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A MILLET AND SORGHUM CROP ESTIMATION PROGRAM

FOR NIGER AND UPPER VOLTA

by

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REPORT OUTLINE

I. Summary

This report covers travel in Upper Volta and in Niger from August 25 to September 16, 1973. The principal purpose of this travel was to determine a method of obtaining statistically reliable indications of the production of cereal crops, principally millet, and soybean, in these two countries. Particular emphasis was to be placed on the possible use of ERTS imagery in a land use stratification and in establishing an area sample survey.

Principal findings included in this report are:

1. An area sample survey is possible. However, even a demonstration project, just for practice, could not well be implemented in time for the 1973 harvest. A larger program, large enough to give results of even minimum reliability, should not be attempted, again because of the time factor.
2. To develop an efficient area sample would depend upon the effectiveness of the land use classification from which the area sample is drawn. This will require the use of the proper scale ERTS and aircraft photography. If the land use classification procedure results in a "cultivatable land" stratum in which the major portion of the land is not cultivated, the relative efficiency of an area sample for crop estimates will be low. Also, the need to consider livestock and demographic statistics should be determined before finalizing plans for an area sample frame.

3. Niger has an operational annual sample survey which is technically sound and which obtains statistics on production of principal crops, livestock numbers, and demographic data. Weaknesses of the system are a lack of money for travel, both supervisory and to collect completed survey forms, and an overall lack of urgency which results in delayed hand tabulation of the survey data.
4. Upper Volta has the technology, but not the experience to mount a large-scale survey. They also do not have any equipment.

If timely statistics on crop production on these two countries are to be obtained for this year, I would recommend:

1. USAID subsidize the current sample survey in Niger to the extent of providing money for supervisory travel and to provide money and technical assistance for computer tabulation of the survey.
2. USAID support a small-scale sample survey in Upper Volta to the extent of purchasing needed equipment, providing money for supervisory travel, and tabulating the survey results. The crucial factor here could be the amount of time required to obtain the needed equipment.

Immediate action would be required if either of these recommendations is to be carried out. Harvest in Upper Volta will start around October 15. Field work (selecting and measuring fields) should begin sooner. Also, at least 4 weeks lead time would be required to set up and test the computer programs required for tabulation.

II. Field Travel and Contacts

A. Upper Volta

My contact at the American Embassy in Ouagadougou was Dr. Douglas Butchart, Regional Veterinary Officer. Interpreters working with me on different occasions were Mr. Some (a recent graduate in English of the University of Lagos), Mr. Sam Bagie (Dr. Butchart's secretary), and Dr. Butchart. The principal contact outside the Embassy was Mr. Garvey, head of the statistical branch of the Ministry of Agriculture. I also had a short meeting with Mr. Garvey's supervisor. Other contacts in Ouagadougou were with Mr. Pierrard at the Bureau de Cadastre and with Jean-Pierre Arnot, an FAC livestock marketing advisor, who had been assigned the job of setting up a sample survey to determine livestock numbers.

Mr. Pierrard seemed to be pleased that someone was finally interested in the aerial photography of Upper Volta. It was taken in 1958 and is at a scale of 1:50,000. Contact prints can be ordered from Paris at an approximate cost of 200 CFA each. He had no information about the availability or cost of enlargements but volunteered to get this data from Paris.

Field travel in Upper Volta was limited to a single 2-day trip northeast from Ouagadougou to Kaya and Duri. Principal tribal groups in these areas were the Mossi and Fulani. The Mossi generally appeared to live in small villages and in small scattered groups of compounds scattered over the cultivated part of the countryside. The topography is gently rolling, broken by

sandstone buttes which have not yet eroded down. There appeared to be very few year-round streams but an abundance of dry washes. A major portion of the flood plains is cultivated. The principal food crop is millet, with some sorghum and occasionally, maize. A kind of ground-bean, niebe, is often interplanted with the millet. Other crops observed were groundnuts, (peanuts), small patches of cotton, and, in favored areas, rice. Fields are also located in the upland areas. Many of these appear to be randomly located. Goats may be staked out during the day or herded by boys. Cattle generally are herded but some are also staked out. Fields generally are unfenced.

The Fulani compounds are grouped more closely together than the Mossi, and appear to be in larger groups. This could imply that they would need to travel a longer distance to their fields. The Fulani also appeared to have many more cattle than did the Mossi and smaller areas of the flood plains were cultivated.

