

CAMEROON  
AGRICULTURAL  
PLANNING AND  
POLICY  
PROJECT

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REPUBLIQUE DU CAMEROUN

Paix - Travail - Patrie

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MINISTERE DE L'AGRICULTURE

REPUBLIC OF CAMEROON

Peace - Work - Fatherland

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MINISTRY OF AGRICULTURE

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**THE NEW SAMPLES FOR  
AGRICULTURE  
IN CAMEROON**

**ITS DESIGN, SELECTION  
AND APPLICATION**

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By

Montie WALLACE (Statistician, CAPP)

August 1991

DEPARTMENT OF AGRO-ECONOMIC SURVEYS  
AND AGRICULTURAL PLANNING

AGRICULTURAL AND FORESTRY  
PLANNING SERVICE

*Cameroon Agricultural Policy and Planning Project*

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CAPP

The Net: Sample for Agriculture in Cameroon  
-its Design: Selection and Application.

by Montie Wallace

August 20, 1991



The New Sample for Agriculture in Cameroon - its Design,  
Selection and Application.

As always, the frame must be available before any type of proper sampling can be accomplished. In this case, the frame that was used for the 1987 demographic census is at our disposal. This frame is nothing more than a listing of enumeration zones (ZD's - zone de denombrement) arranged geographically by province, department and subdivision. In addition to the geographical classification, the ZD's are also divided into rural and urban. A ZD is an area of land with boundaries shown on a map. The sum and total of ZD's encompasses the total area of Cameroon so this frame will meet the basic requirement for a frame which is 100% coverage of the population to be sampled. However, this is not a measured area and area coverage is only visually verified.

Lacking measured area, some other criteria must be used for selection of the sample and expansion of the data. The Cameroonian Census Bureau is providing this in the form of special listings for each department that show (a) total number of households enumerated by the census in each ZD; (b) the number of households in which at least 1 person is engaged in at least 1 of the following activities:

01. Production of food crops.
02. Production of industrial and export crops.
03. Livestock raising, hunting and trapping.
04. Fishing and/or raising fish in ponds.
05. Silviculture and forest exploitation.

Only one count is made per household for each activity. The household will be classified as an agricultural household if one person from the household is engaged in any one of the five activities.

This count of agricultural households will be used in the selection of ZD's to be segments (Primary Sampling Units) in the new agricultural sample and for the expansion of survey results. In areas where activities 04 and 05 are predominant, it will be necessary to adjust the number of agricultural households to make it better reflect the true number of agricultural/livestock households.

Lists received from the Census Bureau should be handled in the following manner:

1. Read them into a data base without modification and always keep a backup copy of the data base.

2. Prepare 2 printouts of each listing without modification. One will be the permanent file copy. The other may be used to indicate needed modifications such as number of farm households.

3. From the data base, prepare listings for urban ZD's and rural/ZD's showing the ZD Id (Prov., Dept., Arrond, and ZD number), total number of households, and number of agricultural households for each ZD. Any and all adjustments made in the census number of agricultural households will be reflected in this listing. Add a cumulative column of agricultural households to each printout. These can then be called the "Sample Selection" listing. These modified listings can be stored in a "Sample Selection" file.

The printout of each of these listings will be prepared for sample selection according to instructions shown in Annex 1.

Now that something is known about the frame, the sample can be discussed. The basic design is that of a two stage Cluster Sample in which the primary sampling units (segments) will be the census ZD's (or parts or combinations thereof- see annex #1). The secondary units or reporting units will be farms selected from a complete listing of households and farms within each sample segment.

The sample will be selected independently within each department and will be divided into 4 replicates in the rural stratum. This number of replicates fits into a 25% annual rotation of the sample which can be accomplished simply by retiring one replicate and adding a new one. The replicates also provide flexibility for the management of the sample in regard to funds available and precision required. Since each replicate is an independent sample of the entire population, an unbiased estimate is produced as long as complete replicates are added or subtracted. Naturally precision increases as replicates are added and decreases when they are subtracted.

The sample size was determined by two at least partially conflicting criteria:

1. Estimate the most important crops with a C.V. of 15% or less at the provincial level. This, in turn, will result in a C.V. of 10% or less at the national level.

2. Limit the total size to no more than what was used for the 1984 agricultural census i.e. 954 segments. It is a number that could be enumerated by the present work force in an acceptable amount of time if fields are not measured. It is a

number that could be used to produce a census comparable to 1984 and it is certainly an absolute maximum that could be surveyed in the foreseeable future given the existing economic conditions in the country.

To implement the first point, the most important crops must be defined. Data exists for 20 crops from surveys conducted annually from 1984 through 1989 so consideration is limited to those 20 crops. Preliminary tabulations of '84-'87 data were used to determine the following:

1. For each province, identify the crop or crops of which it is No. 1 producer in the nation.
2. For each province, identify the crops for which the quantity it produces is second or third in the nation.
3. Using sales data, identify the top 4 or 5 crops within each province, in value of sales made by farmers.
4. To calculate a total value of production for each province and each crop for the period '84-'87 by applying sale price to total production. A percentage of the total national value of production for the 20 crops was calculated for each province and the top 10 food crops were rated by order of importance, see Annex # 2.

All the crops singled out by these processes are considered to be the most important crops. Within each province, crops were also classified as Non existant (NE) or Not Important (NI). Cotton, for example, is NE in the 7 southern provinces. NI is applied to those crops where the number of farmers producing the crop within the province is so low that a usable estimate cannot be made. There are other crops in a province that are produced in an appreciable quantity, but were not classified as most important. These were considered in setting sample size but were not given maximum emphasis.

During a TDY in Cameroon, Dr. Charles Perry, USDA/NASS calculated a combined variance for area and production for each of the 20 crops over the period '85-'87 at the provincial level. These variances were then incorporated into tables where it is possible to read the number of primary units needed using a specified number of secondary units (farms) to achieve a desired C.V. Readings using 10 farms per PSU were made for all crops in each province except for those classified as NE or NI. These readings were then consolidated into one sample size for the province considering both the desire to properly estimate the most important crops and the absolute necessity of limiting sample size see annex # 3.

A tabulation and analysis of farm numbers estimated by all surveys '85-'90 was prepared and a single estimate of farm numbers was made for each department that would serve to distribute the sample to departments within a province. This

number of farms was subdivided into those estimated by the rural segments see annex # 4 . and those estimated by the urban segments. This served as a means of dividing the sample between rural and urban segments. At the national level, only 11% of total farms was accounted for by urban segments so it was decided to limit the urban sample to  $\pm$  11% instead of the 21% in the previous sample. A minimum of 1 urban segment was assigned to each department. Variance calculations for the urban stratum would only be possible at the provincial and national level.

The provincial samples were distributed to departments and divided into rural and urban based on farm numbers with the following constraints for the rural stratum:

1. The minimum number of rural segments assigned to any department was 8.
2. The number of segments assigned to the rural stratum in a department must be divisible by 4.

Changes in sample size to meet the constraints and to conform to farm number distribution were always made in an upward direction provided an increase in sample size was supported by a review of the sample size reading by crop within the province. In all cases an increase was acceptable. The worksheet used to distribute the sample to departments is annex # 5 .

After making the modifications needed to properly distribute the provincial samples to departments, the provincial samples were again reviewed taking into account:

1. Sample size needed to properly estimate the most important crops.
2. Percentage of total farms in the province.
3. Percentage of total national crop value produced by the province.

