Final Report

Area Sampling Frame Pilot Activity in Malawi

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Government of Malawi
City Centre
Lilongwe Malawi

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List of Acronyms

AAIC	Agricultural Assessments International Corporation
ADD	Agricultural Development Division
ARPU	Agricultural Research Policy Unit
ASF	Area sampling frame
CV	Coefficient of variation
DEA	Department of Environmental Affairs
DF	Department of Forestry
DURS	Data users' requirements study
EPA	Ecological Planning Area
FAO	Food and Agriculture Organization of the United Nations
FCC	False color composite
FFQ	Field and farm questionnaire
FS	Forest Service/ U.S. Department of Agriculture
GIS	Geographic information system
GOM	Government of Malawi
LRCB	Land Resources and Conservation Branch
MFS	Multiple frame sampling
MoA	Ministry of Agriculture and Irrigation
MoL	Ministry of Lands Housing, Physical Planning and Surveys
MRI	Multiresource inventory
M&E	Monitoring and evaluation
PPS	Probability proportional to size
PSU	Primary sampling unit
RDP	Rural development project
RUSLE	Revised universal soil loss equation
SLEMSA	Soil loss equation model for Southern Africa
SSU	Secondary sampling unit
TILF	Tract identification and listing form
TM	Thematic mapper
UA	University of Arizona
USAID	United States Agency for International Development

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Abstract

This document reports the work completed by Agricultural Assessments International Corporation (AAIC) and the Land Resource Conservation Branch (LRCB) of the Ministry of Agriculture and Irrigation (MoA) in constructing and pilot testing an area sampling frame (ASF) for Malawi during the contract period of January 1996 to November 1997. The Government of Malawi (GOM) and the United States Agency for International Development (USAID) contracted with AAIC through the University of Arizona (UA) in 1994 to test the feasibility of establishing a national multiresource inventory (MRI) system. The project goals of AAIC were to improve monitoring and evaluation (M&E) data, to assess the feasibility of developing a national MRI, and to collect integrated data so that relationships can be established among variables in the following sectors: agriculture, natural resources/environment, and socioeconomic conditions of the rural people.

A pilot survey was designed to collect data in the Machinga Agricultural Development Division (ADD) in Malawi. The ASF technology with its associated advanced methods utilized by AAIC is a means of data collection that is the most effective and efficient information system for agriculture and natural resource sectors. Moreover, once established, ASF methods can be used for ten years or more without modification to the original design. Thus, data can be collected to measure change over time.

The time period for this initial study was 22 months and involved the active participation of staff from several ministries in every step of the process. Twenty-one supervisors and enumerators from the MoA located 47 of the 48 segments selected in the customary and estates lands and collected data in the field. Data were then entered into the computer at Bunda College and summarized by AAIC staff in Washington DC. The results of the survey indicate that the Machinga ADD produced significantly more food than government data would support. Results also revealed that 5 % of the customary land stratum was, in fact, estate land and that about 38% of the estate land stratum was actually customary land. Again, results indicated that income from burley tobacco is relatively high compared to all other farm activities including selling wood for fuel.

The main data users in the MoA, the Planning Division staff, concluded that this ASF technology can be replicated in all ADDs of Malawi. When the system is implemented in Malawi, improved crop data will be obtained at a reduced cost. Additional technical assistance will be required to fully implement the technology.

I. Background

The purpose of this project was to assist the Government of Malawi to develop an effective agricultural and environmental monitoring and information system. AAIC was contracted by USAID through the UA to design an information system based on ASF methodology that would be multiresource and multisector. Thus, keeping in mind the distinction between gathering and summarizing accurate data and the subsequent use of that data, this project focused specifically on the former task. There are many uses of the data generated by this pilot project. Such uses include, but are not limited to: 1) humanitarian, 2) strategic, 3) reporting on program and project impact, and 4) supporting food and agricultural policy and planning.

The project initially was presented to and accepted by Malawi Government staff in 1994 and the project was initiated in 1996. Chapter V. of this final report reviews three stages of the project since its inception. Stage one, prior to survey, included the following steps: 1) obtain ASF materials, 2) conduct a training workshop, 3) stratify the land of Machinga, 4) construct and select primary sampling units (PSUs), and 5) construct and selected secondary sampling units (segments).

During stage two, the survey period, questionnaires and training manuals were completed, and data entry, edit, and summary procedures were programmed. All survey materials were reviewed, and AAIC and the LRCB trained enumerators at a training school conducted in December 1996. Questionnaires were modified after this date. Although AAIC was not requested to return to Malawi after the questionnaire was redesigned, AAIC updated the data entry programs and additional training was provided by UA and the LRCB. Enlarged photos of the segments were obtained in April of 1996. In June of 1996, funds were made available to send enumerators into the field. Most of the data collection was completed six weeks later.

In July 1997, AAIC sent Visual Dbase survey data entry programs to the Agricultural Research and Policy Unit (ARPU) at Bunda College and the LRCB ASF team leader delivered the completed questionnaires from the Machinga ADD to ARPU. In three weeks (seven person weeks of effort), 1426 questionnaires were entered using the AAIC Visual Dbase programs. After data on the questionnaires were entered into the computer, they were emailed to AAIC in Washington DC where data cleaning and summary took place. After an initial summary, AAIC personnel traveled to Malawi to discuss problems with enumerators and to present preliminary results. This report is the Final Report for the pilot study.

II. Current Methods of Crop and Natural Resource Estimation

A. Malawi's Crop Production Forecast/Estimate Survey

Malawi's current crop production forecast/estimate survey was designed by the Food and Agriculture Organization (FAO) supported by the Early Warning System for Food Security in the Planning Division of the Ministry of Agriculture. The methodology was tested in two ADDs (Blantyre and Salima) during the 1989/90 and 1990/91 growing seasons.

1. Categories of Crops

The current survey system divides crops into: 1) major crops, which account for approximately 95 percent of the total crop area, and 2) minor crops, which account for the remaining crop area. Some crops which are major at the national level are minor in a particular ADD and vice versa. Each ADD lists the major and minor crops.

2. Crop Estimation Procedures in the MoA

The survey, conducted annually, occurs in four distinct phases. In the first phase, a listing of agricultural blocks is prepared from which sample blocks are selected on a random basis. The agricultural households are listed, and survey sample households are chosen from the listing again on a random basis. The survey originally excluded estate lands but in 1996/97 estate lands were also covered. In some cases, crop production from estate land is a substantial part of Malawi's total crop production.

The second phase of the survey involves an area measurement of major crops grown by the sample households in selected blocks. Results are used to determine Extension Planning Area (EPA), Rural Development Project (RDP), ADD, and national level area for major crops. Sample block estimates are also used for determining the area of minor crops.

The third phase of the survey involves a refinement of the earlier area measurement of major crops grown by the sample households in selected blocks. These results are then used to determine EPA, RDP, ADD and national level area of minor crops.

The final phase of the survey is undertaken at harvesting time during May and June. No alterations to crop areas previously determined are made during this phase. Survey activities are concerned with the quantity harvested for major crops using selected sample households for this purpose. Area estimates are combined with yield-per-hectare estimates to obtain final production estimates for the average household. Estimates of total production are made by multiplying the production of an average household by the total number of households in the customary land section.

B. Malawi's Natural Resource Estimation Procedures.

Previously, natural resources (soil, water, and forests) have been monitored in intermittently where donors along with the government agency responsible for the natural resource obtains project funds. For example, the World Bank provided funds to assess biomass and land cover in 1991. That project was a satellite interpretation project with little funds for field work. The

Department of Forestry (DF) was the government agency that headed the effort. It was a useful study in that it provided experience, good quality training, equipment, and satellite imagery but the result was no national system that periodically updates forest resources and no national forest inventory has been conducted since that time. Soil erosion has not been monitored at the national level. The University of Arizona designed monitoring systems in five water sheds. Soil erosion data in these five water sheds has been intensive; however, it is not possible to make an inference about the land of Malawi from these five water sheds because they were not selected to be representative of all land of Malawi. No other project has developed a method to monitor soil erosion at the national level.

There are several projects that monitor silting, water, and fish production in Lake Malawi. One project is funded by the Canadian International Development Agency (CIDA). This project is headquartered near Salima. There are scientists, including liminologists, with sufficient funds to monitor certain variables in the lake.

While the GOM has agencies mandated to monitor natural resources, in reality, monitoring takes place intermitently or not at all because of staff funding shortages. For example, in the Department of Forestry (DF) only two or three persons are available to manage national matters with regard to monitoring the public and private forests in Malawi.