Crops generally are planted in rows of variable widths. Stands of millet within fields generally were quite uneven, both with regard to plant density and height of plant. I do not know how much of this is normal and how much it might have been influenced by the reportedly abnormally light rainfall at the start of the rainy season. However, local officials I met in both Kaya and Duri indicated that if the rains continued, that they expected at least normal crops. The individual fields I saw along the road did not appear to be suffering at that time from lack of rain.

A planned aerial over-flight of a larger area was aborted when a French mission preempted the local aircraft.

B. Niger

Principal contact at the American Embassy was Mr. Arthur Braunstein, Assistant Program Director. Other contacts in the Embassy were Mr. John Buche, Charge d'Affairs, and Mr. James Hill, Acting RDO. (Mr. Garvey, with whom I probably would have worked with otherwise, was on TDY in the United States.) Interpreters in Niger were Mrs. Joan Tall and Mr. Braunstein. Contacts outside the Embassy in Niamey were with Mr. Illo Katche head of the statistical service in the Bureau of Rural Economics, the director of the Bureau, and two advisory officials of the OPVN (Grain Price Stabilization Board), Mr. Pattinson and Mr. Jomni.

Mr. Pattinson and Mr. Jomni both expressed concern about the reliability of the official estimates and a desire for more timely estimates, even production forecasts. However, neither of them appeared to be aware of the nature of the statistical program in operation nor of the reports issued by it.

As in Upper Volta, my time in Niger did not allow time to attempt a look-see at the entire country--or even the cultivatable portion of it. I did make two 1-day trips from Niamey by ground and a 5 hour flight over the three western departments. The first ground trip was northwest from Niamey to Tillaberry, through the uplands east of the Niger River. The second was to the east, through Dosso to Dogondoutchi. The aerial flight was a circle, from Niamey to Tillaberry to Filingue to Tahoua to Birni-N'kosa

to Dogondoutchi to Dosso to Niamey. The only stop made was at Tahoua.

Topography in Niger appeared to be more rolling than in the area I saw of Upper Volta. Sandstone buttes were still very much in evidence. Cultivation patterns and crops appeared to be much the same as in Upper Volta. However, there appeared to be a much greater tendency for the habitations to cluster in larger groups--even small towns. In turn this could result in a considerable scattering in the fields held by a single household. (In an area of sporadic rainfall, this seemingly inefficient system of scattered land holdings may be a form of drought insurance.) Also, a large number of fields in Niger had some kind of enclosure around them.

With the single exception of Dogondoutchi, crops generally appeared (and were reported by local officials) to be in good condition with prospects, given continued rain, for a good harvest. Even at Tahoua, near the edge of the northern limit of cultivation, rains though light had been consistent enough that the millet was in good condition. The sub-prefect at Tahoua commented that about 80 percent of the livestock in the area had died. Also, that Tuareg refugees from the north had found employment in the fields, that some would probably settle there but that others were saving money to buy livestock and to return to the north.

The Dogondoutchi area was in a pocket which had had no rain for 20 days. Most of the millet was completely brown. The remaining millet, on the more fertile ground, had its leaves tightly rolled so was obviously suffering.

C. BNEDT Computer Center

The Bureau Nationale des Etudes Development Techniques (BNEDT) in the Ministry of Plans at Abidjan, Ivory Coast has an IBM model 1130 computer. My contact at the BNEDT was Mr. Ebbe Ehouman, Chief, Computer Center. His supervisor, Mr. Bookensey Amongua, was not in at the time of my visit (September 17).

Hardware at the center is composed of an IBM model 1130 computer having 16,000 bytes of core and two model 2310 discs. The discs are to be replaced soon (possibly October) with model 2311 disc packs. Input-output devices are a model 1442 card read-punch and a model 1403 line printer.

The program language used is Fortran - for the IBM 1130.

If any programs were to be written for use at the BNEDT Center, specifications could be prepared elsewhere but coding and testing should be done in Abidjan. Any specifications should be prepared both in English and in French (Mr. Amongua, a systems engineering graduate of UCLA, reportedly speaks excellent English, Mr. Ehouman speaks only French).

Computer charges are 25,000 Francs CFA (about $120) per hour.

III. Area Sampling

The stated reason for this trip to Upper Volta and Niger was to determine if ERTS one to one million scale false color photographs taken about April 1973, could be used as a frame for an area sample. The expectation was that such an area sample could be used in estimating both acreage and production of major crops. If possible, I was to set up at least a "demonstration project" in these two countries. This procedure could then be applied to other countries, both in the sub-Sahelian area of West Africa and elsewhere, in succeeding years.

