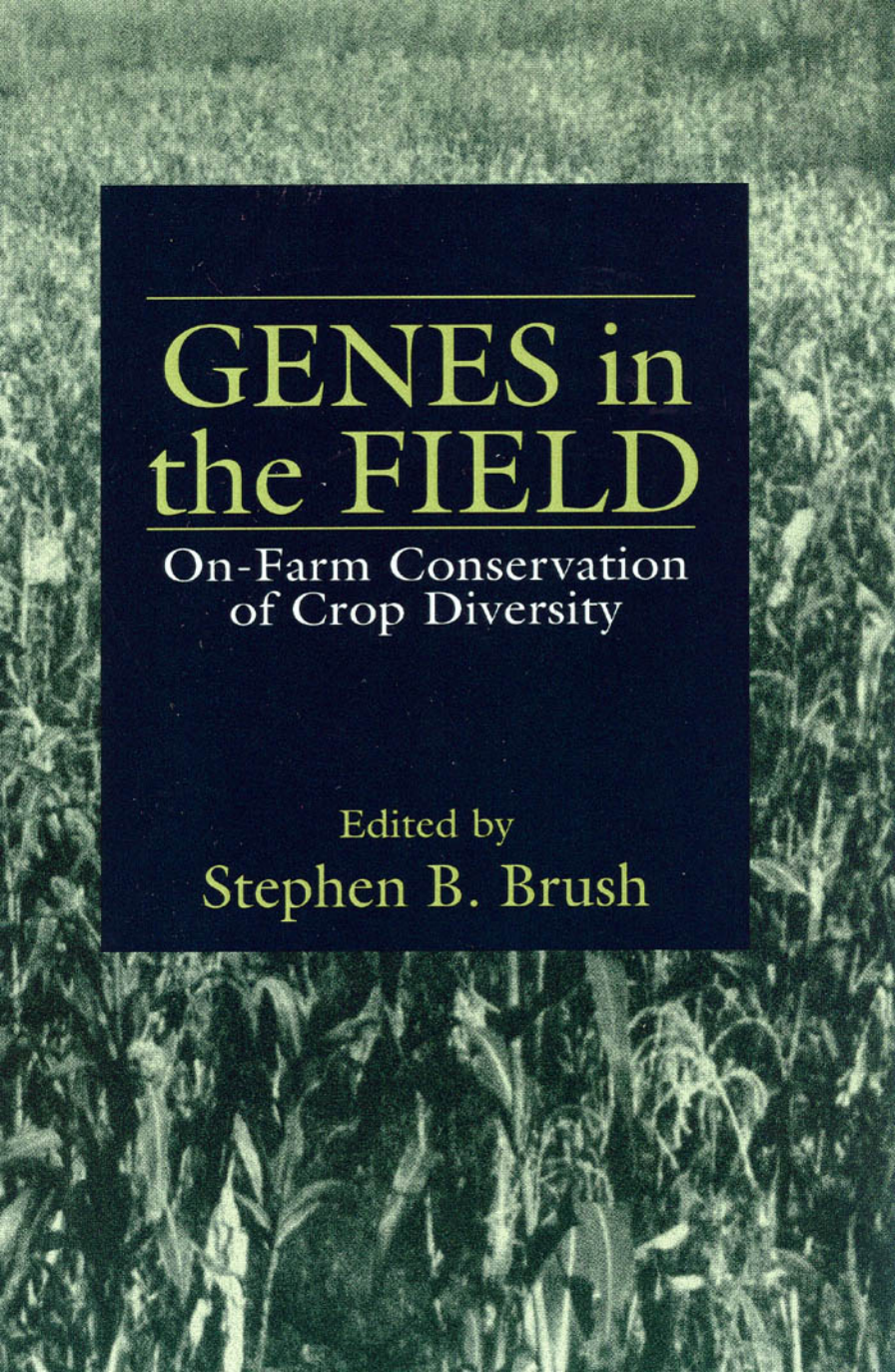
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On-Farm Conservation of Crop Diversity
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Edited by

Stephen B. Brush, Ph.D.

INTERNATIONAL PLANT GENETIC RESOURCES INSTITUTE
ROME, ITALY

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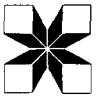

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Section IV. Policy and institutional issues

chapter nine

On-farm conservation of crop diversity: policy and institutional lessons from Zimbabwe[1]

Elizabeth Cromwell and Saskia van Oosterhout

Introduction

The milestone international Convention on Biological Diversity (CBD), which was signed at the United Nations Conference on the Environment and Development in 1992, emphasizes in Article 8 that conservation of agricultural biodiversity is important in farmers' fields as well as in protected areas and in gene banks. It states that signatory countries should:

> regulate or manage biological resources important for the conservation of biological diversity **whether within or outside protected areas**, with a view to ensuring their conservation and sustainable use [Article 8 (c)]; and
> respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity **and promote their wider application...** [Article 8 (j)] (UNEP 1994:8-9, emphases added).

However, this approach to conserving agricultural biodiversity remains unfamiliar, ambiguous, and controversial to many people. In particular, there has been little exploration of the economic, sociocultural, and environmental

variables influencing farmers' attitudes toward maintaining crop diversity on-farm, and therefore little understanding of farmers' willingness to get involved in on-farm conservation.