A listing of the new sample as it relates to % of total farms, % of sample and the previous sample is shown in annex # 6 . It will be noticed immediately that the Extreme North varies considerably from the distribution of total farms. This is acceptable because the sample is adequate for the most important crops and the province produces only 7% of national crop value. The distribution of the new sample to departments is shown without additional analytical details in Annex # 7 . This can be compared to the sample used for the 1984 Agricultural Census as shown in Annex # 8 .

The recommended new sample is slightly smaller than the 1984 sample but should be significantly more efficient because the segments will be more uniform in size and the sample of farms in each segment will be approximately proportional to the total number of farms in the segment thus holding the variation in expansion factors well below that of the previous sample. Also,

distribution of departmental samples according to farm numbers will put the larger samples in the departments with the most farms where they are needed.

When the sample selection is completed for a division, the list of chosen ZD's is taken to the Bureau of Census where the maps are being prepared by one of their cartographic technicians. Three copies of each segment map and a division master map showing all segments have been requested.

When the maps for a department are received from the Bureau of Census they should be carefully reviewed and checked against the master map to insure proper location and against our list to be sure the proper ZD's were reproduced.

Cases will be found where segments that it was desirable to combine are not contiguous. In these cases, use the sample selection listing to determine which of the ZD's in the combination was actually selected by the random number. This ZD will be used for the segment. The other ZD shown on the map will be crossed out. This modification must be indicated on the master sample documents.

The field work of identifying boundaries, listing households and identifying farms should begin no later than Jan. 1, 1992. Field investigation of ZD's with dubious boundaries and other obvious problems should begin immediately.

The identification of boundaries and listing of households and farms must be done very carefully. Failure to carry out these activities properly was a major source of error in all previous surveys. It is even more important with the new system since a new listing of households will not be made each year unless there has been an obvious change in the number of households.

The number of sample farms in each segment will be proportional to the total number of farms listed and will be managed to provide an average of approximately 8 farms per segment. In a division with 28 segments in its sample, a total of at least 224 farms for enumeration would be expected and would be distributed in accordance with the number of farms listed for each segment. Some segments will have more than 8 farms and some will have less than 8 but the average will be about 8/(slightly more in most cases). The sample size as previously discussed, was based on using 10 farms per segment but there isn't much difference in number of segments using 8 farms and the current budget crisis decrees the use of fewer farms. This will still be an improvement over the previous sample.

At this point it is necessary to decide if the same farmers can be surveyed each year for four years. If not, make the number of sample farms an even number and rotate half of them each year. In this way each farmer will have to serve only two years. This requires a minimum of 4 farms in each segment. A new half sample of farms would be selected each year.

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Expansion factors should be calculated and recorded using the same format as the segment file for the previous frame.

As mentioned earlier, replicates allow considerable flexibility in managing surveys. For example, using the entire sample is out of the question at the moment for economic reasons but it should be possible to survey two replicates of the rural stratum (30) plus approximately half of the urban stratum (10). Approximately half because at least one urban segment should be left in each division. This results in a manageable sample of approximately 480 segments.

See Annex = 9 for summarization and variance calculation.

See Annex = 10 for segment field identification, listing of households and procedure for selecting sample of farm households.

A commentary on the use of a list of large farms in conjunction with this frame is to be found in Annex = 11.

ANNEX 1

June 2, 1991

Procedure for Sample Selection- Rural Stratum

1. Prepare a continuous listing of the "700" Series of ZD's including all arrondissements in the department. The listing should show total households, Agricultural households and a cumulative figure based on Agricultural households for each ZD.

2. Prepare the listing for sample selection according to the following rules:

A. All ZD's with 250 total households, or more will be marked for subdivision according to the following scheme:

<u>Households</u>	<u>Segments</u>
250 - 400	2
401 - 600	3
601 - 800	4
	etc.

B. All ZD's with less than 100 households should be combined with an adjoining ZD provided the total households in the combination is less than 250. If the combination of 2 ZD's yields 100 households or more, they would not be combined with a 3rd ZD even if the sum of the 3 is less than 250 households. Do not combine ZD's that are in different arrondissements. They probably are not adjoining.

C. These rules for subdivision and combination are based on total households and not on agricultural households.

3. Get the sample size, number of replicates and number of segments in each replicate from the sample design.

4. Establish paper strata by dividing the final figure in the cumulative column by the number of segments in each replicate. The result of this division sets the approximate limit of the first paper stratum. The real limit will be that which includes the ZD whose cumulative number is nearest the approximate limit. Draw a line across the listing at the real limit. Make sure that "real" limit either includes or excludes both of a pair of ZD's that you wish to combine. To determine the next approximate limit, multiply the result of the first division by 2, applying the rule stated earlier to determine the real limit. Draw the line across the listing for the second paper stratum limit. Find the limit of the

third paper stratum by multiplying the result of the first division by 3, next limit by multiplying by 4 and so on until the number of paper Strata is equal to the number of segments in one replicate. A replicate will then be made up of one segment from each paper stratum.

5. Segment Selection within each paper stratum will be proportional to size as expressed by the number of farms in the segment.

It is suggested that 8 replicates be selected at first; 4 for immediate use and 4 for sample rotation and special uses. The easiest way is to select all 8 replicates in one trip through a random number table. To do this take the following steps:

A. Determine the number of digits in the final figure of the cumulative column for farm households and lay off columns in a random number table with an equal number of digits.

B. Select a starting point and define the path you will follow through the random number table. These must be clearly marked so your work can be checked.

D. Acceptable numbers will be those between 1 and the final number in the cumulative column. Go through the random number table from your starting point in the predetermined direction until the first number is encountered within the acceptable range. Write this number to the right of the cumulative column on a line with the ZD that contains it. Also, indicate with a 1 that it belongs to the first replicate in the paper stratum. If the next random number falls in the same paper stratum it would be given the number 2 assigning it to the 2<sup>nd</sup> replicate and so on. Continue in this manner until you have 8 segments numbered consecutively in each paper stratum. Random numbers encountered within a paper stratum after selecting 8 segments will be passed over but continue selecting random numbers until there are 8 segments selected in each paper stratum. Mark the end point of the usage on the random number table.

6. Transfer the data for selected ZD's (segments) to a form such as the one shown in the attached example. This will be the master record for the sample which relates the census identification with the DEAPA codes. As soon as the households in the segments are listed, the columns for listed farms and sample farms can be completed. Once completed, this form supplies the necessary information for the segment file already established for the previous sample.

7. The ZD listing and random number table will be made part of a permanent file for the new Sample for each department.

Procedure for Sample Selection - Urban Stratum

The urban ZD's are those whose identification numbers are less than 700, usually no more than 2 digits within an arrondissement.

1. Begin by carrying out steps 1 and 2 in the Procedure for the rural stratum.
2. Get the sample size from the sample design. Replicates will not be used in the Urban Stratum. Rotation or replacement will be done by random selection as needed.
3. Segment selection within the Urban Stratum will be proportional to size as expressed by the number of farms in the ZD.
  - A. Determine the number of digits in the final figure of the cumulative column of farm households and lay off columns in a random number table with an equal number of digits.
  - B. Select a starting point and or define the path you will follow through the random number table.

Acceptable numbers will be those between 1 and the final number in the cumulative column. Go through the random number table from your starting point in the predetermined direction until the first number is encountered within the acceptable range. Write this number to the right of the cumulative column on a line with the ZD that contains it. This is the first sample segment. Continue in this manner until you have selected the specified number of sample segments.