C. Comparison of Current Crop Estimation Methodology with ASF Methodology

Malawi's current crop production forecast/estimation survey relates crop area and production to households. The advantage of this system is that data are relatively easy to collect. An enumerator questions the farm operator directly as to what he is growing or how much he produced. The location of where the crops are grown is unimportant.

The disadvantages of associating crops with households are: 1) follow-up quality-check surveys are difficult because one never knows if the enumerator did not collect correct data or the farmer did not provide correct data, 2) the survey design does not allow for control of the size of a farm and this produces large survey errors (both nonsampling and sampling), and 3) since total number of households is a dynamic variable and identifying a credible way to estimate total households is difficult. Households can have several families living together, they can have fields that are close in distance or far, many fields or no fields; thus, collecting crop data associated with households has always been difficult to supervise and enumerate.

The last census was completed in 1987 and there have been significant changes in the number of households since then. The total number of households is the most critical expansion factor of the procedure. If a current census were taken, it would be several years before new census data would be available and could again change after a few years. This cycle makes it difficult to accurately estimate the total number of households.

In Malawi, 3000 field assistants (FAs) are requested to collect data from over 50,000 households three times a year. This system is described by Mr. Annex Umphawe, a Senior Ministry of Agriculture Planning Office staff in charge of monitoring and evaluation. He states,

> "This system can no longer be sustained by the government. As a result, staff involved in data collection have relaxed too much and are producing unreliable data after realizing that their supervisors have limited resources to quality check their work."
>
> He further states, "Technically, the Household Sample Survey, which is a major data collection methodology has been challenged for not having direct relevance to the parameters it is intended to measure, especially when estimating agricultural production. Variances in time series data have been observed to be largely due to sampling errors from changes in sampled households and partially as a result of developmental impact. A 1996 Customary Land Utilization Study by GFA-Agrar, using an ASF methodology, found that the total rainfed cultivation in the customary sector was over 2.5 times larger than the National Statistics Office estimate based on NSSA and 62% higher than the MoA crop estimates. This discrepancy has brought a lot of confusion in all camps of agricultural data users creating the need for a methodology that will provide more realistic data than the present ones and assist policy makers, agro-entrepreneurs, donors and project managers and subject matter specialists in making realistic decisions."

It is our understanding that the GFA-Agrar revised their estimate down. If this is true, it would be interesting to understand on what basis the estimates were revised down and by how much.

The following example shows the estimates and coefficients of variation (CV which is a measure of relative sampling error) for Maize in 1997. Maize is the best crop for comparison because it is the most important crop, as well as the most precise to estimate because it is the most widespread. Below we show a number line with a vertical bar that locates two estimates.

```
|_____________________________(|)_____________________________(_|_)

0                              261,000                          499,000
```

The current system's estimate is 261,000; the ASF estimate is 499,000. The number line above illustrates this comparison with the current crop production system. The CV is presented as parenthesis around a vertical line that represents the estimate. The current system estimate of 261,000 has a small CV because it is based on 10,000 households while the ASF estimate is 499,000 hectares. The true "target" value (hectares of maize in Machinga) is approximately two times the current estimate and would be close to the ASF estimate because nonsampling errors have been greatly reduced eventhough the ASF has a small sample with a larger CV.

The ASF will use 100 enumerators and supervisors for a national survey. Their tasks will be to collect data for land that is specifically identified both on aerial photography and in the field with physical boundaries such as roads. The enumerator must consider this a permanent plot of land and must account completely for the land. During field visits, individual fields must be marked and identified on the aerial photograph. Subsequently surveys will based on field and farm data collected on the first survey such as: 1) woods for forest inventories, 2) fields for soil erosion information, 3) maize fields for yield and production surveys, 4) households for social and economic data, and 5) special project areas in order to measure programme and project impacts. The same photograph will be used until this segment is rotated out and a new one rotated into use in five to ten years. Consequently, supervisors can easily monitor the enumerators' field work.

The ASF not only has control mechanisms, but also can detect when enumerators do not

complete interviews correctly. In the ASF pilot study, it is possible to identify exactly where and how data collection can be improved. Finally, the ASF system can reduce the number of enumerators from 3000 to 100 so a select group of enumerators and supervisors can be obtained, trained, and compensated.

In conclusion, the greatest difference between Malawi's current system and the ASF system is that the current system does not have adequate control mechanisms to monitor field work. Moreover, the total number of farm households (the critical expansion factor for the current system) is unknown. In addition, the current system is inadequate for collecting physical data associated with the land. Accurate estimates of crops which some claim can be associated with the farms, in fact, are better associated with fields as in the ASF questionnaire.

III. Objectives of the Pilot ASF Project in Machinga ADD

Primary objectives of the ASF Pilot Survey are delineated below.

1. To pilot test a multiresource inventory (MRI) system within Malawi to support information requirements of the DEA (formerly MOREA), MoA (formerly MoALD), Department of Forestry (DF) and the Ministry of Lands, Physical Planning and Surveys (MoL).

2. To provide a standardized national information system that permits data users to compare data: a) among administrative areas, b) across years, c) across projects, and d) between sectors.

3. To support technology transfer to GOM institutions such as DEA, MoA, DF, and MoL.

4. To provide more efficient methods to collect data for monitoring and evaluation projects and programs associated with agriculture, natural resources, environment, nutrition, demography, and health.

5. To provide knowledge of procedures and estimates of resources required to expand the system to the entire country.

IV. Presentation of Results

The purpose of this pilot study was to test procedures for a national ASF system that can be used to collect multiresource inventory (MRI) data. All aspects of data collection and analysis needed to be tested. In June 1997, the ASF data were collected.

The total land area of the Machinga ADD was first divided into five rural development projects (RDPs). The area within each RDP was then divided into five land-use strata (public lands, customary , estate, cities and other). In three of these strata, independent systematic samples were selected for data collection. In customary land and estate land strata, enumerators collected field and farm data from farm operators in June 1997. In the public lands and forest land, as identified by enumerators, fields have been selected for a forest inventory which will be completed within the next several months.

In order to present the results of this pilot study in a clear and useful manner, a specific format has been chosen. The following results are presented and numbered, section by section, in the order in which the sections are found in the questionnaire. Numbering each section not only allows for commentary on specific parts of the questionnaire itself, but also enables the writer to discuss relevant observations specific to resultant data.

Before addressing the questionnaire sections and results, however, the screening form (termed a tract identification and listing form (TILF)) is presented below. This TILF identifies three tracts: two farm operations (A and C) and one unclaimed parcel of grassland and scrub forest (B).

Tract Identification and Listing Form (TILF)

	Segment No. _____	PSU No. _____		
	Enumerator Name _____			
	Tract Identification and Listing Form	Page No. ____ 1		
Tract Letters	Name Address	crops present	Livestock present	hectares
A	Phiri Steven, Wiliki Village	yes	yes	1.6
	T.A. Msamala, Machinga			
B	customary grasslands and scrub	no	no	4.2
	marked on photo as tract B			
C	Mkandawire Wilson, Wiliki Village	yes	yes	0.4
	T.A. Msamala, Machinga			

Enumerators were asked to account for all land inside each segment. Data were obtained using two forms and an aerial photograph at 1:10,000 scale. The tracts were identified and accounted for on the photograph and listed without overlap or omission on the TILF. The TILF indicates whether crops or livestock were present. If crops or livestock were present, a field and farm questionnaire (FFQ) was completed when nonfarm land (e.g., churches, factories, and mosques) was identified on the TILF, an FFQ was not required.

Field Farm Questionnaire

Each FFQ was divided into two major sections: 1) **field data** with subsections for land cover and land use, crops and permanent crops, soil conservation, land tenure and soil erosion, and 2) **farm data** with subsections for livestock, water/health/other, household resources, and household land resources.

The five subsections that follow document questions on and results of field level data.

Questionnaire Section 1

ID Information and Land Cover/Land Use

Machinga Pilot Survey 1997

Segment No. _____ Operator name _____

Enumerator name _____ Tract letter _____ Date _____

How many hectares do you operate inside the segment boundaries of this aerial photo? _____

Now I am going to ask you about the use of each field you have inside the segment boundaries.

Section 1 Land Cover and Land Use		**Field Number**			
ITEMS	**1**	**2**	**3**	**4**	**5**
(units)	**ha**	**ha**	**ha**	**ha**	**ha**
1. total hectares in field					
2. crop name or land use					
3. land in dwelling houses/other building (has)					
4. waste land, ditches (noncrops)					
5. plantation eucalyptus					
6. plantation pine					
7. plantation other					
8. mixed miombo woodland					
9. scrub forest					
10. grassland					
11. degraded lands					
12. pasture as primary use					

13. fallow 2 years or less					
14. fallow more than 2 years					
15. Was this land cleared in the last five years?					
16. Will the land use change in the next 2 years?					