This chapter begins with a presentation of the results from recent research into these issues. We then use these results to explore how farmers need to be supported if they are to maintain on-farm crop diversity. We conclude by offering some insights into the viability of using on-farm conservation as a tool for conserving agricultural plant genetic diversity, based on these results. We use evidence from the Southern Africa region because this is one region of the world where the challenge to undertake on-farm conservation has been taken up actively, with a number of important initiatives at the regional, national, and farm levels, as well as an active and vibrant debate among the main stakeholders.

The evidence that we present is taken from the work of the Sorghum Landrace Study of the Government of Zimbabwe Department of Research and Specialist Services, and of the Darwin Initiative for *In situ* Conservation in Zimbabwe, which was implemented by the Overseas Development Institute and the Sorghum Landrace Study.[2] We have also benefited from the thoughtful insights into crop diversity issues offered by participants at a workshop on Supporting Diversity Through Sustainable Livelihoods: What Are Farmers' Choices? held in Harare in November 1996 under the auspices of the Darwin Initiative for *In situ* Conservation in Zimbabwe.[3]

Definitions

The CBD states that biodiversity "means the variability among living organisms from all sources and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems" (UNEP 1994:4). For our research, we focused on two of these measures in relation to agricultural biodiversity: diversity within species (varieties/landraces) and between species (crops).

Landraces and varieties produced by the formal sector are of course different in important respects. We define a landrace as a local farmer's variety of a particular crop. Landraces exhibit varying degrees of morphological and genetic integrity and may change with time, but they are recognized by farmers on the basis of a number of morphological and agronomic criteria. By formal sector varieties ("modern" varieties), we mean distinct and stabilized assemblages of local or exotic material which have been selected for certain criteria, most often higher yield and pest or disease resistance, by formally qualified plant breeders. In this research, we use "variety" to refer to both types of material, except where specifically stated otherwise.

As regards crops, we focus on the on-farm conservation of "small grains": sorghum *(Sorghum bicolor),* pearl millet *(Pennisetum vulgare),* and finger millet *(Eleusine coracana).* We chose this focus because these are crops for which the Southern Africa region is an important center of diversity but

which, at the same time, are under great threat from the "modern" cash-based economy which promotes maize monoculture. Note that reference to "maize cropping" throughout this chapter refers specifically to the cultivation of commercially sold hybrid varieties, not to the growing of open-pollinated varieties, which is much less common in Zimbabwe.

Even with these relatively tight definitions, it is difficult to know how to measure diversity in farmers' fields. We decided to use three very simple measurements of on-farm crop diversity:

1. the number of crops grown on-farm;
2. the number of crop varieties grown on-farm; and
3. the proportion of the total farm area allocated to growing small grains.

We selected these criteria based on the assumption that there is a direct relationship between the number of crops and crop varieties grown on-farm and the level of crop diversity on-farm. Likewise, we assumed that the greater the proportion of the farm area allocated to growing small grains, rather than hybrid maize, the greater the likelihood of a high level of on-farm diversity, compared to those farms with smaller portions of land allocated to growing small grains.

It is difficult to draw conclusions about whether certain crops and varieties are more "valuable" or "important" than others; or whether landrace material is preferable to "modern varieties." We have not attempted to do this, i.e., to assess "optimal" levels of diversity within a given farming system; rather, as we explain in the section on methodology below, our aim is simply to identify those economic, sociocultural, and environmental variables that influence whether diversity on one farm is higher or lower than on another.

The study area[4]

The research on which this chapter is based was carried out in Mutoko and Mudzi districts in Zimbabwe, which lie next to each other northeast of the capital city Harare and straddle one of the main roads to the Mozambique border (see Figure 9.1). These two districts were chosen because they encapsulate the wider situation in the Southern Africa region: while the districts are rich in crop diversity, farmers' ability to maintain this diversity on-farm is apparently threatened by intense livelihood pressures.

Mean annual rainfall is less than 600 mm over most of the two districts,[5] with a high likelihood of severe midseason dry spells during the rainy season, and of droughts occurring every 3 to 4 years. Population densities range from nearly 50 people per sq km in Mutoko to around 30 people per sq km in the more easterly and remote Mudzi. There has been considerable economic and sociocultural dislocation in the study area, caused by two primary factors. First, as a consequence of the Independence struggle, the then government of Rhodesia forcibly relocated many families into camps

Figure 9.1 Location of Mutoko and Mudzi districts.

between 1976 and 1979. Second, the Mozambican civil war spilled over into the border areas of Zimbabwe, so as late as 1993 families in some parts of the area were sleeping in village schoolrooms for safety. This dislocation has had a disruptive effect on many aspects of traditional farming systems.

The average household consists of five people, but many able-bodied men work away from home for all or part of the year, resulting in a high dependency ratio. Approximately 60% of the people actively farming the land are women, although only just over 20% of households are formally or informally headed by women. Most household heads have some education, usually at the primary level. Small grains are important crops in the area because of their drought tolerance, but over time maize has become an increasingly dominant part of the cropping system for reasons that will be discussed later. Land is allocated to families by traditional authorities (chiefs) and mean holding size is 2.5 ha, although this varies widely.

At present, land availability is not usually a limiting factor in crop production. Rather, shortage of labor, infertile soils, and lack of draught

power are more significant. Over half of all households apply fertilizer, primarily inorganic; the use of organic fertilizers (leaf litter and cattle manure) is very limited. Crop production is insufficient to produce a surplus at the household level for most families, who are therefore net buyers of grain and reliant on non-agricultural activities, including casual labor, informal gold-panning, or craft-making, for a significant portion of total household income. **In** addition, 30% of household heads work away from home and 75% of households receive financial help from urban relatives.