4. Transfer the data for the selected ZD's (segments) to the standard form that can be used for both urban and rural segments. Always use a separate form for the urban segments.
5. The use of the form and the filing of the listing will be as described in items 6 and 7 of the procedure for selecting rural segments.

ANNEX 2

Prov. \_\_\_\_\_ Div. \_\_\_\_\_ Stratum \_\_\_\_\_ Page \_\_\_\_\_  
N = \_\_\_\_\_ Reps = \_\_\_\_\_ Census Farms = \_\_\_\_\_

Note Selected:

'87 Census: ED DEF ID Census Listed Sam.  
Private - Prov - Div - Stratum - Seq. Farms Farms Farm

BEST AVAILABLE

Province	Cassava	Plantain	Bananas	Palm Oil	Sugar Cane	Taro/Macabo	Maize	Sorghum	Millet	Beans	Ground Nuts	Yams	Peas	Potatoes	Rice
ex. North	146	—	—	—	—	—	2,250	53,478	7,149	5,905	6,745	69	1,087	—	253
North	2,241	—	119	—	329	48	6,567	18,679	437	1,348	12,239	1,408	504	—	43
Adamawa	23,355	1,254	1,380	428	740	1,427	9,014	2,988	83	97	1,417	677	92	—	—
East	43,636	21,032	5,594	4,354	1,233	6,377	8,524	—	—	135	8,162	1,443	21	73	—
Center	85,176	55,808	15,140	11,612	4,654	35,104	10,250	—	—	130	21,689	9,677	129	131	—
South	26,904	12,855	4,113	4,034	3,140	8,957	2,625	—	—	95	2,973	723	9	86	—
Littoral	21,542	15,054	4,498	13,790	903	14,902	3,117	—	—	1,148	2,932	3,604	578	—	—
South West	35,534	48,844	15,855	12,321	824	57,587	3,566	—	—	804	1,471	5,577	—	—	—
North West	18,366	29,842	14,020	16,914	2,769	26,576	39,312	—	—	9,439	6,276	3,604	153	3,335	4,176
West	15,808	25,362	17,728	5,657	4,123	23,056	23,449	—	—	9,689	7,514	1,107	276	4,030	274
Cameroon	272.7	210.1	78.4	62.1	18.7	174.0	108.7	75.1	7.7	28.8	78.0	27.9	2.8	7.7	7.4
Billions CFA	1	2	5	8	3	4	7	9	6	10					

Value of total Production 84-87 using price of sales 1,160

Province	value - Food Crops (000,000)	Food Crop Ranking	Value Including EXPORT CROPS (000,000)	All Crop Ranking	% of total value
Extreme North	79,362	17	98,948	7	7
North	44,351	19	76,719	19	5
Adamawa	42,952	18	49,252	10	3
East	100,584	3	110,609	3	8
Center	249,500	1	324,711	1	22
South	72,574	16	106,742	6	7
Littoral	72,068	16	78,455	8	7
South West	182,383	5	256,257	2	17
North West	175,282	6	189,026	13	13
West	138,073	11	154,044	11	11

Total Value (APP Est.) 84-87 of SALES  
(Million CFA)

Province	Cassava	Plantain	Bananas	Beans	Sugar Cane	Cocoa- Yams	Maize	Sorghum	Millet	Beans	Ground nuts	Yams	Peas	Potatoes	Cotton	Cocoa	Arabica	Robusta	
EX. Nord	108	—	—	—	—	—	339	2,964	265	652	2,939	26	175	3	19,586	—	—	—	27,194
Nord	804	23	111	—	329	33	1,157	1,668	47	319	4,428	1,468	46	—	32,418	—	—	—	42,551
Nord-Ouest	8,969	1,106	1,376	2,041	808	275	3,155	645	—	62	298	678	70	22	—	—	—	215	18,153
Est	7,260	7,959	2,521	750	1,595	2,246	1,794	—	—	29	2,946	304	8	7	—	10,025	—	3,182	41,126
Centre	17,032	2,115	6,798	2,517	2,275	12,038	1,476	—	—	2	3,567	2,810	16	7	—	73,618	—	6,643	145,534
Sud	2,327	3,053	556	593	765	2,908	487	—	—	9	1,212	180	1	6	—	34,035	—	134	46,266
Sud-Ouest	4,043	7,588	1,740	1,424	195	1,774	533	—	—	56	229	723	133	—	—	8,762	—	* 10,257	37,087
Ouest	16,525	22,815	4,966	4,035	317	19,364	1,151	—	—	235	774	3,912	—	1	—	64,525	—	9,319	147,330
Nord-Ouest	8,434	12,466	4,353	6,878	1,969	5,162	4,790	1	36	4,301	4,328	1,296	136	1,602	—	158	13,634	652	72,196
Ouest	3,927	10,091	2,724	1,310	2,404	6,096	3,499	—	—	2,785	1,803	1,477	66	1,040	—	1,101	18,592	6,218	63,395
Cameroun (Province)	69.5	86.2	2314	17.7	11.5	49.9	204	5.3	0.95	9.4	23.7	13.4	0.65	2.7	52.0	192.2	32.2	31.7	649.660
Ranking Top 100 crops:	3	2	9			5	10				8				4	1	17	6	

\* - Adjusted for an extreme value in 1985.

ANNEX 3

# Seas. Needed for 15% C.V. with 5% O.L. Adjustment and 10 Farms

Area (Farms)	Crops										Segments in previous sample	No. of Departments	NEW SAMPLE								
	Cassava	Plantain	Bananas	Perim. Oil	Sugar Cane	Coco Yams	Maize	Sorghum	Millet	Beans			Groundnuts	Yams	Peas	Potatoes	Cotton	Cocoa	Avocado	Robusta	Prelim.
EX North	1360	53	46	90	72	142	43											94	6	96	96
East	40	80	31	374	70	84			105	8	185				63	40		62	4	72	82
Central	152	62	120	138	145	60	460		360	66	352	440	290		102	200		128	8	128	146
ITTOYA	70	60	42	150	100	93	42		79	57	34	256			40	54		49	4	72	80
Southwest	66	34	28	64	106	71	66		185	115	192				84	82		44	4	80	89
Northwest	79	74	50	56	229	41	54		57	182	61	442	47		29	113		70	5	100	113
West	60	46	57	121	221	104	63		49	159	76	527	223		322	129	95	80	6	96	123
North	26	139	79	75	66		172		204	130	115				98			45	4	64	76
Adamaoua	180	60	127	61	254	31	297	254										40	5	60	67
South	22	23	12	22	105	17			57	6	30	50			22			46	3	48	51
																		558		816	923