The enumerator completes the identification data at the top of the FFQ and asked the farm operator to report hectares contained inside segment boundaries. The farm respondent then is shown the aerial photograph and the enumerator identifies each field on the photo as they complete the field portion of the questionnaire.

Table 1

Land Cover / Land Use Results

Section 1. Land Cover/Land Use (expanded hectares)

RDP	Mangochi	Namwera	Balaka	Kawinga	Zomba	Total
Total hectares on field section	136,484	191,159	130,307	90,787	176,989	725,726
Plantation eucalyptus	0	101	0	0	481	582
Pine plantation	0	0	0	0	62	62
Other species plantations	19,640	3,723	0	0	940	24,303
Miombo woodland	10,484	9,818	0	0	5,393	25,695
Scrub woodland	22,649	3,932	0	0	1,632	28,213
Grassland	18,833	46,127	0	2,380	4,904	72,244
Degraded lands	138	13,411	0	0	1,269	14,818
Primarily pasture	315	0	0	287	139	741
Answers below Not expanded						
Fallow for two years or less	6.9%	1.9%	0.0%	5.4%	0.4%	
Fallow for more than two years	2.2%	1.2%	0.0%	8.7%	0.2%	
Previous years land use						

Do Not know	32.0%	0.0%	0.0%	0.0%	14.1%
Crops	31.8%	62.4%	64.2%	66.3%	64.5%
Fallow	11.7%	3.9%	4.8%	9.7%	6.0%
Un-cleared	13.1%	29.1%	0.0%	1.3%	6.9%
Blank	11.4%	4.5%	31.0%	22.7%	8.5%
	100.0%	100.0%	100.0%	100.0%	100.0%
Land use two years ago					
Do Not know	29.5%	0.0%	0.0%	1.5%	12.8%
Crops	32.3%	61.2%	65.3%	57.1%	64.7%
Fallow	11.3%	2.1%	3.7%	11.1%	5.7%
Un-cleared	15.2%	30.9%	0.3%	2.7%	6.8%
Nonresponse	11.7%	5.8%	30.6%	29.1%	10.0%
	100.0%	100.0%	100.0%	100.0%	100.0%

Table 1 delineates forest lands and land cover/land use reported in the FFQ. While there was frequent nonresponse in some sections, sufficient data were collected to enable selection of fields for a detailed forest resource inventory survey. If a field had no crops or livestock, enumerators were told to account for the field on the TILF and a FFQ was not required. Balaka and Kawinga did not report plantations, miombo forest, or scrub forest. Balaka did not report grasslands, degraded lands or pasture. Nonresponse rates for questions 13, 14, and 15 which ask how the land was used one year ago and two years ago were low across all five RDPs. Mangochi and Zomba had fewer nonresponses overall. According to the soil expert working with the UA, data acquired in the soil erosion section is not sufficient for soil erosion modeling. Perhaps data needs to be collected on a special soil erosion survey in order to support the soil loss erosion models.

Questionnaire Section 2

Monoculture and Permanent Crops, Maize with Intercrops

Field	1	2	3	4	5
	has.	**has.**	**has.**	**has.**	**has.**
17. local maize (pure)					
18. local maize (+ intercrops)					
19. composite maize (pure)					
20. composite maize (+intercrops)					
21. hybrid maize (pure)					
22. hybrid maize (+intercrops)					
23. other intercrops					
24. cotton					
25. vegetables					
26. rice					
27. groundnuts					
28. burley tobacco					
29. flue-cured tobacco					
30. other tobacco					

ITEMS	**1**	**2**	**3**	**4**	**5**
	has.	**has.**	**has.**	**has.**	**has.**
31. sorghum					
32. millet					
33. beans (pure)					
34. pigeon (peas)					

35. soybeans (pure)					
36. Irish potatoes					
37. sweet potatoes					
38. cassava					
39. other pure crops not listed					

Permanent Crops

40. coffee					
41. tea					
42. nuts -macademia or cashew					
43. citrus					
44. other					

Section 2 of the questionnaire (page 11) is a standard crops section for an ASF survey. If a survey of crops is conducted by the MoA, this section can be lengthened.

Table 2

Monoculture and Permanent Crops, / Maize with Intercrops Results

B. Crops (has.)	Mangochi	Namwera	Balaka	Kawinga	Zomba	**Total**	CV
Pure local maize	5,584	72,983	62,792	28,251	56,670	**226,280**	19%
Local maize and intercrops	5,733	3,562	9,671	4,146	59,390	**82,502**	29%
Pure composite maize	5	143	3,912	0	0	**4,060**	49%
Composite maize and intercrops	0	0	4,548	0	476	**5,024**	61%
Pure hybrid maize	21,153	14,235	29,939	34,503	71,485	**171,315**	22%
Hybrid maize and intercrops	503	964	2,189	959	3,559	**8,174**	46%
Recycled maize	18	1,074	0	257	0	**1,349**	81%
Recycled maize and intercrops	92	0	0	0	154	**246**	72%
Total Maize all categories	33,088	92,961	113,051	68,116	191,734	**498,950**	13%
Other intercrops	0	0	0	34	118	**152**	
Cotton	0	0	10,563	3,500	543	**14,606**	28%
Vegetables	0	411	3,032	44	23	**3,510**	
Rice	0	0	418	228	124	**770**	47%
Groundnuts	4,085	2,368	287	1,277	909	**8,926**	32%
Burley tobacco	2,594	6,240	0	3,517	1,148	**13,499**	27%
Flue-cured tobacco	0	1,725	0	34	0	**1,759**	98%
Other tobacco	0	3,357	0	0	0	**3,357**	100%
Sorghum	0	411	542	247	0	**1200**	
Pure beans	0	1,655	253	0	0	**1,908**	

		Pigeon peas	0	850	0	0	77	**927**	
		Sweet potatoes	455	907	215	155	2,067	**3,799**	35%
		Cassava	12,842	345	0	1,284	7,498	**21,969**	50%
		Other	1,093	102	0	35	679	**1,195**	
		Coffee	0	0	0	420	723	**1,143**	
		Other permanent crops	51	941	0	0	0	**992**	

The coefficients of variation (CVs) associated with crop estimates for the Machinga ADD are presented for crops that have sufficient entries. CVs are measures of relative sampling errors associated with estimates. For example, if surveys were repeated under identical conditions, the CV indicates the range of values one could expect to obtain as results. CVs are not presented for rare crops. CVs decrease as the square root of the size of the sample increases and as crop estimates increase.

The estimate for all maize (499,000 hectares) is nearly double the government figure of 261,000 hectares for the Machinga ADD. The burley tobacco estimate is made up of a component for customary land and a component for estate lands. The customary land burley tobacco estimate from the June ASF deviated only slightly from the government figure. The government figure was supported by check data from the tobacco auction and should be close to the actual target value.

Questionnaire Sections 3 and 5

Soil Conservation and Soil Erosion

45. Area needing conservation					
46. Area pegged to marker ridges					
47. Area with marker ridges constructed					
48. Area realigned					
49. Area under systematic interplanting					
	Meters	Meters	Meters	Meters	Meters
50. Length with vetiver grass					
51. Length of raised footpaths					
52. Length of raised boundaries					

53. Length of agroforestry hedgerows					
54. Length of gullies being reclaimed					
	No.	No.	No.	No.	No.
55. Total No. of gullies in field					
56. Number of check dams					
57. Number of buffer strips					

Soil Erosion Factors

Field Number

ITEMS	**1**	**2**	**3**	**4**	**5**
	ha	**ha**	**ha**	**ha**	**ha**
63. soil type 1 loam 2 clay, 3 red soil, 4 mix, 5 sand					
64. slope degrees					
65. length of slope - meters					
66. planting date day/month/year					
67. canopy height at time of visit					
68. residue ground cover at time of planting					
69. fertilizer type 1. (organic), 2. (Chemical)					
70. pesticide used y yes, n no,					
71. type of operation 1. (machine), 2. (hand tools)					
72. percent ground cover					

Sections 3 and 5 on soil conservation was technical in that enumerators needed to classify soil, estimate slopes and understand soil conservation measures. A high nonresponse rate might be expected but did not occur because expert assistance was provided by the LRCB staff.

Table 3 presents summarized data for section 3 (soil conservation) and section 5 (soil erosion). Data were collected so that LRCB programmes could be monitored and also in order to run the soil loss

erosion models.