In general terms, Mutoko is more economically developed than Mudzi, located closer to jobs and markets in Harare, and better served by transport and other economic infrastructure. Mutoko has more "Master Farmers"[6] and members of farmer groups, as well as more educated household heads. Cropping systems are more diversified and farmers in Mutoko employ more casual labor for on-farm activities. Soils are less fertile, however, as they have been continuously cropped over a longer period of time, and hence more inorganic fertilizer is used in Mutoko than in Mudzi, where farmers generally still consider their soils to be fertile.

Methodology

The purpose of our research was to test the following hypothesis:

> *H: farmers may not be willing to maintain crop diversity on-farm due to the influence of exogenous economic, socio-cultural, or environmental variables.*

Our assumption was that our three chosen measures of on-farm crop diversity could be taken as proxy indicators of farmers' willingness to maintain crop diversity on-farm, i.e., greater numbers of crops and varieties on-farm and larger farm areas allocated to small grains demonstrate a greater willingness to maintain crop diversity on-farm. Our challenge, therefore, was to identify which economic, sociocultural, and environmental variables are strongly correlated — positively or negatively — with our three chosen measures of on-farm crop diversity.

Our research took place over the course of the 1995-1996 cropping season. Twelve villages in Mutoko and Mudzi districts were selected to represent a range of different economic, sociocultural, and environmental conditions. The research started with participatory rural appraisal exercises with representative groups of farmers in each village. Our aim was to gain a thorough understanding of farmers' thought systems concerning on-farm crop diversity. Accordingly, we used seven different exercises: mind-mapping; history time-lines; wealth ranking; social mapping; matrix ranking of farmers' problems; mobility mapping; income and expenditure ranking; and semi-structured interviews on seed sourcing.

The results from the participatory rural appraisal exercises helped us to draw up a questionnaire about on-farm crop diversity, which was applied

to 25 farm families in each of the 12 villages, i.e., to 300 farm families altogether. Together with relevant background information, the questionnaire provided data for each family for the range of economic, sociocultural, and environmental variables that we believed might influence levels of on-farm crop diversity. These are described in Box 9.1. Our decisions about which variables to include in the questionnaire were based on our understanding of on-farm crop diversity obtained from the wider literature, previous research carried out in Mutoko and Mudzi by the Sorghum Landrace Study, and participatory rural appraisal results. Multiple regression analysis was then carried out on the data from the questionnaires, with the aim of identifying which specific economic, sociocultural, and environmental variables appear to be strongly associated with high levels of on-farm crop diversity, as measured by our three proxy indicators. Box 2 specifies the equations used in each case. The results from the multiple regression analysis are discussed in the next section.

Box 9.1 Variables Hypothesized to Influence On-Farm Crop Diversity in Zimbabwe*

Economic variables

Area cultivated (ha) (e1)

Sum of areas planted to each crop in current season (i.e., does not include fallow areas).

Wealth status (e2)

During the participatory rural appraisal exercise on wealth ranking, farmer groups assigned families as being' rich,' , average,' or' poor' according to a wealth index that took account of numbers of livestock; type of housing; type of farm implements; size of crop production; employment of labor; employment of household members in town; and children's education. Interestingly, farm size was not considered to be a relevant indicator of wealth, on account of the fact that some families had relatively large holdings to compensate for the poor quality of the land.

Shortage of labor

We hypothesized that two dimensions of labor shortage might be influential:

- casual labor (e3) — whether respondents or other family members worked as casual laborers for other farmers, and considered this to cause them to delay or neglect their own farming duties;
- labor for seed sourcing (e4) — whether respondents considered they do not normally have enough labor for seed sourcing.

Maize-mindedness

(note: the phenomenon of maize-mindedness is explained in more detail in Economic variables section in text.

Two dimensions of maize-mindedness were hypothesized to be potentially influential:

- increased maize area over time (e5): whether the proportion of the farm area planted to maize in the current season is greater than at Independence (1980);
- proportion of cultivated area planted to maize (e6): area planted to maize in the current season as a proportion of total area cultivated.

Extension contact (e7)
Whether respondents consider they have contact with the extension services for the purpose of receiving extension advice (as opposed to for free inputs, drought relief, etc.).

Seed security
We hypothesized that two aspects of seed security might be influential:
- access to preferred varieties (e8): whether respondents are growing as many varieties as they would like;
- secure access to seed (e9): whether respondents had sufficient quantity of seed in the current and previous season (the latter being a major drought year).

Location (e10)
In either Mutoko or Mudzi District.

Sociocultural variables

Age of household head (s1)

Local position of authority (s2)
Respondents were asked whether they or the head of the household held any position of authority in the local community, either elected (e.g., a local councillor) or traditional (e.g., chief, traditional healer).

Education of household head (s3)
Respondents were asked whether the household head had any education (yes/no).

Sex of household head (s4)

Cropping decisions made by women family members (s5)
Respondents were asked who in the household makes the decisions about which crops and varieties to grow, and the area to allocate to each crop.

Value placed on small grains by family (s6)
Respondents were asked to identify and rank various agronomic, economic, and cultural reasons why growing small grains is important to them (e.g., for disease resistance, for food security, for the spirits)

Environmental variables

On-farm environmental variability (v1)
Respondents were asked to rank the degree of variation in on-farm slope, soil type, and other aspects of terrain.

On-farm environmental quality (v2)
Respondents were asked to state whether pests, poor soils, and leaching of nutrients were problems on their farm.