\* = First in Volume Produced in Cameroon

• = Second or 3<sup>rd</sup> in Volume produced

V. First in value of sales

√ = Special Class 3<sup>rd</sup> in value within department

- = distant 3<sup>rd</sup>

NE = Non-existent

NI = Not important

ANNEX 4

# Farm Numbers - Urban Stratum (10)

BEST AVAILABLE

Province	Division	Total Pop. of State	Urban Stratum Farm	% of Total Urban		% of National Urban		Farmers in old Sample		Rural Farms
				Urban	Total	Urban	National	Urban	Rural	
01 Extremes North	101. Laane et Chari	41,200	500	1	1	2	14	2	14	39,200 - 12
	102. Mangu Java	22,730	600	3	5	2	14	2	14	23,130 - 10
	103. Mayo Tsanaga	45,400	900	2	7	2	13	2	13	44,500 - 17
	104. Diamaré	44,500	6,500	15	10	4	11	4	11	37,650 - 12
	105. Mayo Kanai	48,750	1,700	3	3	2	14	2	14	47,030 - 21
	106. Kadié	38,700	2,000	5	15	2	14	2	14	36,700 - 16
		242,110	12,200	5		10	14	80		228,910 (22)
02 East	101. Lam et Diarem	18,420	2,400	13	38	4	12	4	12	16,020 - 26
	102. Kadeu	16,410	2,000	12	32	2	14	2	14	14,410 - 23
	103. Haut Niéna	24,900	1,100	4	17	2	14	2	14	23,800 - 38
	104. Boum et Nkoko	9,000	850	9	13	2	12	2	12	8,150 - 13
		68,730	6,350	9		5	10	52		62,380 (6)
03 Central	101. Mbari	36,200	4,000	11	32	4	12	4	12	32,200 - 21
	102. Haute Savana	9,500	1,650	17	13	2	14	2	14	7,850 - 5
	103. Lektie	35,500	1,400	4	13	2	16	2	16	34,100 - 22
	104. Ma Fole	32,230	820	3	8	2	14	2	14	31,410 - 21
	105. Mfoundi	3,220	250	8	2	10	6	10	6	2,970 - 2
	106. Nioua et M'poumou	14,800	1,200	8	11	2	12	2	12	13,600 - 9
	107. Nioua et Kelle	16,500	640	4	6	2	14	2	14	15,860 - 11
	108. Nioua et Soko	14,260	620	4	6	4	12	4	12	13,640 - 9
		162,210	16,390	7		8	22	100		145,820 (14)
04 Littoral	101. Mounao	59,800	25,000	42	87	8	8	8	8	34,800 - 60
	102. Nkarr	7,130	940	13	3	2	6	2	6	6,190 - 11
	103. Wouzi	2,337	1,200	52	4	6	4	6	4	1,137 - 9
	104. Savana Maritime	17,540	1,700	10	6	4	11	4	11	15,840 - 27
		86,807	28,840	33		21	20	29		57,967 (6)
05 Southwest	101. Niangui	12,000	700	6	4	2	10	2	10	11,300 -
	102. Niagar	10,185	3,000	29	17	2	6	2	6	7,185 - 10
	103. Nieme	32,110	5,200	14	30	4	10	4	10	26,910 - 3
	104. Fako	30,600	8,500	28	49	4	4	4	4	22,100 -
		89,930	17,400	20		13	12	32		72,530 (7)
06 Northwest	101. Niangui	15,100	1,100	6	9	2	11	2	11	14,000 -
	102. Niangui	30,000	1,700	6	14	2	9	2	9	28,300 -
	103. Niangui	22,000	1,500	6	13	2	11	2	11	20,500 -
	104. Niangui	15,600	1,300	7	10	2	9	2	9	14,300 -
	105. Niangui	24,530	2,500	20	34	2	10	2	10	22,030 -
	131,930	7,100	9		0	10	50		124,830 (11)	

Farm Numbers - Urban Stratum (10)

Province	Division	Total Farms	Urban Stratum Farms	# of Total	% of Urban	Segments in old Sample		Rural Farms	Q <sub>10</sub>
						Urban	Rural		
07 West	01 Noun	37,400	6,300	17	24	4	12	5,600	25
	02 Bamoules	30,710	1,900	6	7	2	14	2880	19
	03 Menoua	40,500	2,800	7	10	2	14	2700	24
	04 Mifi	33,170	9,100	27	34	4	12	24070	15
	05 Haut Nkam	25,700	4,600	18	17	2	6	21100	14
	06 Nde	15,000	2,150	14	8	2	6	12850	8
		182,480	26,850	15		20	16	64	155630 (15)
08 North	01 Mayo Louti	36000	2,700	8	27	2	12	33300	33
	02 Benoue	43,750	5,000	11	50	2	12	38750	33
	03 Faro	6,300	800	13	8	2	7	5500	6
	04 Mayo Reu	25,000	1,500	6	15	2	6	23500	23
	0	11,050	10,000	9		7	37	8	37
09 Adamaoua	01 Farae-Deo	4,600	450	10	7	2	6	4,150	9
	02 Vina	12,400	2,100	17	30	2	6	10,300	23
	03 Mbere	15,000	1,500	10	22	2	6	13,500	30
	04 Mayo Banko	16,000	2,200	14	32	2	6	13,800	30
	05 Djerm	4,500	600	13	9	2	6	3,900	8
		52,500	6,850	13		5	10	30	45650 (4)
10 South	01 Ocean	12,170	800	7	31	2	12	11,370	29
	02 Dia-Labo	18,340	800	4	31	2	14	18,040	36
	03 Ntem	22,250	970	4	38	4	12	21,280	42
		53,260	2,570	5		2	8	38	59690 (5)
		1,179,600	135,040	11		138	520		1,044,560 = 658
						% = 21	79		
04 Littoral	21								
07 Ries	20								
05 Soudanes	13								
01 Extrême Nord	10								
06 Nord-Ouest	9								
03 Central	8								
08 Nord	7								
02 Est	3								
09 Adamaoua	1								
10 South	2								

BEST AVAILABLE

EXpenditure Number of Farms Lot 2

Province	Division	85	86	87	88	89	90	Estimate	Prov. %	Natl. %
01 Ex. North	01 Looone et Chayi	44447	44366	45314	34864	38443	38442	41,420	17	
	02 Nava Gava	23,021	25956	22860	22415	24074	24074	23,730	10	
	03 Nava Gava	49363	49363	46432	52020	40,428	40,428	45,400	19	
	04 Diamare	42298	42023	40144	44686	47808	47808	44,130	18	
	05 Nava Gava	52,162	53,908	51,276	47045	44005	44005	48,730	20	
	06 Kacie	32736	44672	37745	37487	40702	40702	38,700	16	
								242,110		21
02 East	01 Lim et Diem	20631	20631	19556	19476	15148	15148	18,420	27	
	02 Kadey	17501	17491	16521	14882	15227	15226	16,410	24	
	03 Haut Nuona	12299	25683	26145	22891	22340	22340	24,900	36	
	04 Boumka et Ngoko	8,138	8,612	9053	9275	9222	9224	9,000	13	
							68,730		6	
03 Central	01 Mbam	38964	38963	38772	36932	32887	32887	36,200	22	
	02 Haute Sanga	8835	8835	9470	9887	9257	9257	9,500	6	
	03 Lekie	42245	42245	35565	34521	29708	29708	35,500	22	
	04 Mefou	29396	29446	31455	32531	35496	35496	32,230	20	
	05 Mfoundi	4619	4798	2668	2188	2037	2037	3,220	2	
	06 Nuona et Mfoundi	11736	11907	11614	17200	15596	15598	14,800	9	
	07 Nuona et Kadey	16249	16249	17942	15493	15754	15754	16,500	10	
	08 Nuong et Sango	12643	12776	10812	14698	15305	15305	14,260	9	
							162,210		14	
04 Littoral	01 Moundou	44648	44648	52542	82209	89802	88454	59,800	69	
	02 Nkam	6922	6708	6263	7714	2478	2478	7,130	8	
	03 Vouyi	1225	879	1,171	1,109	2331	2331	2,330	3	
	04 Sanga Maximie	17858	17732	17323	17211	10,696	10,696	17,540	20	
							86,800		7	
05 Southwest	01 Manku	13947	10498	12293	11595	11972	16003	12,000	13	
	02 Ndiar	10,330	9458	10736	10673	9839	9119	10,180	12	
	03 Manku	35129	34332	33025	33389	42530	53411	36,450	41	
	04 Faku	32566	32566	32194	34250	25466	25466	30,600	34	
							89,230		8	
06 North West	01 Dongo	18108	16539	14601	19187	19315	18316	18,100	14	
	02 Manku	25541	24437	24538	21878	40,650	40650	20,600	23	
	03 Manku	22557	22220	20617	26681	27554	27554	28,850	22	
	04 Manku	12027	12535	17042	12740	19135	20962	19,600	15	
	05 Mezam	21552	37972	39469	33229	27518	27818	34,100	26	