Table 3

Soil Conservation Results

C. Soil and Water Conservation Practices (SWC)						
	Mangochi	Namwera	Balaka	Kawinga	Zomba	**Total**
SWC present on field (counts)						
Yes	85	164	3	1	26	**279**
No	539	156	204	312	651	**1,862**
Nonresponse	16	10	87	100	146	**359**
Which SWC practices present						
Ridges on gradient	81	153	0	2	133	**369**
Marker ridges (MR)	0	0	1	0	2	**3**
MR & ridges on contour	1	7	0	0	92	**100**
Marker ridges only	0	2	0	0	0	**2**
Vetiver hedge rows approx. interval	0	0	0	0	1	**1**
Tree or alley hedgerows	0	0	0	0	1	**1**
Systematic interplanting	0	0	0	0	0	**0**
Buffer strips	0	0	0	0	2	**2**
Other	0	0	0	0	13	**13**
% of field covered by SWC	measures					
0-05	91	23	98	151	407	
06-13	105	2	0	3	6	
14-25	70	3	0	10	57	
26-50	61	33	2	209	271	
50-up	76	7	16	2	90	

Do SWC appear to be	effective					
Yes	74	26	0	0	166	**266**
No	28	135	37	3	478	**681**
Nonresponse	538	169	257	410	369	**1,743**
Evidence of soil erosion						
Yes	159	196	13	31	475	**874**
No	435	104	179	236	305	**1,259**
Nonresponse	46	30	102	146	233	**557**
Type of soil erosion						
Sheet	71	69	3	5	142	**290**
Gully	32	124	10	15	217	**398**
Gully on footpaths	57	5	0	9	118	**189**
Total fields with erosion	160	198	13	29	477	**877**

Table 3

Soil Conservation Results (continued)

Number of gullies present						
0	547	200	282	393	672	**2,094**
1	33	68	1	10	141	**253**
2	41	35	4	9	151	**240**
3	10	18	2	1	36	**67**
4	5	5	3	0	9	**22**
5	1	1	2	0	2	**6**
6	2	0	0	0	2	**4**

Evidence of gully reclamation						
Yes	17	8	10	4	156	**195**
No	119	130	70	103	524	**946**
Nonresponse	504	192	214	306	333	**1,549**
Total	640	330	294	413	1013	**2,690**
If Yes						
Raised footpaths	13	10	4	0	30	**57**
Check dams	17	0	1	1	11	**30**
Grass	4	0	0	0	1	**5**
Banana	5	2	2	0	21	**30**
Combination	0	0	0	0	1	**1**
Ridges on contour	8	2	2	2	112	**126**
Ridges tied at gully, footpath or boundary	0	2	0	2	1	**5**
Other	0	0	0	0	10	**10**
What happens with crop residue?						
Burn	175	67	57	90	35	**424**
Bury	46	69	139	166	480	**900**
Feed livestock	4	0	0	0	1	**5**
Leave on field	13	62	2	0	79	**156**
Fuel	3	0	0	1	25	**29**
Total fields reported	241	198	198	257	620	**1,514**
Presence of footpaths						
Yes	594	158	6	210	461	**1,429**
No	24	143	157	81	271	**676**

		Nonresponse	22	29	131	122	281	**585**
		Total	640	330	294	413	1013	**2,690**
	Location of footpaths							
		Field	88	68	2	10	71	**239**
		Field boundary	509	91	6	203	393	**1,202**
	Orientation of footpaths							
		Up & down	550	101	4	44	214	**913**
		Contour	43	58	2	3	247	**353**
		Nonresponse	47	171	288	366	552	**1,424**

LRCB staff provided instruction for enumerators at both training schools in December 1996 and in April 1997. Results from Table 3 suggest that when technical staff who use the data participate in training the enumerators, high response rates can be expected. The soil scientist from the UA who reviewed the soil erosion data was not involved with early activities because he had not started working in Malawi. He concluded that data may not be useful for soil erosion modeling. He indicated that he may run the Universal Soil Loss Equation, the Revised Universal Soil Loss Equation (RUSLE) as well as the Soil Loss Equation Model for Southern Africa (SLEMSA). Nevertheless, a start has been made in collecting data for a wide-area soil erosion model. Data collection and results will be improved in the future as soil scientists become more involved.

Questionnaire Section 4

Land Tenure

Land Tenure	ha	ha	ha	ha	ha
58. Customary land					
59. Public land					
60. Private land freehold					
61. Private land leasehold					
62. Customary freehold					

Questions on land tenure were included in the questionnaire because many hypotheses are based on the assumption that land owners manage land for sustainable production in contrast to customary land operators. Land tenure was a stratification variable when the ASF was constructed. **Table 4**

Land Tenure Results

D. Land Tenure	Mangochi	Namwera	Balaka	Kawinga	Zomba	**Total**
Customary land	km.	Km.	km.	km.	km.	Km.
ASF frame	1533.3	1905.9	2064.6	1754.4	1974.7	**9,233**
Estimated Customary	1203.6	1520.7	564.4	792.7	1491.7	**5,573**
Estimated Freehold	0.0	47.2	0.0	2.2	0.0	**49**
Estimated Leasehold	120.6	170.0	0.0	69.2	0.0	**360**
Screened out TILF	209.1	167.9	1500.2	890.3	483.0	**3,251**
Estate land						
ASF frame	6.2	228.3	57.8	17.1	361.2	**671**
Estimated Customary	4.7	0.0	0.0	0.0	248.0	**253**
Estimates Freehold	0.0	0.0	0.0	1.1	0.0	**1**
Estimated Leasehold	1.9	151.6	0.0	17.8	0.0	**171**
Screened out TILF	-0.4	76.7	0.0	-1.8	113.2	**188**
Public land (not sampled)						
ASF frame	12.6	1331.6	0.0	434.7	516.8	**2,296**
Customary Expanded	0.0	0.0	0.0	0.0	0.0	**0**
Freehold Expanded	0.0	0.0	0.0	0.0	0.0	**0**
Leasehold Expanded	0.0	0.0	0.0	0.0	0.0	**0**
Screened out TILF	0.0	0.0	0.0	0.0	0.0	**0**
Cities not sampled)						
ASF frame	0.0	0.0	0.0	0.0	1.1	**1**

			Customary Expanded	0.0	0.0	0.0	0.0	0.0	**0**
			Freehold Expanded	0.0	0.0	0.0	0.0	0.0	**0**
			Leasehold Expanded	0.0	0.0	0.0	0.0	0.0	**0**
			Screened out TILF	0.0	0.0	0.0	0.0	0.0	**0**
		Other (not sampled)							
			ASF frame	0.0	0.0	0.0	281.5	451.7	**733**
			Customary Expanded	0.0	0.0	0.0	0.0	0.0	**0**
			Freehold Expanded	0.0	0.0	0.0	0.0	0.0	**0**
			Leasehold Expanded	0.0	0.0	0.0	0.0	0.0	**0**
			Screened out TILF	0.0	0.0	0.0	0.0	0.0	**0**
		Total							
			ASF frame	1552.1	3465.8	2122.4	2487.7	3305.5	**12,933**
			Estimated Customary	1208.3	1520.7	564.4	792.7	1739.7	**5,826**
			Estimated Freehold	0.0	47.2	0.0	3.3	0.0	**51**
			Estimated Leasehold	122.5	321.6	0.0	87.0	0.0	**531**
			Screened out TILF	208.7	244.6	1500.2	888.5	596.2	**3,438**

Land tenure was a stratification variable. However, Table 4 indicates that land tenure information was mixed in both the customary and estate lands strata. Nearly 5 % of the land stratified as customary land in the ASF was leasehold or freehold land; 38 % of the land stratified as estate lands are actually customary lands. Information about land tenure must be obtained in the survey by enumerators administering questionnaires.

There was a low nonresponse rate in the land tenure section of the questionnaire. A senior administrator at the Ministry of Lands (MoL), Mr. Amos Kainja, assisted in training enumerators at the Nimiasi Training Center. Land tenure data will continue to be improved as MoL staff such as Mr. Kainja review and fine-tune questions in this section.

The land tenure section concludes the **field data** summary. **Farm level** data are presented in the next four sections. A farm household had to be located inside the segment boundaries for it to be included in the farm level survey.

Questionnaire Section 6

Livestock Information

101. Zebu cattle (total)	
102. Exotic cattle for beef (total)	
103. Exotic dairy cattle (total)	
104. Goats (total)	
105. Sheep (total)	
106. Pigs (total)	
107. Chickens	

Livestock data can be collected on a field level basis or a farm level basis. In this survey, livestock data were collected at the farm level. Section 6 of this questionnaire is a standard livestock ASF section.