Access to on-farm resources (v3)
Respondents were asked whether they had access to a range of resources on-farm, including fruit trees, agro-forestry trees, a variety of good soils, and good water supplies.

Access to off-farm resources (v4)
Respondents were asked whether they had access to a range of resources off-farm, such as wild fruit trees, leaf litter, forest area, thatching grass, or grazing.

* Note that the characterization of variables as "economic," "sociocultural," or "environmental" is based on our own best judgments and is slightly arbitrary in some cases.

Box 9.2 Multiple Regression Analysis Used to Investigate Variables Affecting On-Farm Crop Diversity in Zimbabwe: Specification of Equations

D1 = e1 + e2 + e4 + e5 + e7 + e8 +e9 + e10 + s1 + s2 + s3 + s4 +s6 + v2 +v3 + v4
D2 = e1 + e2 + e4 + e5 + e7 + e8 +e9 + e10 + s1 + s2 + s3 + s4 +s6 + v2 +v3 + v4
D3 = e1 + e2 + e3 + e4 + e5 + e6 + e7 + e8 + el0 + s1 + s5 + v1 + v3 + v4

where:

D1 = number of crops grown on-farm
D2 = number of varieties grown on farm
D3 = proportion of farm area allocated to small grains (measured as proportion of farm area allocated to all non-hybrid maize cereals)

and

e1 = area cultivated
e2 = wealth status
e3 = shortage of labor: casual labor
e4 = shortage of labor: seed sourcing
e5 = maize-minded: increased maize area over time
e6 = maize-minded: proportion of cultivated area planted to maize
e7 = extension contact
e8 = seed security: access to preferred varieties
e9 = seed security: secure access to seed
e10 = location

s1 = age of household head
s2 = family in local position of authority
s3 = education of household head
s4 = sex of household head
s5 = cropping decisions made by women family members
s6 = values placed on small grains

v1 = on-farm environmental variability
v2 = on-farm environmental quality
v3 = access to on-farm rescues
v4 = access to off-farm resources

Analysis

A summary of the multiple regression results on which the analysis is based is presented in Table 9.1.

Table 9.1 Variables Found to Be Related to On-Farm Crop Diversity in Zimbabwe: Summary Results of Multiple Regression Analysis

Variables Related to Number of Crops Grown On-Farm		
Independent Variable	Significance	T-value
Adjusted $r^2 = 0.85680$		
Mudzi District (e10)	.000	(9.180)
Access to preferred varieties (e8)	.000	5.172
Area cultivated (e1)	.000	5.039
Shortage of labor for seed sourcing (e4)	.001	3.555
Poor on-farm environment (v2)	.006	(3.036)
Secure access to seed (e9)	.012	2.716
Contact with extension (e7)	.047	2.111
Small grains valued (s6)	.080	1.835
Variables Related to Number of Crop Varieties Grown On-Farm		
Independent Variable	Significance	T-value
Adjusted $r^2 = 0.80274$		
Mudzi District (e10)	.000	(6.709)
Area cultivated (e1)	.000	5.191
Shortage of labor for seed sourcing (e4)	.000	3.911
Contact with extension (e7)	.002	3.426
Access to preferred varieties (e8)	.008	2.896
Small grains valued (s6)	.035	2.245
Secure access to seed (e9)	.040	2.183
Position of authority (s2)	.046	2.116
Variables Related to Proportion of Farm Area Allocated to Small Grains		
Independent Variable	Significance	T-value
Adjusted $r^2 = 0.51046$		
Proportion of cultivated area planted to maize (e6)	.0000	(13.366)
Poor family (e2)	.0030	2.997
Mudzi District (e10)	.0170	2.402
Age of household head (s1)	.0377	2.089
Access to off-farm resources (v3)	.0481	(1.987)
Increased maize area over time (e5)	.0609	(1.882)
On-farm environmental variation (v1)	.0789	1.764
Access to on-farm resources (v3)	.0877	1.714

Numbers of crops and crop varieties grown on-farm

Our regression analyses showed that there is a significant relationship between the number of crops and crop varieties grown on-farm and the following variables:

- *Location:* families in Mutoko grow more crops and varieties than those in Mudzi.
- *Cultivated area:* families with a larger cultivated area grow a larger number of crops and varieties than do families cultivating smaller areas.
- *Seed security:* those households that are seed secure grow more crops and varieties than those households that are not seed secure.
- *Extension contact:* those families who are in contact with the extension services grow more crops and varieties than those families who have no or minimal contact.
- *Small grains valued:* those families who value small grains highly, grow more crops and varieties than those families who do not.

In addition, the number of crops grown and the number of crop varieties grown were each significantly influenced by one of the following variables:

- *On-farm environmental quality:* those families with a good environment on-farm cultivate more crops than those with a poor on-farm environment.
- *Position of authority:* those households with a position of authority in the local community grow more varieties than those without a position of authority.

Proportion of farm area allocated to small grains

The regression analysis identified a number of variables influencing the proportion of the farm area allocated to small grains. Interestingly, only one of these (namely, location) is the same as the variables influencing how many crops and crop varieties are grown on-farm:

- *Proportion of farm area allocated to maize:* this is the variable that most strongly influences the proportion of farm area allocated to small grains. Not surprisingly, those households that allocate a smaller proportion of their farm area to maize allocate a greater proportion to small grains.
- *Wealth:* poorer families allocate a greater proportion of their farm area to small grains than rich families.
- *Location:* families in Mudzi allocate a greater proportion of their farm area to small grains than those in Mutoko.
- *Age of household head:* those families with older household heads allocate a greater proportion of their farm area to small grains than those households with younger household heads.
- *On-farm environmental variation:* those families with farms with great environmental variation allocate a greater proportion of their farm area to small grains than those with more uniform land.