A basic requirement of any sample scheme is that the units of the population be distinct and identifiable. In the specific case of an area sample, each parcel of land must be uniquely associated with one and only one sample unit. Further, the boundaries of the sample units must be identifiable on the ground. For West Africa, acceptable boundaries for sample units could be roads, streams, dry washes (marigot du riviere) or ravines, and possibly the lower edges of the sandstone bluffs which cover much of the area. Since only the sandstone buttes and larger streams or dry washes are discernible on the one to one million scale photographs, the basic (first stage) sampling units would need to be quite large. Smaller first stage sample units probably could be defined if either the French geologic survey maps (scale of 1 to 500,000) or enlargements of the ERTS photographs (scale of 1 to 250,000) were used.

In the United States, the procedure for constructing an area sample frame requires first a classification of major land areas by type of use. For example, cultivated land would be one classification

(stratum), and the uncultivated land (urban, range, parks, forests, etc.) would be placed in other strata. In some areas, the cultivated land would be divided further into irrigated and nonirrigated. After this first gross classification of land areas by type of use, the land area in each stratum would be divided into primary sampling units. Any number of these primary sampling units could then be selected by some random procedure--but with probabilities proportionate to some measure of size of the units. The selected primary sampling units are then subdivided into secondary units such that they all have about the same size. Then, if a uniform number of secondary sampling units are selected at random and with equal probabilities of selection, from each of the selected primary units, this procedure is equivalent to having selected the same total number of secondary sample units from a population of secondary sample units. The advantage to this procedure is that it avoids the labor of physically defining all of the secondary sample units.

A similar procedure could be used in the sub-Sahelian areas. Areas beyond the "northern limit of cultivation" (criteria--average rainfall in August, less than 200 m.m.) would be, except for isolated spots such as Agadez, classified as nomadic grazing areas. The "brouse tigre" (sandstone bluff) areas could be defined on either ERTS photographs or on the French Geologic Survey maps. These areas are uncultivatable, but possibly could provide some livestock brouse and firewood. Still another classification would be areas within villages.

The remaining area then would be classified as potentially cultivatable--although a large portion of it is not now under cultivation. This area could be divided and subdivided into primary and secondary sampling units as indicated above for closed-segment surveys of crop area and production. Any demographic or livestock surveys would also need to include the villages. At least the secondary sample units in such a scheme would have to be defined on copies of aerial photographs taken by the French in 1958. These photographs can be ordered from Paris through the Bureau de Cadastre in Ouagadougou or the Service de Cadastre in Niamey at a cost of about $1.00 each. They are at an approximate scale of 1 to 50,000. Later photographs of some areas are at scales of 1 to 15,000 and 1 to 5,000.

A characteristic of an area sample such that individual sample units are selected with equal probabilities is that the sampling errors of any estimated acreages can be approximated as the sampling error of the estimated proportion (p) of the total land area for the cultivated stratum which is in that crop. Therefore, it is possible to estimate the number (n) of sample units required to produce an acreage estimate of some desires precision, given that a probable proportion of the cultivatable stratum is in fact used for a particular crop, or combination of crops. The formula used is derived from:

$$[\text{standard error of } (p)]^2 = p(1-p)/n, \text{ or}$$

$$n = \frac{p\,(1-p)}{[\text{standard error of } (p)]^2}$$

Table 1.--Probable number of sample units (n) required to produce acreage estimates having specified standard errors (as a percentage of the estimate) for various values of p

Relative sampling error...%	20			10		
p	.50	.25	.10	.50	.25	.10
p(1-p)	.2500	.1875	.0900	.2500	.1875	.0900
[Standard error]^2	.0100	.0025	.0004	.0025	.0006	.0001
n	25	75	225	100	312	900

The above figures show the importance of a good land classification system. One which will remove most of the uncultivated land from the cultivatable stratum.

The probable standard error of an estimated yield cannot be predicted without more data than I have now.

Particular disadvantages of an area sample in this region would include:

1. At least in the Songhai and Hausa areas of Niger and particularly where sample units fell some distance from the villages, it would be difficult to find the owners of the parcels in the sample area--if that was required.
2. Because of the lack of large-scale maps in these areas, it would be necessary to supply a string of photographs to lead the enumerators from the nearest identifiable point (usually some village) to the sample unit.
3. Enumerators would need to be trained in the use of the aerial photographs.

In any event, the timing and short duration of my survey trip to Niger and Upper Volta together did not allow enough time to cope with

logistical problems of constructing area sample units and training people in their use before the harvest season. Therefore, I searched for an alternate survey procedure which could be used to provide factual information for this crop year.

