Maize production in Luangwa Valley in relation to farming practices: strategies for sustainable agriculture and natural resource conservation – *prepared by Wildlife Conservation Society (not for circulation)*

Introduction

Arable land in Luangwa Valley is restricted to alluvial soils along the major tributaries that flow into Luangwa River. Areas in between these alluvial drainages are generally heavy clay soils more ideally suited for wildlife production than agriculture. This mixture of land use practices creates a range of challenges for accommodating both people and wildlife. On the one hand, farmers have a finite land area to accommodate a growing human population that is largely food subsistent. Crop failure or insufficient food production creates increased human pressures to rely on destructive use of wildlife and other natural resources to compensate food shortfalls or related income loss. If farming practices do not meet food security needs through improved management of soils, weeds and water, then families generally clear new land or depend on larger farms to produce a yield sufficient to meet their needs.

Wildlife, on the other hand, is a renewable resource of high commercial value, particularly for the private sector, but its interference with farming at the household-level makes wildlife a common and often destructive source of conflict for most residents of Luangwa Valley. The severity of wildlife-based conflicts is in many ways related to local farming practices and the crop yields they sustain. If families cannot produce sufficient crop yields on existing farmland, then new land is often sought. Use of fertilizer is typically not an option because of high input costs for low income families. As land clearing spreads into more marginal soils and where wildlife may be more of a threat, crop returns per unit effort diminish and crop losses from wildlife begin to have a disproportionate effect on a family's food security. With less margin of food security, such conflicts are more likely to precipitate increased resistance to conserve wildlife and a reluctance to depend solely on farming to meet family livelihood needs, causing many families to adopt environmentally harmful coping strategies.

These relationships demonstrate the importance of developing sustainable, higher-yielding agricultural practices in areas where rural people reside in close proximity to wildlife or other valued natural assets. Wildlife Conservation Society (WCS), working in close partnership with the World Food Program (WFP), undertook a four year program to use WFP maize assets as a currency for "buying" time from food impoverished families to learn and adopt improved farming skills, which involved the use of carefully laid out planting stations, called pot holes. These holes or basins, if applied properly, help capture rainwater to support more rigorous early season plant growth and also help to concentrate organic matter and soil nutrients in the soil through the use of compost. An additional technique promoted by WCS was the application of mulch between each line of pot holes, which suppresses weed growth and reduces the need for burning crop residues during the non-farming season.

From 2001 to 2005, WCS provided WFP-supported maize assistance to about 31,000 families in exchange for commitment to learn and adopt these improved farming skills, referred to collectively as conservation farming (CF). In 2006, WCS undertook a survey of 689 farm plots in the Luangwa Valley to assess the impact of these farming practices as well as other variables, such as the influence of crop rotation and maize seed variety, on farm yields. WCS sought to answer a number of questions from this study:

1) Did the use of CF add significantly to the yield of maize from more traditional farming practices, which relied on the use of soil ridges for planting and dry season burning of crop residues?
2) Did non-maize crops grown in rotation with maize influence crop yields?
3) To what extent did the use of different maize seeds contribute to increased yields?

4) Does the use of WFP maize as an investment in poor, food insecure families provide a reasonable return in terms of sustained food security?

This paper presents the results of this survey and its analysis in regard to the above questions and provides a discussion on how this joint initiative by WCS and WFP is contributing to increased opportunities for natural resource conservation and improved rural livelihoods of Luangwa Valley.

Methods

689 farm plots were sampled over 8 chiefdoms in Luangwa Valley by selecting plots supporting CF and those that used traditional farming practices. Selection of CF plots included sub-samples of those that used compost in the pot holes and those that did not. Selection of plots were assigned independently to field staff to promote randomness of sites selected. Table 1 summarizes the breakdown of sampled plots by chiefdom.

Table 1. Summary of plot distribution by farming practice

Chiefdom	Conservation farming with composting, no fertilizer	Conservation farming without compost or fertilizer	No conservation farming, no composting, no fertilizer
Chifunda	50		27
Chikwa	14		8
Chitungulu	29	1	13
Kazembe	33	1	13
Mwanya	11	13	1
Kakumbi, Mkanya	82	13	17
Tembwe	127		
Nsefu	153	31	52
Total:	499	59	131

The survey consisted of three phases:

1) location of farm plots, mapping of farm fields with GPS to determine area, and collection of farming practice details from owner of fields (Feb-Mar)
2) counting of maize cobs in centre of field within a 10m by 5m sampling area (Mar-Apr)
3) weighing of dried maize kernels from random selection of cobs (May-June).

Results

Cultivation in Luangwa Valley is done almost entirely by hand plow and manpower is an obvious constraint to total area cultivated. Based on the 603 plots mapped by plotting corner points for each farmed area sampled, mean plot size was 2734 m^2 or approximately 1.1 limas[1]. Table 2 shows mean plot size for farms in relation to the three farming practices surveyed in this study.