- *On-farm resources:* those families with access to a large number of resources on-farm allocate a greater proportion of their farm area to small grains than those with poor access to on-farm resources.
- *Off-farm resources:* those families with poor access to off-farm resources allocate a greater proportion of their farm area to small grains than those with good access to off-farm resources.

Discussion of regression results

Perhaps one of the most important findings from the above analysis is that it is not one single set of variables, whether economic, sociocultural, or environmental (see Box 9.1 for definitions and categorizations) that determines on-farm crop diversity, but rather a complex combination of these sets of variables. As we shall see below, the complexity of this combination produces conflicting signals when trying to identify particular sets of conditions that need to be satisfied in order for farmers to be willing to undertake on-farm conservation.

Economic variables

The regression results for some economic variables influencing on-farm crop diversity are difficult to interpret. As regards area cultivated, the results suggest that families with larger cultivated areas grow a greater total number of crops and crop varieties. This is contrary to the apparently widespread assumption that families with larger areas under cultivation are less interested in on-farm crop diversity and more oriented toward monoculture.[7] At the same time, the results suggest that poorer families allocate a greater proportion of their farm area to small grains, although they grow fewer crops and varieties than do richer families. Taken together, these results imply that, although the proportion of cultivated area allocated to small grains by richer families may be proportionally smaller than that of poorer families, the absolute number of varieties will be relatively larger. This may also be a result of the fact, identified during the participatory rural appraisal exercises, that families with smaller cultivated areas consider it unwise to grow many different crop varieties: where cultivated area is limited, families prefer to concentrate on growing a few varieties.

Furthermore, other data collected via the farm family questionnaires show that poorer families are caught in a vicious circle that pushes them away from their farms in an effort to earn their living. These data show that poorer families often have to neglect important farming duties, such as planting and weeding, because they are trying to earn cash or get food off-farm for their immediate needs. Often this involves laboring for richer families at precisely the time their own farms should be planted or weeded. Thus, their harvests are poor and the following season these families are even more dependent on alternative sources of survival, their own farm is further neglected, and the vicious circle continues.

As regards the location, the regression results suggest that households in Mutoko (i.e., in locations with a higher level of "economic development") grow a greater number of crops and crop varieties. However, in Mudzi (i.e., in locations with a lower level of "economic development") households allocate a greater proportion of farm area to small grains. This may be explained in part by the fact that in recent years a non-governmental project has been distributing seed in Mutoko brought in from other areas, so some families in Mutoko district have had greater access to seed of a number of varieties, and also greater exposure to publicity concerning the value of on-farm crop diversity. Perhaps this has encouraged families in Mutoko to maintain a greater number of crops and varieties on their farms; this requires further investigation.

In discussing the influence of economic variables on on-farm crop diversity, it is necessary to explain the phenomenon which farmers call "maize-mindedness." With the attainment of Independence in Zimbabwe in 1980, the focus of agricultural research and extension turned to the so-called communal (small farm) areas to redress previous neglect, with the aim of increasing production and marketed surplus from these areas. Packages of hybrid maize seed and fertilizer started to be distributed widely to smallholder farmers and 90% of the total short-term loans handed out in the 1980s by the Agricultural Finance Cooperation, which provides credit facilities to smallholder farmers, were related to maize production (MLARR 1990). A series of droughts resulted in the further free distribution of these seed and fertilizer packages for "drought relief" in subsequent years. At the same time, market prices were adjusted to encourage greater maize production and sales.

According to our participatory rural appraisal results, all this resulted in farmers becoming increasingly oriented toward investing all the best household resources of labor, land, and agricultural inputs into the production of hybrid maize, i.e., becoming "maize-minded" as they describe it. The amount and quality of land, labor, and inputs devoted to other crops are thus primarily allocated *after* decisions concerning how and where to grow the hybrid maize crop have been made. Farmers say that "maize-mindedness" has affected on-farm crop diversity by reducing the area farmers allocate to small grains, and by reducing the number of different small grain varieties as these have become redundant in the modified farming system.

"Maize-mindedness" has not, however, translated into increased household food security. Page and Chonyera (1994) report that most maize sales — even in high potential areas — can be accounted for as "distress sales," whereby families have to sell most of their harvest in order to repay the credit received at the start of the season. This has left a large proportion of farm families food insecure and, over the years since Independence, "maize-mindedness" has resulted in families becoming severely indebted — especially in the more resource-poor, low rainfall, marginal areas such as Mutoko and Mudzi. Much circumstantial evidence is available which positively relates food security to crop diversity, but little concrete information is as

yet accessible (Guveya 1996). Finally, the regression results show that household seed security, in terms of access to seed in general and access to seed of preferred varieties, has a significant influence on the number of crops and crop varieties grown. Regarding household contact with the extension services, the regression results refute the commonly held assumption that *greater* contact with extension agents results in farm families being more oriented toward monoculture and *less* interested in maintaining a large number of crops and varieties on-farm.

Sociocultural variables

According to the regression results, some sociocultural variables have a significant positive influence on on-farm crop diversity, in line with prevailing assumptions. These variables are, namely: the extent that small grains are valued within the farm family; whether the household head is relatively old; and whether the family has a position of authority within local society. We suggest that the positive correlation between the age of the household head and the proportion of the farm area allocated to small grains may pose a threat to the longer-term maintenance of on-farm crop diversity. As the older generation dies, and economic pressures on younger families continue to increase, the area allocated to small grains may become reduced to such an extent that it may be insufficient to maintain diversity at biologically meaningful and economically satisfactory levels.