BEST AVAILABLE

# Expanded Number of Farms

2 of 2

Province	Division	85	86	87	88	89	90	Estimate	Prov. %	Natl %
07 West	01 Noun	29442	37611	38867	36124	37037	37037	37,400	21	
	02 Boumba	30475	30525	27744	32199	31625	31626	30,710	17	
	03 Menoua	46715	47067	35498	34848	32376	32376	40,500	22	
	04 Mifi	27376	27376	27376	34541	37594	37593	33,170	18	
	05 Haut Nkam	23007	22989	25081	29091	26640	26641	25,700	14	
	06 Nde	15639	15639	12,922	14733	15525	15525	15,000	8	
							182,480		15	
08 North	01 Mayo Loufi	38460	38986	39007	30488	35475	35475	36,000	32	
	02 Benoue	43304	43099	40751	42343	49259	49259	43,750	39	
	03 Faro	7734	7798	5607	6440	6634	6633	6,300	6	
	04 Mayo Rey	23065	22899	23882	21406	26060	26060	25,000	23	
							111,050		9	
09 Adamaoua	01 Faro et Deo	4029	4101	4582	5084	4635	4635	4,600	9	
	02 Vina	12880	12880	12317	12561	11376	11376	12,400	24	
	03 Mberé	21390	21396	19055	19096	8987	8987	15,000	29	
	04 Mayo Bangou	11928	11957	14046	14756	18810	18810	16,000	30	
	05 B. Jerem	5212	5169	4500	3800	3800	3800	4,500	8	
							52,500		4	
10 South	01 Ocean	10552	10239	11861	12967	11058	13613	12,170	23	
	02 Diai-Lobo	20293	19611	19617	18593	17557	17557	18,840	35	
	03 Ntem	23489	23459	22097	21777	21680	21681	22,250	42	5
							53,260			

BEST AVAILABLE

% of National		CAMEROON	
01 Ext. North	21	6,179,600	07
07 West	15	1,180,000	
03 Central	14		
06 Northwest	11		
08 North	9		
05 Southwest	8		
04 Littoral	7		
02 East	6		
10 South	5		
09 Adamaoua	4		

Prov.	Division	Urban - 10				Rural - 30				Total			
		old n	New			old n	New			old n	New		
			n	% of Farms	% of Sample		n	% of Farms	% of Sample		n	% of Farms	% of Sample
North	01 Logone et Charri	2	1	11	8	14	16	18	19	16	17	17	18
	Ext. 02 Mayo Sava	2	1	5	8	14	8	10	10	16	9	10	9
	03 Mayo Tsanaga	2	1	7	8	13	16	19	19	15	17	19	18
	04 Diamaré	4	5	49	42	11	12	16	14	15	17	18	18
	05 Mayo Dany	2	2	13	17	14	20	21	24	16	22	20	23
	06 Kaele	2	2	15	17	14	12	16	14	16	14	16	14
		14	12	10	11	80	84	22	10	94	96	21	10
East	01 Lom et Diere	4	2	38	33	12	20	26	26	16	22	27	27
	02 Kadey	2	2	32	33	14	16	23	21	16	18	24	22
	03 Haut Ouona	2	1	17	17	14	28	38	37	16	29	36	35
	04 Bounba et Noko	2	1	13	17	12	12	13	16	14	13	13	16
			10	6	5	6	52	76	6	9	62	82	6
Center	01 Mbarm	4	2	30	30	12	28	21	20	16	31	22	21
	02 Haute Sangha	2	1	1	10	14	8	5	6	16	9	6	6
	03 Lekie	2	1	13	10	16	28	22	21	18	29	22	20
	04 Mefou	2	1	1	10	14	28	21	20	16	29	20	20
	05 Mfoundi	10	1	1	10	6	8	2	6	16	9	2	6
	06 Yeina et Mfoumou	2	1	1	10	12	12	9	9	14	13	9	9
	07 Ouona et Kelle	2	1	1	10	14	12	11	9	16	13	10	9
	08 Ouona et Solo	4	1	1	10	12	12	9	9	16	13	9	9
		28	10	8	9	100	136	14	17	128	146	14	16
Littoral	01 Moungo	8	16	87	82	8	28	60	17	16	44	69	15
	02 Nkam	2	1	5	5	6	8	11	12	8	9	8	11
	03 Wouri	6	1	4	5	4	8	9	15	10	9	3	11
	04 Sangha Maritime	4	2	6	10	11	16	27	27	15	18	20	23
		20	20	21	19	29	60	6	17	49	80	7	19
South-west	01 Niamey	2	1	4	8	12	12	16	16	14	13	13	15
	02 Niamey	2	2	17	15	6	8	10	10	8	10	10	11
	03 Niamey	4	4	30	31	10	32	42	42	14	36	41	40
	04 Niamey	4	6	49	46	4	24	31	32	6	30	34	34
		12	13	13	12	32	76	7	9	44	80	8	10

ANNEX 5



ANNEX 6

6-6-91

# Comparison of Samples

Province	Old		New			
	N	% of Total Sample	N	% of Total Sample	% of total Farms	% of total Crop Value
Extreme North	94	14	96	10	21	7
East	62	9	82	9	6	8
Center	128	20	146	16	14	22
Littoral	49	7	80	9	7	7
Southwest	44	7	89	10	8	17
Northwest	70	11	113	12	11	13
West	80	12	123	13	15	11
North	45	7	76	8	9	5
Adamaoua	40	6	67	7	4	3
South	46	7	51	6	5	7
	658	100	923	100	100	100

ANNEX 7

# NEW SAMPLE - June, 1991

Province	Division	Urban-10	Rural-30	Total
01 Extreme North	01 Logone et Chari	1	16	17
	02 Mayo Sara	1	8	9
	03 Mayo Tsanaga	1	16	17
	04 Maméré	5	12	17
	05 Mayo Dounou	2	20	22
	06 Kélé	2	12	14
		12	84	96
02 East	01 Lom et Djirém	2	20	22
	02 Kadéï	2	16	18
	03 Haute Koukou	1	28	29
	04 Bourkou et N'goko	1	12	13
		6	76	82
03 Center	01 Mbam	3	28	31
	02 Haute Sanaga	1	8	9
	03 Léké	1	28	29
	04 M'pou	1	28	29
	05 M'foundi	1	8	9
	06 Ouona et M'poumou	1	12	13
	07 Ouona et Kéïé	1	12	13
	08 Ouona et Sap	1	12	13
	10	136	146	
04 Littoral	01 Mourou	16	28	44
	02 Nkari	1	8	9
	03 Wouri	1	8	9
	04 Sanaga Maritime	2	16	18
	20	60	80	
05 Southwest	01 Marou	1	12	13
	02 Ndian	1	9	10
	03 M'pou	1	20	21
	04 M'pou	1	24	25
		4	65	69