Table 2. Farm plot size by farming practice

Farming practice	Sample size	Mean Plot area (m2)	Std. Dev.
CF with compost	411	2582.0	1989.6
CF without compost	61	2742.2	2419.6
No CF, no compost	131	3207.0	4375.9

[1] A lima is the standard unit farmers use for measuring their fields and equals 50 meters by 50 meters.

Figure 1 shows mean and standard deviations of maize produced per lima. Area-specific rainfall was not collected but wide variation in timing was noted with a more delayed beginning in the northern areas, which likely contributed to the large standard deviations. Based on these mean values, increase in maize yields attributed to CF with and without composting in comparison to traditional farming practices was 151.5 kg and 103.2 kg, respectively.

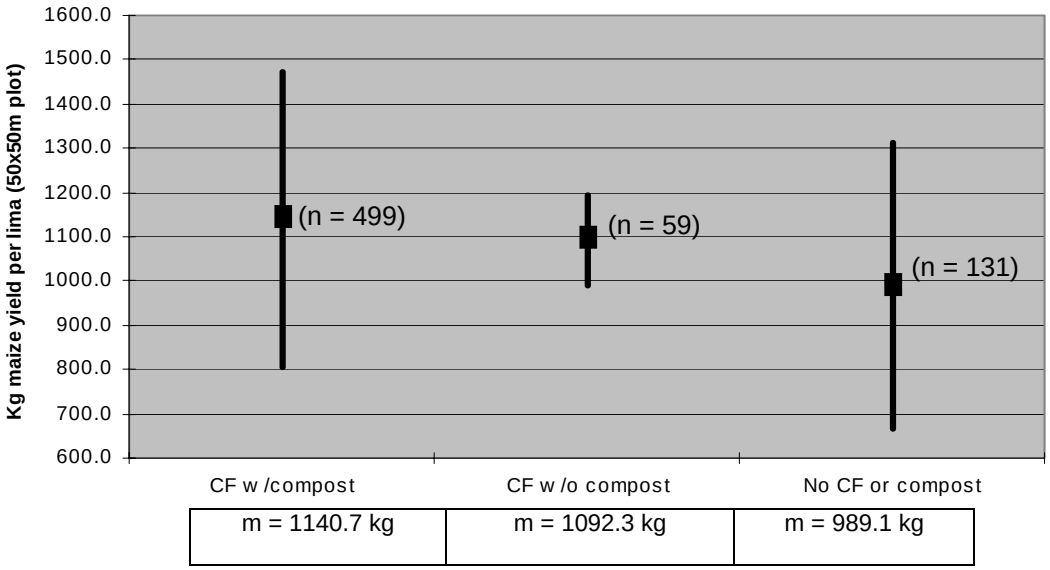
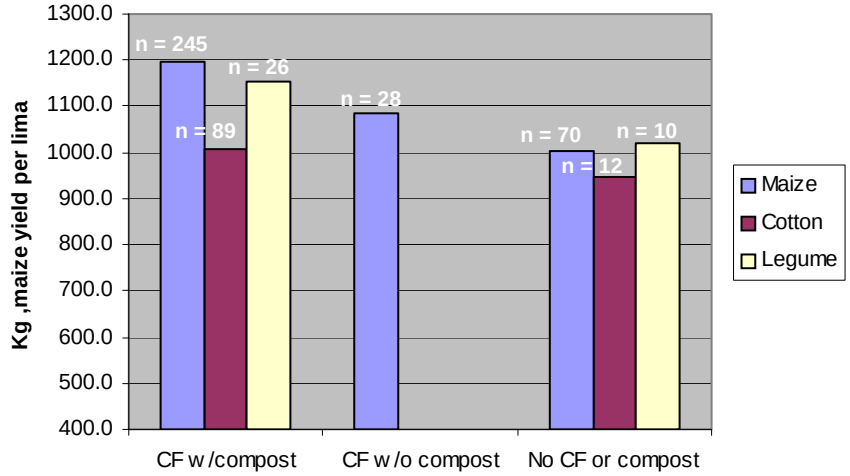


Figure 2 provides a comparison of maize yield by farming practice with different histories of crops grown the previous year, including either maize, cotton or a legume (groundnuts). The survey did not attempt to describe a longer time frame of crop histories on selected crops. By separating the possible effects of farming selected crops on the following year's maize yield, results suggest the actual maize yield increased if the previous year's crop was not cotton. The potential benefit of a legume crop on soil nutrients was not evident from these data. The relative increase in yield attributed to the possible effects of CF with compost showed a 19.3% increase in yields relative to non-CF for field previously grown with maize.