Interestingly, the regression results suggest that two sociocultural variables commonly assumed to be significantly positively correlated with on-farm crop diversity do not have this effect in Mutoko and Mudzi districts. According to our regression results, the sex of the person within the household who decides which crops and varieties to plant and the area to allocate to each crop has no significant influence on any of our measures of on-farm crop diversity, contrary to the findings of, for example, Sperling and Loevinsohn (1993) and Prain and Piniero (1994). Likewise, whether or not the household head is educated had no significant bearing on crop diversity. As regards the former, this may be because, although women farmers place great importance on the nutritional value and storage quality of small grains, the great amount of labor associated with the growing of small grains in terms of thinning, bird scaring, threshing, dehulling, and pounding has become the domain of woman, as more children now attend school, so workloads for women farmers have increased. Women are therefore less keen to grow large areas of small grains than they were at one time.

Environmental variables

The regression results suggest that environmental variables affect on-farm crop diversity more by influencing area allocation decisions than by affecting decisions about the number of crops and varieties grown. As regards the on-farm environment, the results appear to show that the quality of the on-farm environment positively affects the number of crops grown, and the diversity

of the on-farm environment positively affects the proportion of the cultivated area allocated to small grains. This is probably because on-farm environmental diversity presents families with micro-niches which can be exploited by growing a diverse array of crop varieties. The regression results imply that access to on-farm resources positively affects the proportion of the farm allocated to small grains, but families who have greater access to off-farm resources tend to allocate less land to small grains.

Implications for on-farm conservation of crop diversity

In this section, we present our interpretation of the implications of the above analysis for on-farm conservation projects and programs. First, we present what we believe the results tell us concerning how to identify farm families who are willing to maintain on-farm crop diversity; second, we present what we believe the results tell us regarding how these pro-diversity families can be supported in their efforts to maintain on-farm crop diversity.

Identifying farm families willing to maintain on-farm crop diversity

The usual priority for on-farm conservation projects and programs is to identify farmers who are already growing a relatively large number of crops and crop varieties (Maxted et al. 1997; Maxted et al. in press). Our results suggest that projects and programs wishing to do this should target households with larger farms and a good on-farm environment (meaning few pests and fertile soils), who have secure sources of seed, who feel they have good extension contact, who value small grains highly, and who are headed by someone with a position of authority within the local community.

Having identified these households, projects and programs usually then want to find out which households within this group are more likely to allocate a large proportion of their farm area to small grains. Our results suggest that these will be poorer households headed by an older person. Resource-wise, they will be households with good access to on-farm resources, and their farms will show considerable environmental variation, but off-farm resources will not be of great importance.

Supporting pro-diversity farm families

Our results suggest that families who are willing to maintain on-farm crop diversity can be supported in their efforts in a number of ways, by national governments and local government as well as by individual development projects and programs.

Development policies

We saw earlier that the economic development process itself may promote on-farm crop diversity, although this point requires further research. Our results suggest that, where farmers' livelihoods are already buffered to a

certain extent against outside pressures by the economic, sociocultural, and environmental resources at their disposal, encouraging families to maintain greater levels of crop diversity on-farm may well be possible. Examples of policy changes that might promote on-farm diversity include the provision of marketing facilities for all crops and crop varieties, so that farmers can sell a range of crops and varieties for cash, not only maize. This may involve upgrading the general level of transport and market infrastructure, and manipulating crop pricing and marketing policy, as well as input and credit policy. Other policy changes might include investing in the development and dissemination of processing equipment for different crops and varieties, so that non-maize crops do not have the disadvantage of having to be processed by hand, as at present in Zimbabwe. In particular, this might encourage more women to become interested in maintaining crop diversity on-farm: we saw earlier that the great amount of labor associated with the growing and processing of many non-maize grain crops has discouraged women from growing these crops, despite their interest in them for nutritional reasons.

Our results also suggest, however, that it is important for development policies not to focus exclusively on integrating all crops and crop varieties into the market economy, but to recognize the role played by crop diversity in providing household food security, as well as the role of different crops and crop varieties in local bartering and exchange at peak periods of food shortage.

We described the phenomenon of "maize-minded" farmers earlier in the chapter. Maize-mindedness arises from a combination of powerful economic forces as well as from changing cultural attitudes; therefore it may not be possible to reverse farmers' maize-mindedness on a wide scale. Nonetheless, it might be helpful for on-farm conservation, for the reasons outlined above, if these kinds of policy changes were made in order to allow different crops and crop varieties to fulfill a supportive role to maize in farmers' livelihood strategies.

Agricultural extension policy

We saw earlier how contact with extension services appears to have a positive effect on the number of crops and crop varieties grown by a household. This implies that increasing the number of households in contact with extension services would be beneficial for crop diversity. In the present era of pressure on government budgets, it may not be feasible to do this by increasing the number of government extension agents, but alternative approaches could be tried; examples include delivering extension services through pre-existing community groups, identifying local farmers as "para-extensionists," or using mass media (Christoplous and Nitsch 1996).