Table 6

Livestock Information Results

II. Summary of Data from Farm Surveys							
G. Livestock (total number)	Mangochi	Namwera	Balaka	Kawinga	Zomba	**Total**	CV
Zebu cattle (total)	0	5360	45600	0	0	**50960**	52%
Exotic cattle for beef (total)	0	0	1123	574	0	**1697**	74%
Exotic dairy cattle (total)	0	13680	14470	0	8190	**36340**	54%
Goats (total)	73240	40170	145121	49160	120245	**427936**	27%
Sheep (total)	1641	0	10690	1159	16673	**30163**	45%
Pigs (total)	0	62943	119232	33950	36976	**253101**	50%
Chickens	177267	124270	313324	224012	380169	**1219042**	19%

Livestock are difficult to estimate because they are found in both large and small clusters. It should be noted that all CVs are relatively high. Even the chicken estimate has a relatively high CV, although

there are over a million chickens in the Machinga ADD.

The most effective way to reduce the CVs for livestock is to implement list frame sampling conjointly with ASF methods. Increasing the ASF sample will not reduce the CVs because of the extremely large farm operations and the many segments with zero or almost zero numbers. **Questionnaire Section 7**

Water, Health and Other

109. Farm operator <1 male, 2 female>	
110. Age of farm operator	
111. Number of people who have meals at household	
112. Closest health clinic (km)?	
113. Closest public lands (km)? Forest or Game Reserves	
114. Closest water source (km)?	
115. Source of water - 1 unprotected. 2 protected	
Sample number	
116. Is water source 1 seasonal 2 perennial	
117. Does it taste salty?	
118. Do you have a pit latrine? (Y/N)	
119. How many years ago did your family come here?	
120. Which ADD did you come from?	

These questions demonstrate how social data are collected from farm households. Many of these questions can be completed if instructions are adequate during the enumerator training school when suitable definitions are provided in the enumerator manual.

Table 7

Water, Health, and Other Results

H. Water, Health and Other	Mangochi	Namwera	Balaka	Kawinga	Zomba	**Total**
Gender of farm operator						
Male	110	20	69	81	139	**419**
Female	123	11	49	43	138	**364**
Nonresponse	91	144	70	72	255	**632**
Total	324	175	188	196	532	**1,415**
Age of farm operator						
Average	40.9	41.7	47.3	43.2	44.8	
Number of people who eat at household	4.4	5.1	4.8	4.5	4.7	
Closest health clinic (km)	3.5	10.8	7.3	6.8	4.5	
Closest public lands (km)	2.9	1.8	8.5	3.2	3.1	
Closest water source (km)	1.3	1	2	0.5	0.4	
Source of water						
Protected	119	28	0	93	33	**273**
Unprotected	114	2	118	17	241	**492**
Perennial water source	24	25	0	76	29	**154**
Seasonal water source	209	4	119	33	247	**612**
Is water salty	14	0	10	4	3	**31**
Water is Not salty	218	18	103	87	273	**699**
Pit latrine						
Yes	85	10	67	50	190	**402**

No	148	18	47	69	83	**365**
Nonresponse	91	147	72	78	258	**646**
How many years ago did family arrive	5.4	4.1	7.7	9.2	16.4	
Why did family move to area						
No land at previous site	7	0	15	27	3	**52**
Small holding size at previous site	68	9	46	5	17	**145**
Poor land quality at previous site	19	0	13	13	1	**46**
Displaced	32	1	2	8	7	**50**
Other	99	20	19	49	243	**430**

Results of Table 7 indicate a large number of nonresponses. Data were not collected to our satisfaction in this first section of the questionnaire. The users intending to analyze data should provide support in questionnaire design, development of the enumerator manual and should assist in instructing the enumerators on data collection methods.

Questionnaire Section 8

Household Resources and Household Land Resources

121. Number of bicycles?	
122. Does your dwelling have iron sheets?	
123. Do you have at least one radio?	
124. Do you know how much land you have? (Yes or no)	
125. If yes, how much land in hectares?	
126. Does this farm have on-farm income? (Yes or no)	
127. How much from sale of maize?	
128. How much from sale of tobacco?	
129. How much from sale of other crops?	

130. How much from livestock?	
131. How much from wood lot/land?	
132. Does this farm have off-farm income? (Yes or no)	
133. How much from wage labour?	
134. How much from fish?	
135. How much from wood?	
136. From charcoal?	
137. From brick making ?	
138. From other sources?	
139. What tree species for above? 1 planted, 2 natural, 3 both	
140. How many head loads of wood did you use last month?	
141. Is there off farm income other than wood Connected to public or forested land ?	
142. What percent of off-farm income comes from public land?	
Household land resources	
143. Number of hectares rented from other?	
144. Number of hectares cultivated?	

This section of the questionnaire is representative of the type of data that can be collected on household/ household land resources using ASF survey methods. While it does not comprise a full survey, it does provide socioeconomic data that can be associated with environmental variables.

Table 8

Household Resources and Household Land Resources Results

I. Household Resources	Mangochi	Namwera	Balaka	Kawinga	Zomba
Number of bicycles	0	0	0	0	0
Does dwelling have iron sheets					
Yes	3	5	13	3	38
No	92	5	91	119	238
Nonresponse	229	165	85	76	256
Total	324	175	189	198	532
Does family have at least one radio					
Yes	86	9	38	46	125
No	89	3	66	74	141
Nonresponse	149	163	85	78	266
Total	324	175	189	198	532
J. On-farm income					
Does farm have on-farm income					
Amount per season from maize					
Customary	617.58	2583.33	928.57	7250	450
Estate				4119	
Amount per season from tobacco					
Customary	1950	17446.67	4035	15018.57	1743.75
Estate		2,000,000		2394.33	
Amount per season from other crops					
Customary	337.5	572.5	1849.62	1003.33	685.54

	Estate				500	1250
Amount per season from livestock						
	Customary	283.48	200	2076.67	218.75	357.8
	Estate				210	502.67
Amount per season from wood lot/woodlands						
	Customary	900			1800	370
	Estate					

Table 8 (continued)

Household Land Resources Results (Some data from Section 8)

L. Household land resources (has.)		Namwera	Balaka	Kawinga	Zomba	**Total**
Do you know how much land you have?						
Yes	34	6	84	44	55	**223**
No	186	20	34	78	219	**537**
Nonresponse	104	149	71	76	258	**658**
Total	324	175	189	198	532	**1,418**
If you know how much land you have, how much?						
Average	0.10	0.06	0.42	0.26	0.08	
Land rented	0	0	0	0	0	
Land cultivated	0.2	0.2	0	0.5	0.2	

We find it unusual that no bicycles and few dwellings with iron sheet roofing were reported on this survey. More than 37% of the farmers reporting did not know how much land they had. The farm income questions show some ranking trends. However, when farm income data are required, a survey would collect farm production expenditure data and prices received by farmers at the farm gate. An economist would then complete a cost of production analysis. Then the farm income data would have more credibility. This concludes the results for **farm level data**.

V. Relationships and Interactions

Tables 9 through 14 illustrate examples where data are analyzed to establish statistical relationships among or between variables. In this analysis, we use 2-way crosstabulation which shows the interaction of one variable on another.

Table 9

On Farm Income by Types, Results

(missing data not averaged)

	Stratum	**Maize**		**Tobacco**		**Other**		**Livest.**		**Wood**	
		mean kwacha	n	mean kwacha	n	mean kwacha	n	mean kwacha	n	mean kwach	n
Mangochi	Custom.	618	31	1950	6	378	40	283	23	900	2
Namwera	Custom.	2583	6	17447	9	572	4	200	2	--	0
	Estate	--	0	2000000	1	--	0	--	0	--	0
Balaka	Custom.	929	7	4035	1	1850	13	2077	9	--	0
Kawinga	Custom.	7250	2	15019	7	1003	6	219	12	1800	1
	Estate	4119	4	2393	6	500	1	210	2	--	0
Zomba	Custom.	450	2	1744	8	686	46	358	15	370	7
	Estate	--	0	--	0	1250	2	503	3	--	0

Table 9 presents on-farm income. In this pilot survey, we asked income directly. While results are not comprehensive, they show relative income by product. Tobacco is the greatest money producer.

Table 10

Off Farm Income by Types, Results

(missing data not averaged)

		Labour		**Fish**		**Wood**		**Charco**		**Brick**	
	stratum	mean	valid n	mean	valid n	mean	valid n	mean	valid n	mean	valid n
Mangochi	Custom.	3913	163	4709	41	734	44	0	0	200	1
Balaka	Custom.	5062	10	10000	1	0	0	0	0	2800	1
Kawinga	Custom.	2235	13	5357	7	0	0	0	0	0	0
	Estate	885	7	0	0	0	0	0	0	0	0
Zomba	Custom.	4324	95	2292	9	220	7	0	0	800	1

In table 10, labor is a significant money producer. Farmers were asked to report income from charcoal but declined to respond.