Maize	1195.2	1085.7	1001.5
Cotton	1005.6		946.0
Legume	1155.4		1019.0

Another contribution to maize yield is seed variety. The survey examined this effect by comparing yields for local maize variety and hybrid maize seeds. The source of the former was either local maize seed stock or seed obtained from WFP maize. Hybrid maize was either a commercial grade or an improved variety purchased from another farmer. Results in Table 2 suggest that improved seed varieties in contrast to local varieties can contribute improved yields, ranging from 4.0% for fields farmed by CF to 6.1% for fields farmed by traditional farming practices.

Table 2. Maize yield in relation to seed variety by farming practice

Farming practice	Hybrid	Local	% yield increase
Conservation farming with compost	1136.3 (n=136)	1093.1 (n=539)	4.0%
Conservation farming without compost		1090.3 (n=59)	
No conservation farming	1040.1 (n=12)	979.8 (n=123)	6.1%

Discussion

Growing evidence in Luangwa Valley suggests that farming practices that result in reduced food security can contribute to not only increased social and health problems but also increased conflicts with natural resources. Efforts to increase farm yields without aggravating environmental conflicts is a key challenge for maintaining a balance between human needs and natural resource conservation in Zambia's Luangwa Valley.

World Food Program is the world's largest provider of food assistance and plays a critical role in reducing human misery from disaster-related food shortages world-wide. Over the past four years, Wildlife Conservation Society and WFP teamed up to pilot test the potential role of food aid to modify agricultural practices in ways that could reduce future risks of rural hunger while also mitigating environmental conflicts from farming in a wildlife-rich area. Results presented in this study provide a useful assessment of the cost-benefits of this pilot initiative on food security and related gains from improved environmental management.

Estimated food cereal (maize) requirements to sustain a family of six is approximately 744 kg per year (WFP, FAO stats). Favorable rainfall in 2005-2006 contributed to a generally successful farming season among farmers in Luangwa Valley. Farmers not practicing conservation farming or composting and not participating in the WFP/WCS pilot initiative achieved yields on average above this threshold level at about 1081 kg based on mean farm plot size of 1.1 lima and mean yield of 989 kg/lima. However, farmers who participated in the "food-for-better-farming" initiative achieved a 19.3% increase in yields when adopting CF and composting. With improved seed variety, these yields increased from 4% to 6%. The effects of crop rotation when a maize crop followed a legume crop (groundnuts) showed no appreciable change when produced by CF and compost. More noticeable was the reduction of maize yields for fields that grew cotton the previous year. Maize produced with CF and compost on fields with cotton the previous year had yields averaging 15.8% lower than fields with maize the previous year. A lesser reduction of 5.6% was noted for fields farmed with traditional farming practices.

From the total sample of 131 farm plots surveyed that did not use CF, 16.8% failed to produce the required minimum maize yield to sustain a family of six. Chronic levels of food shortages at this level of affected households in a wildlife area can be a serious threat to wildlife by encouraging coping strategies that rely on illegal use of wildlife for meeting household food requirements ( ). Previous studies, for example, suggested wildlife snaring is a common such coping strategy by which food insecure families kill on average 6 animals annually in order to exchange meat for maize ( ). Conservatively, this impact has led to annual losses of 4000 wild animals in Luangwa Valley. Additional ways of coping with food shortages that impact adversely on natural resources is over-exploitative fishing practices

and excessive tree-cutting and related bushfires to harvest wild honey during famine months.

The increased maize yield attributed to CF and composting in this study demonstrates the potential value of large-scale recruitment of food-insecure households into a program that uses WFP maize as a leverage to train and adopt improved farming practices. In addition to the potential reduction of environmental threats, households were able to add approximately 150 additional kilograms to their family food reserve. Given that CF over time is a labor-saving approach to farming in term so reduced need to weed and clear new farmland, families may realize that larger families are not as necessary to sustain a given crop yield. Hopeful outcomes from this realization could include increased time for children of both sexes to attend school, less need for parents to spend time away from home looking for food, and sufficient household food reserves to support successful farming of a cash crop to further reduce economic dependence on natural resources.

Total investment cost by WFP to provide a 50kg bag of maize to a recipient in return for learning and complying with CF guidelines is approximately $24.77. The "food-for-improved-farming" approach developed by WCS uses 3 to 5 bags per household selected on the basis of verified food insecurity. Use of WFP maize not only provides an immediate relief to a family's food shortfall but also brings about a successful compliance to CF for more than 50% of the cases.

Using an average of 4 bags to complete a family's course in the program, WFP invests a total of $99.08 per household with about a 60% chance the family will remain compliant to CF. Based on increased yields documented in this study, WFP will achieve a $74.31 return on this initial investment the first year for every family who successfully completes the program from the additional 3 bags/lima/family produced. Assuming sustained increase in CF compliance, especially as households recognize the benefits of CF from their neighbors, future relief costs to WFP are likely to decline over time. Key variables that will influence this trend are continued efforts to develop local capacity and infrastructure to maintain community food reserves through household contributions of maize surplus, improved development of seed varieties and compost quality, and market incentives that reward farmers for improved yields through the adoption of CF.

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