Although our results suggest that contact with extension services is positively correlated with some aspects of on-farm crop diversity, it is important to remember that the traditional extension emphasis on promoting maize monoculture and pure-stand cultivation is still official policy in Zimbabwe. It might be helpful in encouraging farmers to maintain crop diversity

on-farm if the extension service increased the extent to which it directly promotes on-farm crop diversity. Appropriate changes might include, for example, changing the criteria by which "Master Farmers" are judged by the extension services, away from maize mono culture and pure-stand cultivation toward production of numerous crops and crop varieties; also developing relevant extension messages for non-maize crops, which have often been relatively neglected to date; and adding competitions for on-farm crop diversity to the usual competitions organized by the extension services at local agricultural shows.

Plant breeding policies

We discovered during the participatory rural appraisal exercises that crop diversity is much more central to farmers' existence than has been previously acknowledged. Our results suggest that farmers attach great importance to having a wide range of crop varieties on-farm, to give them the flexibility not only to cope with an unreliable, resource-poor environment, but also to manage environmental variability to their best advantage.

Participatory plant breeding seeks to deliver planting material that is closely in line with farmers' needs, more quickly than is possible through conventional plant breeding. It can do this in a number of ways, including providing farmers with a relatively large amount of material, from which they can select according to their own requirements, discarding material which they consider to be unsuitable (Witcombe et al. 1996). This implies that participatory plant breeding can make a real contribution to supporting farmers in their efforts to maintain a wide range of crop varieties on-farm. So far, participatory plant breeding has not received as much attention in Africa as it has in Asia (Sperling and Loevinsohn 1996), but our results imply that it could usefully be encouraged in this region as well. Providing farmers with information on how to select for desired characteristics, in addition to providing the planting material itself, would give farmers even greater control of the breeding process, thereby further reducing their dependence on "ready-made" finished varieties released by formal sector plant breeders.

Seed supply policies

Our results suggest that seed security — both access to sufficient seed and access to seed of desired crop varieties — is an important variable encouraging farmers to maintain a large number of crops and crop varieties on-farm. Taking steps to support the availability of seed and varieties locally is, therefore, likely to be useful in helping farmers to maintain on-farm crop diversity. Our participatory rural appraisal exercises on mobility-mapping show that effective exchange of seed at the local level depends on different sections of the community interacting with each other, so steps to facilitate seed security could include encouraging increased contact between different sections of the community. In particular, we saw earlier that richer farmers as well as poorer farmers, and also older farmers and those with a position

of authority within the local community, all tend to be willing to maintain crop diversity on their farms, albeit in different ways. This implies that particular efforts should be made to encourage these groups to participate in local level seed exchange. Some examples of how contact between different sections of the community could be facilitated are given in the section on indigenous culture below.

Another way of strengthening local level seed exchange could be to support local seed banking, including investment in local level seed bulking, processing, packaging, and distribution facilities. In the course of our research, we found that a pilot project to build a small number of community seed banks in Mutoko has demonstrated that providing a safe place to store seed within the community can significantly increase the availability of desired varieties locally. We also found that local seed banks can have a demonstration effect, encouraging more farmers to experiment with maintaining crop diversity on-farm, by ensuring that those who are interested have a ready source of seed and information about different varieties.

Our results suggest that supporting links to non-local sources of diversity could further strengthen on-farm crop diversity. Such sources include the formal seed sector, producing modern varieties, and national or regional gene banks holding indigenous landrace material. One example of the former from Zimbabwe is the modern sorghum variety SV2: while popular in its own right, our results show that it is also grown in Mutoko and Mudzi in mixed stands with local sorghum varieties specifically to permit introgression with these local varieties.

Although our results suggest that having enough seed during droughts is positively correlated with maintaining on-farm crop diversity, evidence from elsewhere (see, for example, ODI Seeds & Biodiversity Programme 1996) suggests that handouts of seed of inappropriate varieties and other inputs after drought or armed conflict can have a very negative effect on on-farm crop diversity. This implies that particular care needs to be taken when designing and implementing emergency seed distributions, to ensure that the seed supplied is appropriate to the local farming system.

Indigenous culture

We suggested above that one important way in which local seed exchange can be strengthened is by encouraging interaction between those in the community who have on-farm crop diversity and those who need it. We suggest that supporting indigenous culture, in terms of both community organization and cultural attitudes, is an important means of doing this. For example, our participatory rural appraisal exercises revealed that in Mutoko and Mudzi it is often older women who are interested in keeping seed of different crop varieties, and who retain the knowledge of how to plant and care for them. In the past, these older women have been able to obtain this seed by bartering for it with handicrafts such as clay pots, which are needed by other members of the community. However, as the local economy has become more cash-based, the demand for these handicrafts has declined,

and therefore so has the means of obtaining seed of different varieties. In this context, a useful activity could be to find ways of encouraging the local barter economy.

Our results also suggest that it is also important to support traditional cultural attitudes toward crop diversity, because these usually place a high value on diversity, but may be under threat in "modern" society. This support could be provided by, for example, community meetings, discussions, and plays which present positive images of traditional "cultural identity," and of local indigenous knowledge, such as women's knowledge about how to care for seeds. Other strategies could include encouraging older people to pass on their knowledge of the value of on-farm crop diversity to younger family members; supporting the role of local traditional authorities; and providing opportunities for "study groups" where members can meet and discuss issues around the topic of on-farm crop diversity.