# NEW SAMPLE - June, 1991

Province	Division	Urbani-10	Rural-30	Total
06 Northwest	01 Donga Martuna	1	16	17
	02 Mentehum	1	24	25
	03 Bui	1	24	25
	04 Mamo	1	16	17
	05 Mezam	5	24	29
		9	104	113
07 West	01 Nou n	5	20	25
	02 Samboutos	1	20	21
	03 Menaua	2	24	26
	04 Mifi	6	16	22
	05 iaut Nkam	3	16	19
	06 Nde	2	8	10
		19	104	123
08 North	01 Mauo Louti	2	20	22
	02 Benoué	4	24	28
	03 Faro	1	8	9
	04 Mauo Rei	1	16	17
		8	68	76
09 Adamaoua	01 Faro et Deo	1	8	9
	02 Vina	2	12	14
	03 Mbéré	1	16	17
	04 Mauo Banu	2	16	18
	05 Dferem	1	8	9
	7	60	67	
10 South	01 Occar	1	12	13
	02 Dia et Lobo	1	16	17
	03 Ntem	1	20	21
		3	48	51
Carre		107	816	923

ANNEX 8

Table 1: Sample Size of Segments and Farm Operators, and Segments and Farm Operators from which Data Gathered by Province and Department.

Department/ Province	Segments in Population	SAMPLE SEGMENTS		SAMPLE FARM OPERATIONS	
		Selected	Visited number	Selected	Data Gathered
Logone Et Chara	250	20	20	122	113
Mayo Sava	137	20	20	121	117
Mayo Tsanaga	233	28	28	159	156
Diamare	322	28	28	161	154
Mayo Danav	247	24	23	128	117
Kaele	278	20	20	120	120
EXTREME NORTH	1,467	140	139	811	777
Mayo Louti	139	20	20	118	117
Benoue	164	18	18	102	93
Faro	50	12	12	71	67
Mayo Rey	67	14	13	65	63
NORTH	420	64	63	356	340
Faro Et Deo	42	12	11	63	62
Vina	92	16	15	89	86
Mbere	81	16	16	92	89
Mayo Banyo	59	14	13	79	72
Djerem	27	10	10	54	49
ADAMAOUA	301	68	65	377	358
Loa Et Djerem	105	16	16	89	86
Kadey	97	16	16	91	87
Haut Nyong	148	16	16	93	86
Bouaba Et Ngoko	66	14	14	77	72
EAST	416	62	62	350	331
Mbam	208	24	24	130	127
Haute Sanaga	251	16	15	90	89
Lekie	317	28	28	156	153
Mefou	380	20	20	118	101
Mfoundi	409	20	20	83	60
Nyong Et Mfoumou	351	14	14	74	74
Nyong Et Kelle	395	16	16	98	93
Nyong Et So'o	260	16	15	83	77
CENTRAL	2,571	154	152	832	774

Table 1 (Continued)

Department Province	Segments	SAMPLE SEGMENTS		SAMPLE FARM OPERATIONS	
	in Population	Selected	Visited	Selected	Data Gathered
----- number -----					
Ocean	90	14	14	79	74
Dja Et Lobo	154	16	16	93	87
Ntem	184	20	20	120	110
SOUTH	447	50	50	292	271
Houngo	210	28	27	154	134
Nkam	91	14	13	59	52
Houri	500	18	18	69	50
Sanaga Maritime	132	16	15	84	80
LITTORAL	933	76	73	366	316
Manyu	129	24	19	112	111
Ndian	46	16	12	70	60
Meme	135	24	23	137	123
Fako	113	20	20	114	103
SOUTHWEST	423	84	74	433	397
Donga Mantung	144	24	24	136	130
Mentchou	157	24	24	132	126
Bui	99	22	22	126	124
Moao	108	20	17	94	88
Mezam	191	28	27	149	144
NORTHWEST	699	118	114	637	612
Noun	262	28	24	136	132
Bamboutos	97	22	22	126	125
Menoua	116	28	28	163	160
Mifi	133	28	28	168	158
Haut Nkam	109	16	16	92	86
Nde	83	16	16	97	94
WEST	800	138	134	782	755
Total Traditional	8,477	954	926	5,236	4,931

ANNEX 9

## Summarization Procedures and Variance Calculations for the New sample.

For those familiar with the previous frame and sample, the same procedures for calculating the expansion factors, expanding and summarizing the data and calculating variances could be used. However, it is true that most of these procedures were not well documented if at all. An effort to remedy that will be made here. Also, the use of paper strata and replicated sampling adds the possibility of using different procedures.

One's first step in understanding must be to read the general description of the frame and sample in the beginning pages of this document. It explains there that the sample is selected independently within each department so that estimates can be generated for each department but variances will be high at that level. The basic desire is to have useable estimates at the provincial level and good estimates at the national level for important crops.

Mention is made of a differentiation between urban and rural farms. This is a stratification for convenience of handling and does not indicate that any evidence exists showing that urban farms are different from rural farms. It should be emphasized that all farms in the sample are reached by means of a household. The census classified ZD'S as rural or urban according to population density. Therefore, urban farms are those reached by enumerating households in an urban ZD. It does not mean that the farm itself is in an urban area. Rural farms are those reached by enumerating households in a rural ZD.

Urban segments require different treatment because they usually yield significantly fewer farms per household listed than rural segments. Therefore it is practical to limit their number to the proportion of farms they contribute. At least one urban segment will be selected per department as explained earlier.

The following formulas were left by Dr. Charles Perry as the appropriate formulas to be used in expanding the survey data and calculating the variances.

A simple example demonstrating their application follows the statement of the formulas.

SUMMARY AND ESTIMATION FORMULAS  
FOR  
THE CAMEROON AGRICULTURAL SURVEY

Basic Stratum Level Sampling Procedure:

Assume that at the first stage of sampling  $n$  segments (PSU's) are drawn independently from a stratum so that the expected number of times the  $i^{\text{th}}$  segment is selected is:

$$\pi_i = np_i$$

where  $p_i$  is the relative size of the  $i^{\text{th}}$  segment. That is:

$$p_i = \frac{X_i}{\sum_{i=1}^N X_i}$$

where  $X_i$  is the size of the  $i^{\text{th}}$  segment.

Assume that at the second stage of sampling  $m_i$  farm households (SSU's) are drawn with equal probability and without replacement from the  $M_i$  farm households listed in the  $i^{\text{th}}$  segment.

Basic Stratum Level Summary and Estimation Formulas:

Formulas are given below for estimating the stratum total and its variance under the assumptions outlined above. Formulas are also given for estimating the components of variance associated with the first and second stage sampling. The statistical properties of these estimates are summarized.