Table 11

Pesticides Use by Land Tenure Results

			non-response		no		yes		total	
tenure			count	%	count	%	count	%	count	%
Customary land	(Yes)		774	34.40%	1427	63.50%	47	2.10%	2248	100.00%
Private Freehold	(Yes)		6	60.00%	1	10.00%	3	30.00%	10	100.00%
Private Lease	(Yes)		28	26.70%	61	58.10%	16	15.20%	105	100.00%

Table 11 indicates that only 2 percent of the fields on customary farms used pesticides while over 15 percent of leasehold fields and 30 percent of the freehold fields used pesticides. Some of these averages are based on small samples.

Table 12

Fertilizer Use by Land Tenure Results

land tenure		non-response count	non-response %	no count	no %	yes count	yes %	total count	total %
Customary land		931	41.40%	1029	45.80%	288	12.80%	2248	100.00%
Private Freehold		5	50.00%	1	10.00%	4	40.00%	10	100.00%
Private Lease		27	25.70%	48	45.70%	30	28.60%	105	100.00%

This table presents a relationship between land tenure and fertilizer use. As in Table 11, a higher percentage of farmers use fertilizer on estate lands than on customary lands.

Table 13

Was Soil and Water Conservation Effective? by Land Tenure Results

	non-response		no		yes		total	
land tenure	count	%	count	%	count	%	count	%
Customary land	1377	61.30%	619	27.50%	252	11.20%	2248	100.00%
Private Freehold	9	90.00%	1	10.00%			10	100.00%
Private Lease	77	73.30%	16	15.20%	12	11.40%	105	100.00%

Table 13 indicates that 11 % of the fields had effective conservation measures in both the customary land and the leasehold lands. However, table 13 does not present evidence of a relationship between effective soil and water conservation practices and land tenure.

Table 14

Was Soil and Water Conservation Effective? by RDPs Results

	non-response		no		yes		total	
RDPs	count	%	count	%	count	%	count	%
Mangochi	16	2.50%	539	84.2%	85	13.30%	640	100.00%
Namwera	10	3.00%	156	47.3%	164	49.77%	330	100.00%
Balaka	87	29.60%	204	69.4%	3	1.00%	294	100.00%
Kawinga	100	24.00%	312	75.50%	1	0.20%	413	100.00%
Zomba	146	14.4 0%	651	64.3%	12216	21.30%	1013	100.00%

Table 14 shows a wide variance in the effectiveness of soil and water conservation practices in the five RDPs. Possible reasons for these differences need to be determined. Are these real differences or is there an effect caused by enumerators? The increased involvement of data users will influence the choice of variables that are important for 2-way relationships between variables.

VI. Qualitative Assessment of Pilot Project

The first ASF constructed in Malawi was of excellent quality for several reasons. High quality materials such as maps and 1995 aerial photographs of high resolution were available. LRCB staff are well trained in ASF methodology. Necessary equipment is available not only for the pilot project but also to support a national level effort.

However, data collection quality was uneven. The time of survey was not ideal. LRCB did not receive survey resources from the Malawi government in time to run the survey before some crops had been harvested. Nevertheless, much of the crop data collected were significant. The enumerators were able to locate 47 out of 48 segments and to account for most of the farm land in these segments.

The questionnaire was more lengthy and more complex than is usually recommended for a first ASF survey. However, it contained a variety of questions to demonstrate an MRI system. Future surveys will be improved after a data user requirement study (DURS) is performed and additional expert support provided in the design, training and implementation phases. Decisions must be made as to what data can be collected effectively in a given survey. Perhaps crop enumerators will not be able to collect data in highly specialized areas requiring subject matter experts, i.e., soil scientists for soil erosion models and forestry scientists for forest resource inventories and socioeconomic professionals.

VII. System Concepts and Technical Approach

A. Area Sampling Frame Construction and Implementation.

1. Materials and Staff.

The materials used to construct the ASF were obtained from various institutions in Malawi. The LRCB provided topographic maps at 1:250,000 and 1:50,000 scales. Aerial photography was at 1:23,000 scale. The Department of Forestry (DF) provided Landsat TM data of the area at 1:250,000 scale. The Ministry of Lands and Valuation (MoL) provided the most recent maps that delineate estate lands.

2. Construction of the ASF.

An ASF construction team was made up of seven persons: three persons from the LRCB staff, two persons from the MoL, one person from the Ministry of Water and an AAIC expert. This team worked together for six weeks after the ASF workshop to stratify the land and construct primary sampling units (PSUs). In June 1996, a workshop was conducted to explain ASF concepts and to begin the ASF construction.

At the workshop, participants decided to set up administrative rural development project (RDPs) areas as primary strata. Inside RDPs, land-use strata were developed including: a) cities and large towns, b) public lands (forest and game reserves), c) estate farms, and 4) customary lands identified on 1:50,000 scale maps. Satellite imagery from 1990 and topographic maps were used to determine land use strata. The strata identified on Landsat TM imagery were similar to the strata obtained from the topographic maps so, for the pilot ASF, the team used the 1:50,000

topographic maps to identify land use strata.

The next step in the construction of the ASF was to subdivide the public lands, estate lands, and customary lands into sampling units. This was completed in two steps: PSUs were constructed on 1:50,000 scale topographic maps using physical boundaries, and secondary sampling units (SSUs) were constructed using aerial photos. The PSUs were between 2 and 50 square kilometers. In public and estate lands, PSUs are larger than PSUs in customary lands. In every case, the PSUs have physical boundaries that can be identified on the ground.

Once the PSUs were constructed, they were numbered and measured using hand operated planimeters. The measures were recorded on PSU listing and measurement sheets. A Sample of PSUs was selected using standard systematic sampling and probabilities proportional to size (PPS).

An important step in the selection process was to allocate available resources for data collection to strata. Since the primary strata were RDPs, survey resources were first allocated to the five RDPs and then to the land-use strata within the RDPs. Table 15 shows sample allocation to RDPs and land-use strata. For this first survey, 1200 questionnaires were targeted from 60 segments with 20 questionnaires per segment. Thirty-two PSUs were selected as shown in Table 1. In PSUs in customary and estate lands strata, two segments were selected.

Table 15. PSU Sample Allocation to the Five RDPs

Strata titles	Balaka	Mangochi	Namwera	Kawinga	Zomba
Cities/towns	0	0	0	0	0
Public lands	0	1	1	1	2
Estate land	0	1	2	2	2
Customary lands	4	4	4	4	4

After the PSUs were selected, they were identified on the maps. The next step was to obtain 1:22,000 scale aerial photos of the selected PSUs. Using the more detailed 1:22,000 scale aerial photos, the boundaries of the PSUs were located and subdivided into SSUs.

Once PSUs were divided into SSUs, two SSUs were selected at random and called segments. Aerial photos of a scale of 1:10,000 were obtained of each segment. The exact boundaries of the segments were marked on the 1:10,000 scale aerial photographs. The ASF was then ready for the field data collection.

B. Data Collection Questionnaire design.

Questionnaire design was started in June 1996. Several meeting were held in Lilongwe with different branches in the MoA, with the MoL, and the Ministry of Water and DEA. USAID and the UA also had input into the design of the questionnaire.

The MoA used 21 experienced field crop enumerators and supervisors for the data collection activities. These persons were selected because they were experienced enumerators and able to evaluate the procedures used in the field.

The LRCB was in charge of the enumerator training course but AAIC provided much of the training. Questionnaires, an enumerator manual, and a data entry package were used for training scheduled for December 9 through December 13, 1996 at the Namiasi Training Center in the Mangochi District. The enumerators and supervisors in Machinga ADD did not come to the first day of training. They arrived the first night to be ready to work the second day of training. The first day of the course was attended by the ADD land husbandry staff and other government staff who had attended the ASF workshop in Lilongwe in June. The persons attending the first day reviewed the entire ASF construction and sample selection process as well as the questionnaire in great detail. They had reviewed the questionnaire several times before but now they wanted changes. Their suggestions improved farm income questions. Since rains were late, crops were behind schedule. Consequently, there was time to make changes.

After reviewing the ASF methodology and the questionnaire with the ADD Land Husbandry staff, it was decided to spend the second day in the field collecting data. The ADD Land Husbandry Officers managed most of the field operations while the enumerators who had come the second day observed and reviewed instructions.