Conclusions

Managing vs. conserving on-farm crop diversity

Notwithstanding the discussion in the previous section, which suggests that pro-diversity farmers can be identified and supported, we suggest that our results add to the mounting international evidence (see, for example, Berg 1996) that farmers *manage* rather than *conserve* on-farm crop diversity. In other words, farmers do not preserve a static portfolio of crops and crop varieties on their farms, nor do they prevent introgression from neighbors' fields, field margins, fallow fields, or areas where wild crop relatives grow, but rather they import and discard diversity in a dynamic fashion, according to their needs in any given period of time.

We suggest that most "on-farm conservation" projects that succeed in motivating farmers to preserve individual crops and crop varieties are reliant on compensating farmers, usually through payment.[8] This can result in reducing the dynamism and flexibility in the farming system, because farmers do not usually view on-farm crop diversity in a static way, but rather as a dynamic part of their farming system that can be manipulated as part of their constant struggle to achieve sustainable livelihoods. Consequently, we suggest that it is not possible to achieve long-term conservation of individual crops and crop varieties on-farm using farmers' existing management strategies, although it may be possible to support farmers in maintaining a dynamic portfolio of on-farm crop diversity.

Different actors, different objectives

During the course of this research, we have observed that a wide array of participants are involved in the conservation of crop diversity on-farm, including gene center scientists, non-governmental organization development

workers, and farmers themselves, and each of these groups has a different understanding of how farmers can contribute to crop diversity conservation. We suggest that there should be more debate between these different groups, in order to determine what can be realistically expected from on-farm conservation of crop diversity.

As described earlier, farmers are looking to *manage* on-farm crop diversity with the aim of optimizing their overall livelihoods. This management may involve broadening or narrowing the range of crops and crop varieties used on-farm, and the balance between landrace material and modern varieties, according to the economic, sociocultural, and environmental circumstances of the individual farm family.

Gene center scientists and plant breeders, however, may look to *preserve* particular crops and crop varieties on-farm, as a means of ensuring that the maximum possible range of plant genetic resources is available today and in the future (Maxted et al. in press; Hodgkin et al. 1993). In this context, they are likely to be working to ensure that no genetic material leaves the farm, either discarded by farmers or through natural processes. In addition, they are often interested in ensuring that there is no introgression, which might "contaminate" the genetic material already on-farm. On the other hand, non-governmental organization development workers may look to *maintain* on-farm crop diversity, primarily with the objective of making farmers' livelihoods more sustainable. This was a point made several times by non-governmental organization representatives at the workshop on *Supporting Diversity Through Sustainable Livelihoods: What Are Farmers' Choice?* that we held in Harare in November 1996.

However, only a minority of non-governmental organization development workers are *directly* involved in activities to maintain on-farm crop diversity. Many more are involved in activities which affect on-farm crop diversity by *indirect* means, such as drought relief, agricultural technology transfer, or local level seed supply, without realizing that these activities may have a significant effect on on-farm crop diversity. We suggest that our results call into question the continued widespread promotion of "technology packages" of modern varieties and agrochemicals by many development projects. While increased food production through the use of these packages is proposed as a solution toward improved food security for growing populations, use of such packages results *de facto* in increased penetration of formal sector science into rural peoples' knowledge systems. The very processes by which on-farm crop diversity is managed may be undermined, and may become static or redundant given the pressures smallholder farmers face. We suggest, therefore, for conservation policies to be effective in maintaining on-farm crop diversity, farmers' knowledge as derived from resource management practices should be seen as management *of* shifting boundaries created by economic, sociocultural, and environmental variables, rather than as management *within* boundaries set by a technology package.

Definitions of crop diversity

Gene center scientists and plant breeders are most concerned with diversity at the *molecular* level (for example, whether particular alleles are absent or present in a population) (Hawkes 1991; Dempsey 1996).[9] Farmers, however, are most interested in *morphological* and *agronomic* variation, and how this can be used within the farming system to achieve sustainable livelihoods. Farmers can only easily recognize variation that can be seen by the human eye. Non-governmental organization development workers may not have been trained specifically in crop biology, and so may not have any understanding of the implications of the differences between "seeds" and "varieties," between "landraces" and "modern varieties," and between crop diversification and varietal diversity.

Our research has shown us that there is wide variation between the different actors involved, in their respective interpretations of what "crop diversity" means in practical terms. Again, we suggest that there should be more debate between these different groups, so that each understands what the others are expecting from on-farm conservation of crop diversity.

Notes

1. Using funding provided by SIDA, Sweden and Darwin Initiative of UK Department of the Environment. We gratefully acknowledge the support provided by these two institutions, but responsibility for the final analysis rests with the authors alone and does not necessarily reflect the views of SIDA, the Darwin Initiative, ODI, or DR&SS.
2. This work is described in fuller detail in van Oosterhout and Cromwell (in press) and van Oosterhout (in press). Readers are strongly advised to refer to these sources if further explanation of the methodology used and results obtained are required.
3. Copies of the proceedings of this workshop are available on request from ODI.
4. The information in this section is taken from surveys conducted by the Sorghum Landrace Study and the Darwin Initiative for *In situ* Conservation in Zimbabwe, and from ENDA (1995) and GDI/ENDA (1994).
5. Most of both districts lies within Zimbabwe's semi-arid Natural Regions IV and V.
6. Farmers who follow a set of cultivation practices recommended by the government agricultural extension department.
7. Although this assumption is widespread, we have not found any published evidence that proves it.
8. Mostly through direct personal observation of projects and discussions with project staff, but also through a global survey of on-farm conservation activities summarized in Cooper and Cromwell (1994).
9. We are grateful to Louise Sperling who was the first person who encouraged us to think of actors' differing definitions of diversity in the terms which follow.

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