Unbiased estimates for the  $i^{\text{th}}$  segment total and its variance are given by:

$$\hat{Y}_i = \frac{M_i}{m_i} \sum_{j=1}^{m_i} y_{ij}$$

$$\hat{\text{var}}_2(\hat{Y}_i) = \frac{M_i(M_i - m_i)}{m_i(m_i - 1)} \left( \sum_{j=1}^{m_i} y_{ij}^2 - \frac{\left( \sum_{j=1}^{m_i} y_{ij} \right)^2}{m_i} \right)$$

where  $y_{ij}$  is the commodity value for the  $j^{\text{th}}$  farm household from the  $i^{\text{th}}$  segment.  $M_i$  is the number of listed farm households and  $m_i$  is the number of sampled farm households.

Unbiased estimates for the stratum total and its variance are given by:

$$\hat{Y} = \sum_{i=1}^n \frac{\hat{Y}_i}{\pi_i} = \frac{1}{n} \sum_{i=1}^n \frac{\hat{Y}_i}{p_i}$$

$$\hat{\text{var}}(\hat{Y}) = \frac{1}{n-1} \sum_{i=1}^n \left( \frac{\hat{Y}_i}{\pi_i} - \frac{1}{n} \hat{Y} \right)^2$$

$$= \frac{1}{n(n-1)} \sum_{i=1}^n \left( \frac{\hat{Y}_i}{p_i} - \frac{1}{n} \sum_{i=1}^n \frac{\hat{Y}_i}{p_i} \right)^2$$

Unbiased estimates for the first and second stage variance components are given by:

$$\hat{\text{var}}_2(\hat{Y}) = \frac{1}{n^2} \sum_{i=1}^n \frac{\hat{\text{var}}_2(\hat{Y}_i)}{p_i^2}$$

$$\hat{\text{var}}_1(\hat{Y}) = \hat{\text{var}}(\hat{Y}) - \hat{\text{var}}_2(\hat{Y})$$

DATE: September 25, 1991  
 TO: Montie Wallace  
 FROM: Charles R. Perry, Jr.

SUBJECT: Example for Appendix A.1 Computation Formulas

The example below shows step by step how to apply each of the computation formulas given in Appendix A.1 of my trip report dated May 15, 1991. The computation are based on the example data you sent as requested in your FAX.

1. FARM SAMPLE VALUES FOR ITEM y BY FARM AND SEGMENT

$Y_{1j}$	$Y_{2j}$	$Y_{3j}$	$Y_{4j}$
7	8	6	3
2	1	9	7
7	1	5	8
5	3	0	0
7	3	3	2
7	--	4	4
1	16	4	3
4		0	6
--		1	3
40		--	8
		32	9
			--
			53

2. SEGMENT LEVEL COUNT DATA AND THE PROBABILITIES OF SELECTION  $p_i$

SEGMENT	SEGMENT SIZE	FARMS IN SEGMENT	SAMPLED FARMS	PROBABILITY OF SELECTION
	$X_i$	$M_i$	$m_i$	$p_i$
1	199	150	8	0.057448
2	114	90	5	0.032910
3	159	160	9	0.045901
4	191	200	11	0.055139

Note:  $p_i = \frac{m_i}{M_i}$  where  $\sum_{i=1}^4 M_i = 3464$ .

3. SUMMARY STATISTICS FOR SEGMENT LEVEL DATA

SEGMENT	$\sum_{j=1}^{m_i} y_{ij}$	$\left( \sum_{j=1}^{m_i} y_{ij}^2 - \frac{\left( \sum_{j=1}^{m_i} y_{ij} \right)^2}{m_i} \right)$	$m_i$
1	40	42.0000	8
2	16	32.8000	5
3	32	70.2222	9
4	53	85.6364	11

4. EXPANSION BY SEGMENT OF SEGMENT STATISTICS TO SEGMENT LEVEL

SEGMENT	$\hat{Y}_i = \frac{M_i}{m_i} \sum_{j=1}^{m_i} y_{ij}$	$\hat{Var}_i(\hat{Y}_i) = \frac{M_i(M_i - m_i)}{m_i(m_i - 1)} \left( \sum_{j=1}^{m_i} y_{ij}^2 - \frac{\left( \sum_{j=1}^{m_i} y_{ij} \right)^2}{m_i} \right)$
1	750.000	15975.00
2	288.000	12546.00
3	568.889	23563.46
4	963.636	29427.77

5. EXPANSION SEGMENT STATISTICS FOR SUMMARY TO STRATUM LEVEL

SEGMENT	$\frac{\hat{Var}_i(\hat{Y}_i)}{D_i^2}$	$\frac{\hat{Y}_i}{D_i}$
1	4840502.86	13055.28
2	11583807.91	8751.16
3	11184086.58	12393.91
4	9679353.30	17476.63

SUM EXPANDED SEGMENT STATISTIC OVER STRATUM

$\hat{y} = \frac{1}{n} \sum_{i=1}^n \frac{\hat{Y}_i}{P_i}$	$\sum_{i=1}^n \left( \frac{\hat{Y}_i}{P_i} - \frac{1}{n} \sum_{i=1}^n \frac{\hat{Y}_i}{P_i} \right)^2$	$\sum_{i=1}^n \frac{\hat{Var}_2(\hat{Y}_i)}{P_i^2}$	n
12919.24	38437194.98	37287751.15	4

COMPUTE STRATUM LEVEL STATISTICS

$\hat{y}$	$\hat{Var}(\hat{y})$	$\hat{Var}_2(\hat{y})$	$\hat{Var}_1(\hat{y})$
12919.24	3203099.53	2330484.45	372615.14
CV	CV <sub>2</sub>	CV <sub>1</sub>	
0.13853	0.11816	0.072306	

Note: All the numeric values displayed were calculated with the statistical package SAS using the formulas in Appendix A.1 of my trip report. SAS computations are carried out to several decimal accuracy. When these computations are carried out on a hand calculator the results may differ slightly due to rounding errors.

ANNEX 10

Field Identification, Listing of Households and  
Farms and Selection of Sample of Farms for New Segments

Sometime in late 1991 and early 1992 each department will be receiving a new sample of segments made up of enumeration zones (zones de dénombrement) used by the Guinean Bureau of census during the 1987 demographic census. In reality, the segment itself may be a combination of 2 ZD'S or it may arrive with the instructions that field personnel should subdivide it and select one portion at random to be the sample segment.

Each department (division) will be provided one copy of each map for its number of assigned segments in a scale of on 1:50,000 plus a master map showing the location of all segments. A list will be included showing the number of total households encountered by the census in the ZD. The departmental staff will have 3 important operations to carry out on each of the new segments to prepare them for use in surveys.

1. Completely and permanently identify the segment. Use the master map to arrive in the vicinity of the segment and then switch to the 1:50,000 scale segment map to complete the identification. Fortunately some of the boundaries will be existing features such as roads, trails, watercourses and rivers. Unfortunately many of the boundaries will be a line on a map between two points.

In many cases the words "between two points" are the key to approximating an arbitrary boundary. If a real item such as a crossroads, school, bridge over a river etc. can be located near the end of an arbitrary boundary, a simple ruler can closely indicate the point in question. At a scale of 1:50,000, 2 cm. on the map equals 1 km., 1 cm. = 500m, 1mm = 5m, etc. Also keep in mind that the top of the map is always North.

It is of utmost importance to remember that the line on the map is the indicator of the boundaries of the segment. The villages that are included or not included or split by the line have nothing to do with the boundary. Even if the villages shown within the segment have the wrong names or if there are villages within the boundary that are not shown on the map, it makes no difference. The line on the map determines the boundary.