Fields in training segments were irregular and difficult to enumerate in the enumerator training course, and farmers themselves were not always sure of the size of their fields. Therefore we decided to order aerial photo enlargements of the segments and provide them to the enumerators in order to improve field work. This modification was beneficial to help enumerators collect better data from the segments by improving their ability to estimate the size of fields found inside the segments.

In the training segments, there were many fishermen households that were borderline farm households. Moreover, there were many absentee farmers since the rains were so late. Nonetheless, the ADD officers were able to collect data and understand how the ASF methodology worked. At the end of the second day, we met again at the training center, discussed problems and made some changes in procedures. The land husbandry officers left the training center at the end of the second day.

On the third day of training, the group was comprised of field enumerators, supervisors and some LRCB staff. ASF construction and sample selection were explained in order to clarify that data collection with ASF surveys differs from data collection with household surveys. Their prior experience and training obviously had prepared them for ASF data collection. They had no trouble with the usual areas of difficulty. The enumerators showed professionalism in this survey

training and were largely able to collect the desired information.

C. Data Entry, Edit and Summary.

DBase programs were developed to correspond to the latest changes in the questionnaire. These programs are difficult to modify. ARPU staff at Bunda College entered the survey data in three weeks investing seven person-weeks of time. There were 1426 questionnaires in the pilot survey which generated 2691 field level records.

Data edit and summary was completed in a variety of programs: Visual DBase, Excel, and SPSS. Since data can be passed from one program to another, we used the easiest program to perform a task.

D. Double Sampling for Forest Resources and Specialty Items .

In the case of forest resources, we are employing a double sampling method. Double sampling is sometimes called two phase sampling because, in a first phase, data are collected from the total sample using a general purpose survey form, and then in a second phase of data collection, more detailed, difficult or costly data are collected for a targeted subsample. The purpose of the first sample is to improve or target the second phase of data collection in order to achieve more accurate estimates for the characteristics included in the second phase than would be possible from a single phase sample at the same cost.

In this project, the second phase of sampling was forest land, conducted to obtain a detailed forest resource inventory. The subsample frame was made up of fields identified on the first phase questionnaire as plantation, mixed miombo woodland, or scrub forest, or land identified as any of these categories and screened out on the tract identification and listing form. Fields were expanded to stratum level and listed in each segment and sampled using probabilities proportional to size (PPS). The sample is a self-weighting sample; that is, the final fields are selected so that each hectare in the stratum has the same probability of selection. A sample of xx forest fields has been selected for a forest resource survey in the customary and estate lands strata. In addition, 8 PSUs have been selected for a forest resource survey in the Public lands see appendix A).

VII. Resources for Implementation of an ASF at the National Level

There are two costs associated with implementation of an ASF: setup costs and operational costs. The setup costs we present are for ASF construction only and provide estimates of required resources to construct an ASF in all ADD of Malawi. In several meetings at the Ministry of Agriculture, Ministry staff asked about implementing this system so that EPA level data can be obtained. There are several procedures that can be used to provide EPA level estimates using the ASF methodology. The first is simply selecting a large enough sample in each EPA in order to have reliable estimates. This procedure will require up to 30 PSUs in each EPA.

Another procedure would require some EPA level data in order to ratio the ADD estimates. This procedure is cost effective because the sample size can remain small at the national level. Imagine that

we have data from an agricultural census that shows the percentage of maize produced in each EPA in 1995. Those ratios would remain close to the ratios of maize in 1996 and 1997. The ASF would produce national and ADD level data while EPA level data would be produced by multiplying the ADD totals for maize by the percent of maize grown in each EPA in 1995 as calculated using the 1995 census data. It may be that the Ministry staff want to use percentages, and additional information about the partition of grain among the EPAs is available from subjective sources or from FEWS like activities. The percentages may be shifted slightly based on new information. Moreover, we do not need an agricultural census but we do need a basis for calculating EPA percentages of each crop. There may be additional data available in order to calculate these percentages. For example, we can utilize arable land identified in Landsat and changed to a percentage in each EPA as a basis for calculating EPA percentages.

We recommend this second procedure in order to generate EPA level data because it allows the national level data to be established first. National data are most accurate since they are based on the largest sample. Next, ADD levels are established and the estimates must add to the national levels. Normally EPA estimates are established last and are set so that the total of EPA estimates adds to the ADD and National totals.

ID	Task Name	Resources			Days	Start	Finish
		Agency	Grade	Staff			
1	**ASF FRAME CONSTRUCTION (Manual Method)**						
2	Obtain manager from government (full time)	government	P-7/P-8	1	300	12/1/97 0:00	12/5/97 0:00
3	Obtain 5 staff from each ADD	government		40	10	12/5/97 0:00	12/15/97 0:00
4	Obtain workspace and work tables for ASF maintenance	MoA/PD		0	10	12/5/97 0:00	12/15/97 0:00
5	Obtain maps (5 sets of 180 maps at 1:50,000 scale)	MoA/LRCB	?	0	10	12/5/97 0:00	12/15/97 0:00
6	Obtain maps (2 sets of 12 maps at 1:250,000 scale)	MoA/LRCB	?	0	10	12/5/97 0:00	12/15/97 0:00
7	Stratify area - public lands and Landsat strata	team	?	40	22	12/15/97 0:00	1/30/98 0:00
8	Construct PSUs inside each stratum	team	?	40	22	1/15/98 0:00	2/15/98 0:00
9	Number and measure each PSU	team	?	40	22	2/15/98 0:00	3/15/98 0:00
10	Select PSUs in each stratum	team	?	5	5	3/15/98 0:00	3/20/98 0:00
11	Obtain contact prints for each selected PSU	team	?	5	22	3/22/98 0:00	4/20/98 0:00
12	Construct SSUs inside each selected PSU	team	?	16	33	4/20/98 0:00	5/30/98 0:00
13	Select two SSUs (called segments)	team	?	5	5	5/25/98 0:00	5/30/98 0:00
14	Obtain enlargements	team	?	5	22	5/30/98 0:00	6/30/98 0:00
15	Pen and ink the segments	team	?	16	33	6/15/98 0:00	7/30/98 0:00
16	Prepare data collection packets for each segment	team	?	16	10	7/20/98 0:00	8/5/98 0:00
17	Workshop	team	?	16	5	7/10/98 0:00	7/15/98 0:00

ID	Task Name	Resources			Days	Start	Finish
		Agency	Grade	Staff			
1	**ASF Frame Construction (Digital Method)**						
2	Obtain manager from government (full time)	Government	P-7/P-8	1	300	12/1/97 0:00	12/5/97 0:00
3	Obtain 8 advanced computer GIS staff	Government	P-5s	8	180	12/5/97 0:00	8/30/98 0:00
4	Obtain 8 cartographic aids	Government	P-4	8	180	12/5/97 0:00	8/30/98 0:00
5	Obtain workspace and work tables for ASF maintenance UPSs	Government		1	260	12/5/97 0:00	8/30/98 0:00
6	Obtain four high end computers	Government			260		
7	Obtain maps (5 sets of 180 maps at 1:50,000 scale)	MoA/LRCB	?	1	10	12/5/97 0:00	8/30/98 0:00
8	Obtain maps (2 sets of 12 maps at 1:250,000 scale)	MoA/LRCB	?	1	10	12/5/97 0:00	8/30/98 0:00
9	Scan one set of maps ($4500 USD)	AAIC		0	30	1/1/98 0:00	2/1/98 0:00
10	Obtain Landsat imagery University of Arizona, Tucson	UofA		0	30	1/1/98 0:00	2/1/98 0:00
9	Stratify area - public lands and Landsat strata	Team	?	16	22	12/15/97 0:00	1/30/98 0:00
10	Construct PSUs inside each stratum	Team	?	16	22	1/15/98 0:00	2/15/98 0:00
11	Number and measure each PSU	Team	?	16	10	2/15/98 0:00	3/15/98 0:00
12	Select PSUs in each stratum	Team	?	5	5	3/15/98 0:00	3/20/98 0:00
13	Obtain contact prints for each selected PSU	Team	?	5	22	3/22/98 0:00	4/20/98 0:00
14	Construct SSUs inside each selected PSU	Team	?	16	33	4/20/98 0:00	5/30/98 0:00
15	Select two SSUs (called segments)	Team	?	5	5	5/25/98 0:00	5/30/98 0:00
16	Obtain enlargements	Team	?	5	22	5/30/98 0:00	6/30/98 0:00
17	Pen and ink the segments	Team	?	16	33	6/15/98 0:00	7/30/98 0:00
18	Prepare data collection packets for each segment	Team	?	16	10	7/20/98 0:00	8/5/98 0:00
19	Workshop	Team	?	16	5	7/10/98 0:00	7/15/98 0:00

IX. Conclusions and Recommendations

This pilot ASF project tested a system to collect reliable statistics within Malawi. It set in place a sampling frame with clear rules for data collection and expansion of results in order to estimate totals. The system will need fine tuning, particularly in reference to sample allocation, enumerator training, and survey instrumentation. Even as a pilot project, the results of the Machinga survey demonstrated that an ASF can be built in Malawi, and that the ASF can be operated by the MOA staff. The survey results are significant in themselves. They show that major crops can be accurately estimated, that the system can be operated by a handful of technicians, and that results can be processed quickly.