IV. Statistical Systems Currently in Operation

A. Upper Volta

The statistical service in the Ministry of Agriculture is quite small and is underfinanced. They have received technical assistance from FAO, particularly with regard to crop-cutting surveys. They have conducted crop-cutting surveys on rice and groundnuts but nothing so far on cereals. The sampling procedure used is that of a 2-stage cluster sample where the first stage of sampling is a random sample of villages selected with equal probabilities. The second stage of sampling is of farming households within the village area.

The survey procedures were supplied by FAO. I have not seen them, but Mr. Garvey, the head of the statistical service says that they are very similar to those used in Niger, which I had shown him. If so, the instructions would be adequate, if faithfully executed, to the task of providing acceptable survey results. The difficulty is in the execution.

The field work is carried out by personnel of other agencies who have been assigned to assist with a particular survey. Each person works by himself. Not too surprisingly, the chief interest of many of these is in getting the survey work out of the way as soon as possible. Measurements, particularly of sample plots, are often guesstimates. The statistical service is unable to provide any supervision.

Organizationally, the country is divided into 11 agricultural regions (cercles), each with regional development offices (ORD).

A 5 meter square sample plot has been used for yield determinations on rice and groundnuts.

B. Niger

The statistical service in Niger is located in the Bureau of Rural Economics. The head of the statistical service, Mr. Illo Katche, is a graduate of the FAO training program in France. His deputy, Mr. Randon, is French and is there under the FAO. They have had, since 1967, an annual sample census which obtains information on demographic characteristics of the agricultural population, livestock numbers by sex (cattle also by age), and production and acreage of major crops.

Katche has also worked out an agreement with FAO whereby FAO would provide about $88,000 worth of support in equipment and technical assistance over a 3-year period. In return, Niger would hire additional data collectors, to the amount of $50,000 per year. To date, Niger has not been able to allocate this much money for improved statistics.

The annual survey is carried by agricultural monitors (teaching farmers) who are taken from their regular duties for this survey. They have assistants to help with the measurements and crop-cutting. Reportedly they have had some training and local supervision but I do not believe that the statistical service has been able to do any checking on the execution. Another weak area is that the completed survey forms are picked up as other travel permits so that some forms are not received, and tabulation cannot be completed, until 4 or 5 months after the survey.

Survey procedures are written, appear to be complete and are quite detailed. A 10 meter square plot is used for estimating crop yields.

The statistical service also prepares a periodic (weekly?) summary of crop conditions in the different sub-prefectures (arrondisements).

Organizationally, Niger is divided into seven departments, only six of which have any appreciable amounts of land under cultivation. Each department is divided into arrondisements and districts.

For 1973, Niger will conduct a probability survey to include 360 villages, 2 villages per district. Acreage measurements and yield cutting will be made in all fields belonging to a total of 670 farming households.

They also hope to conduct a special survey for rice production in the villages along the Niger River and near Lake Chad.

V. Recommendations

A. 1973 Crop Year

It would be feasible, because of the very short amount of time remaining till harvest to have more than a very token demonstration project in the way of using an area sample to estimate crop yields this year. Further, the statistical base for such a token sample would be so small that the results would be worthless for current use.

Assuming that a basic need of AID in administering the drought relief program is timely, statistically valid data on the amount of grain production in these countries, I have worked with the statistical services of Upper Volta and of Niger to prepare proposals which would, if implemented, supply this information. Because of the very short time span remaining before harvest in these countries, these proposals were cabled to AID/Washington from Niamey and from Ouagadougou to alert AID/Washington of their nature before my return.

These recommendations, with additional details, are included in the following paragraphs.

Niger:

Given that an area sample of sufficient size to produce usable estimates could not be prepared in the time remaining before harvest, there then appeared to be two possible courses of action open. These were:

1. To contract with the Government of Niger to conduct a relatively small survey for AID, using their present methodology; or

2. To support their present survey, particularly in the area of supervision and more timely tabulation.

Niger is perfectly willing to conduct a separate survey provided that USAID pays for it. By their calculations, it would cost USAID a minimum of $232 for each sample village selected. This would include all equipment, personnel costs, and some travel. A breakdown of anticipated costs follow.

Table 2.--Probable costs of a small-scale survey of millet and sorghum production in Niger, 1973, per village, using Niger's two-stage cluster sample

Item	Cost	
Equipment:		
Compass	$89*	
20 meter measuring tape	$24*	
20 Kgm capacity Chattillon scale	$31*	
SUBTOTAL		$144*
Enumerators:		
1 agent plus 1 assistant for 1 month		73
Gasoline for travel		15
TOTAL, per village		$232

*Indicated costs are derived from amounts paid by Niger for similar items in 1972, at a rate of 215 Francs CFA to one dollar.