When, after using all available information, the division chief arrives at the best possible identification of the segment, ample notes and even additional drawings must be made to insure the future identification of the segment so that enumerators always return to the same segment. Make as many notes as possible on the map itself that can be made without destroying necessary detail.

2. Prepare a listing of all households within the identified segment. A listing sheet similar to the previously used Form 0 will be provided for this purpose using appropriate questions to identify farmers and or livestock raisers in each household. The listing sheet will be accompanied by detailed instructions for its use.

The household listing should be done with great care. If the listing is incorrect, the expansion factor is incorrect thus, the estimate is incorrect. Furthermore, the listing will be made only once during the period of continuous usage of the segment which is a maximum of 4 years, unless there is concrete evidence of significant change in number of households and/or farms.

A new listing of households will be made when a segment is put back into the sample after a period of retirement.

3. Select the sample of farms to be interviewed in each segment. It has been decided that, for the moment, an average of 8 farms per segment will be selected. If there are 15 segments in a department at least 128 ( $16 \times 8 = 128$ ) farms must be selected for interview. The total number of farms will be allocated to the segments in proportion to the farms listed and at the same time inversely proportional to the segment's probability of selection.

The allocation for the rural stratum (30) will be made at the department level. Sample farms for the urban stratum (10) will be allocated at the provincial level.

The following example uses an imaginary department with only 4 segments in the rural stratum. This means that we will distribute 32 farms ( $4 \times 8$ ) among the four segments

Segment Number	$X_i$ Census Agricultural Households	$M_i$ DEAPA Farms Listed		$\frac{M_i}{X_i}$
1	199	150	$150 \div 199 =$	0.7537688
2	114	90	$90 \div 114 =$	0.7894736
3	159	160	$160 \div 159 =$	1.0062893
4	191	200	$200 \div 191 =$	1.0471204
				<hr/> 3.6054242

The proportion of farms to be allocated to each segment is determined by dividing each value of  $\frac{M_i}{X_i}$  by the sum of the  $\frac{M_i}{X_i}$ .

That is  $0.7537688 \div 3.6054242 = 0.2090652$  etc.

Segment Number	Proportion of Sample Farms	$M$ Total Sample Farms	$\frac{M_i}{X_i}$ Optimum Number of Sample Farms
1	0.2090652	X 32	= 7 (6.69)
2	0.2189683	X 32	= 7 (7.01)
3	0.2791042	X 32	= 9 (8.03)
4	0.2904291	X 32	= 9 (9.09)

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This procedure will result in very similar expansion factors for each segment, so close that it would be almost self weighting. An example from Dr. Charles Perry follows showing the difference in expansion factors between the optimum process and a simple allocation proportional only to the number of farms listed. In the example, the numeral "4" in the last term " $M_i/4$  ( $m_i p_i$ )" is the number of segments in the sample.

DATE: September 23, 1991  
 TO: Monte Wallace  
 FROM: Charles R. Perry, Jr.

BEST  
 AVAILABLE

SUBJECT: Example for Appendix A.1 Second Stage Allocation Formulas

The example below shows step by step how to apply each of the second stage allocation formulas given in Appendix A.1 of my trip report dated May 15, 1991. The example is based on the example data you sent in your FAX. The computations show that when the second stage allocation is made using the formula of Appendix A.1 the expansion factors are all very similar in contrast those computed from the example data. This shows that allocating the second stage sample as recommended in my trip report will make the sample nearly self-weighting and eliminate those outliers that result from variations in expansion factors.

1. MEASURE OF SEGMENT SIZE, SECOND STAGE POPULATIONS SIZE, SECOND STAGE SAMPLE SIZE, SEGMENT SELECTION PROBABILITY, AND EXPANSION FACTOR FOR INDIVIDUAL FARM IN THE SEGMENT.

i	X <sub>i</sub>	M <sub>i</sub>	m <sub>i</sub>	P <sub>i</sub>	M <sub>i</sub> /4 (m <sub>i</sub> P <sub>i</sub> )
1	199	150	8	0.057448	81.595
2	114	90	5	0.032910	136.737
3	159	160	9	0.045901	96.827
4	191	200	11	0.055139	82.437

2. OPTIMAL PROPORTION OF THE 33 SEGMENTS FOR EACH SEGMENT, OPTIMAL SECOND STAGE SAMPLE SIZE (AND ROUNDED VALUE) FOR EACH SEGMENT, AND EXPANSION FACTOR FOR INDIVIDUAL FARM IN THE SEGMENT BASED ON THE OPTIMAL SECOND STAGE SAMPLE SIZE.

i	$\frac{\left(\frac{M_i}{X_i}\right)}{\left(\sum_{j=1}^4 \frac{M_j}{X_j}\right)}$	$m_i = \frac{\left(\frac{M_i}{X_i}\right)}{\left(\sum_{j=1}^4 \frac{M_j}{X_j}\right)} \cdot 33$	optm.	M <sub>i</sub> /4 (optm.p.)
1	0.20958	6.91598	7	93.2520
2	0.21957	7.24353	7	97.6697
3	0.27972	9.23290	9	96.8271
4	0.29114	9.60751	10	90.6806

The number of farms to be finally selected will also depend on whether the decision is made to rotate farms or not. See the last paragraph on page 5 of this document.

Once the number of assigned farms is determined, the selection within each segment will be simple systematic selection following the usual procedure of calculating a sampling interval ( $150 \div 7 = 21$ ), choosing a random number between 1 and 21 inclusive (9). The first farm will be farm number 9, the next will be farm number 30 ( $9+21$ ), the next 51 ( $30+21$ ) and so on until 7 farms are selected.

ANNEX 11

### Preparation and use of the List of Large Farms.

Experience has shown that with a small sample such as will be used in Cameroon, it is virtually impossible to properly represent in the sample of segments, farms that are significantly larger than the average operation. These large farms will be treated as a separate population for which the sampling frame will be a list. This list of large farms and the list of farms encountered in the sample of segments must be mutually exclusive. This is accomplished by removing from the segment data all farms that appear on the entire large farm list. Control of duplication should be done at the departmental level so that it would be possible to select replacement farms for those removed for being on the large farm list.

Completed lists must be carefully reviewed at the departmental and provincial level to remove duplication and insure legibility.

After all duplication is removed and data for replacement farms gathered, the data for the sample of segments will be expanded as usual.

The list of large farms can be prepared at the departmental level by the department chief and an assistant. The departmental chief will, of course, know many of the large farmers but to expand and update his list he must contact extension agents, farmer's organizations, village chiefs, cooperatives agricultural delegate and all other sources he considers useful. For each farm listed, it is important to have the name and location of a person who can supply detailed information about the operation.

Considering that the average size of farm in Cameroon is about 1.7 hectares, 10 hectares appeared to be a reasonable lower limit for building the list. If the list is not large, under 30 farms, all farms on the entire list could be enumerated each survey cycle. Larger lists would be stratified according to size. The largest size stratum would probably be completely enumerated unless there is an unusual number of extremely large farms, in which case the stratum containing the largest farms could be sampled. Other strata containing the smaller classifications would also be sampled. The number to be enumerated and sampled will be decided on a departmental basis depending on size of the list and resources available.

Data gathered by using the large farm list will be tabulated and expanded separately and the result added to that of the sample segments. If all the large farms are enumerated in a department, they will not contribute to the overall variance. If the large farm list is sampled, it can be treated as an additional stratum, or strata, in the calculation of overall variance.