The pilot project demonstrated steps involved in implementing a multiresource inventory system. A data user requirements study (DURS) would help define information needs that should be reflected in survey questionnaires. Our experience in other countries indicates that government users will not consider survey results unless they have participated in survey design. A DURS takes about four months of work involving interviewing officials. The data user community should be composed of staff from the main Ministries of Malawi, the donors, data producers, and/or analysts.

One anticipated outcome of a DURS would be to identify wide-area projects that may need to be monitored. If a project is implemented on a nation wide basis like Malawi's Agricultural Services Project (ASP), then the ASF will be able to provide national level data on various project objectives, at the National and ADD levels. If the project covers a small section of the country such as two RDPs or two EPAs, then these project areas should be identified ahead of time in order to select additional samples in the project area. If the project is not a wide-area project but the project participants are scattered, then list sampling would be more appropriate. List frames are integrated using multiple frame sampling techniques. If the project objectives are non-behavioral, then survey methods are usually not the best way to monitor project results.

Recommendation: The GOM needs to implement a DURS in order to document data requirements and to begin a discussion between data producers and data users.

Recommendation: The GOM should develop a plan to implement ASF methods in all ADDs. There are two different procedures to construct an ASF in Malawi: 1) on tables using maps and cartographers as in the Machinga ADD pilot study, and 2) on computers using scanned maps and Landsat TM imagery. Digital ASF construction methods will produce by-products that can be input into a GIS program. The manual method will be easier to complete in Malawi

Recommendation: The GOM should adapt ASF methods to produce crop, livestock, and natural resource surveys over time.

Recommendation: In the first year the new ASF should be used in a national survey with half the sample. Malawi's current crop survey should be continued with either the full sample or with half the sample. Running parallel surveys the first year will allow same-year-differences in data series to be measured. Phasing out the FAO designed system will be the task of the Planning Division.

Recommendation: List frames should be included in the national MRI system. The lists should contain 100 or fewer of the large important farm operations.

Appendix A

Forest Inventory Sample

October 26, 1997

The forest inventory sample consists of two components: 1) eight primary sampling units (PSUs) are selected representative of the public lands sector, and 2) sample fields from the customary and estate lands in each of the following types of forestry,

plantations (all types- six fields),
miombo (six fields),
forest (eight fields),
scrub (ten fields).

The samples are allocated and selected from different forest types in proportion to the expanded area in each forest type.

Public Lands Samples

Eight PSUs in the public lands sector are land parcels containing 1000 or more hectares. There are expansion factors for each public sector PSU that will take PSU level data to the rural development project (RDP) level. RDP estimates are added together to obtain ADD level data.

Aerial photos of the selected public sector PSUs will need to be obtained from Mr. Vincent Mkandawire of the Land Resource Conservation Branch (LRCB) for the Forest Department (FD). Using the aerial photos and ground staff, the FD forest resource teams will proceed with the public sector forest resource inventory in Machinga.

Once selected, PSUs are identified in the field, sample plots are laid out inside and counts and measures made for the forest resources. Plot data will need to be expanded to a hectare level. The hectare level data will be expanded using expansion factors provided here to estimate forest resources for the RDPs.

Thirty sample plots are allocated to the 8 public sector PSUs proportionate to the public land in each RDP.

Mangochi
PSU #13 expansion factor for PSU 13 = 12.63 Lay out 1 plot

Kawinga
PSU #1D expansion factor for PSU 1D = 434.73
PSU #1H expansion factor for PSU 1H = 434.73
Lay out 6 plots

Balaka
No public land

Namwera
PSU #20K expansion factor for PSU 20K= 1331.55
PSU #38A expansion factor for PSU 38A= 1331.55
PSU #90L expansion factor for PSU 90L= 1331.55
Lay out 16 plots

Zomba
PSU #16 expansion factor for PSU 16 = 516.80
PSU #52 expansion factor for PSU 52 = 516.80
Lay out 7 plots

Customary/Estate Lands Samples

Sample fields in the Customary and Estate lands are selected from the list of all fields that were identified as plantations, miombo, forest, or scrub lands during the 1997 June ASF survey. Two systematic replications are selected for each forest type. Each sample replication represents the forest type from which it is selected. If resources are not available to complete all replications, then one replication can be completed. It is also possible that two replications in miombo and forest can be competed while one replication in plantations and scrub is sufficient. These fields were identified on the June 1997 ASF survey although it is possible that some fields were mislabeled. If a field is mislabeled, we need to report that. One field should not be substituted for another.

When the field is selected from the field and farm questionnaire, both tract and field number are available. When the field is selected from the tract identification and listing forms (TILFs), there is tract information only. The sample fields are specific in that a field is identified as completely as possible using the information recorded on the June 1997 ASF survey.

If a selected field is 4.5 hectares, the forest resource inventory staff must lay out plots in the field, make counts and measurements, and expand it to a hectare. For example, if the field plot data are 10 by 10 meters, one would multiple by 100 to expand the field plot data to a hectare. The expansion factors provided for the Customary and Estate Lands strata are for data from one hectare to the total hectares in the respective RDPs. The 30 sample fields are allocated to the four categories of forest type land: plantations (all types), miombo, forest, and scrub.

Plantations (all types) have six samples selected in two sets of three each. The expansion factor for plantation (all types) is 158,124.

The first replication is as follows:

RDP	stratum	PSU	SSU	tract	field	hectares	
1	10		14	51	A	1	33.00
1	10		14	51	A	1	33.00
1	10		14	51	A	1	33.00

The second replication is as follows:

RDP	stratum	PSU	SSU	tract	field	hectares	
1	10		14	51	A	1	33.00
1	10		14	51	A	1	33.00
5	10		50	59	CC	1	5.20

Miombo has six samples selected in two sets of three each. The expansion factor for Miombo is 126,656.

The first replication is as follows:

RDP	stratum	PSU	SSU	tract	field	hectares	
1	10		14	5	AF	2	0.56
1	10		25	25	A	1	3.40
2	12		102	3	B	1	6.27

The second replication is as follows:

RDP	stratum	PSU	SSU	tract	field	hectares	
1	10		14	18	GQ	5	1.50
2	10		125	36	AE	2	3.60
5	12		55	55	L	4	5.20

Forest has eight samples selected in two sets of four each.

The first replication is as follows:

RDP	stratum	PSU	SSU	tract	field	hectares	
1	10		64	4	A	1	2.28
1	10		64	4	G	1	3.20
1	10		64	4	K	1	2.08
4	10		68	15	C	TILF	13.20

The second replication is as follows:

RDP	stratum	PSU	SSU	tract	field	hectares	
1	10		64	4	B	1	9.00
1	10		64	4	I	5	5.40
2	12		102	8	A	5	2.25
5	12		55	75	I	1	3.10

Scrub has ten samples selected in two sets of five each. The first replication is as follows:

RDP	stratum	PSU	SSU	tract	field	hectares	
3	10		45	91	AM	TILF	2.20
3	10		68	13	??	TILF	10.90
3	10		68	13	??	TILF	10.90
3	10		68	38	D	TILF	3.00
3	10		94	30	H	TILF	15.00 (natural)

The second replication is as follows:

RDP	stratum	PSU	SSU	tract	field	hectares		
3	10		68	13	??		TILF	10.90
3	10		68	13	??		TILF	10.90
3	10		68	38	G		TILF	4.20
3	10		94	30	H		TILF	15.00 (natural)
3	10		94	30	H		TILF	15.00 (natural)

The questionnaires and the TILFs are at the ARPU unit at Bunda College. Copies of the questionnaires containing the selected samples and the tracts must be obtained from Bunda College. See Mr. Nick Shawa (277-433 or 277-439). The photographs that show the PSUs and identify the tracts are with LRCB staff. In order to complete this forest inventory, forest inventory staff need copies of selected questionnaires and TILFs that were selected for forest resource survey.