Mr. Katche says that the measuring tapes and scales normally can be obtained in Niamey. Compasses normally would be ordered from Paris. However, compasses which have been ordered for another department could be diverted and reordered.

Assuming a minimum size sample of 30 villages, 1 village per arrondisement in the area below the "northern limit of cultivation," such a survey would cost a minimum of $7,000 to collect the data plus another $3,500 to tabulate the survey. Any supervision of the data collection by U.S. personnel would be extra.

Such a survey would be a small-scale duplicate of the larger survey that Niger would be conducting at the same time. Its only advantages are that:

1. The results would be obtained much sooner than is usual for the official survey; and
2. It would provide an independent check on the official estimates of acreage and production, capable, however, of detecting only gross differences.

The second alternative appears to offer more for the money. It would take an existing larger survey with statistically sound methodology, and strengthen its weaknesses--the present lack of supervision and the delayed tabulation of the survey results.

Specifically, I would propose that USAID provide $3,000 for gasoline and other travel. This travel would be in supervising the survey and to collect the completed survey forms. USAID would also provide for computer tabulation of at least the cereal acreage and production portion of the survey.

Possible courses of action for tabulating the 1973 crop production surveys are:

1. To hand-tabulate in country as has been done in the past;

2. To develop and test computer programs in the United States, to have the completed survey forms hand-carried here and tabulated on some Washington area computer; or
3. To develop program specifications in the United States but to have the program coding, testing, and survey tabulation conducted at the BNEDT computer in Abidjan, Ivory Coast.

Hand-tabulation is an eminently workable procedure which the countries concerned are used to. The chief disadvantage is the amount of time required to complete the job. This possibly could be 6 weeks for Niger, if they did not have to wait on any survey-forms.

Where speed in tabulation is important, a computer can be the answer, once the necessary programs have been developed and tested. If the programs must be developed and if the time factor is all important, then the program development, coding, testing, and tabulation should be all at the same location, i.e. in Washington, D. C.

However, if there is also a need to develop a computer system which can be taken over and used by the individual countries at some future time, then we must be prepared to sacrifice some timeliness in the tabulation of the data, at least for the first year. Assuming that this is the desire of AID, the following cost items should be budgeted.

Program preparation in the United States	
Crop estimation specialist--2 weeks	$1,600
Systems analyst--2 weeks	1,400
Translator--1 week	500
Program coding and testing at BNEDT, Abidjan	1,000
Tabulation, in Abidjan	
Crop estimation specialist 2-1/2 weeks TDY	2,500
Travel	1,000
Interpreter	300
Niger statistical service official	
2 weeks TDY to Abidjan, including travel	1,000
Card punching (6,000 cards)	400
Computer tabulation	1,000
Post-survey statistical analysis, in Washington, D.C.	
Crop estimation specialist--2 weeks	1,600
Computer analysis	500
TOTAL	$12,800

Upper Volta

The only possibility for obtaining any factual data on the amount of millet and sorghum harvested in Upper Volta this year is for some outside agency to finance at least a minimum survey in that country. I had recommended via cable from Ouagadougou that AID support such a survey, subject to the following critical conditions.

1. A relative sampling error of 15 to 20 percent would be acceptable for AID purposes.
2. Since harvest starts about October 15, and Upper Volta will need some lead time to arrange for the survey,
   a. approval of AID support for the survey should be given Upper Volta not later than October 3, 1973, and
   b. equipment needed for the survey should be delivered in Ouagadougou not later than October 10, 1973.

The recommended sample size is two households from each of 22 randomly selected villages, two villages from each of the 11 agricultural regions in Upper Volta. All millet and sorghum fields belonging to the selected households would be measured and sampled for yield.

The recommended numbers of households and villages represent about the smallest size sample that could give results of even moderate reliability. At the same time, it is about the largest

size survey that the statistical service of Upper Volta would want to handle on a rush, first-time basis. Mr. Garvey, head of their statistical survey unit, is very concerned about getting adequate supervision of the survey.

Final agreement as to the amount of support, particularly in the area of supervisory travel, required by Upper Volta for this survey could not be reached as the Minister of Agriculture was not available at that time. In his absence, Mr. Garvey and myself prepared a proposal to be presented jointly to both parties, the Ministry of Agriculture and AID.

Under this proposal, the statistical service of the Ministry of Agriculture would select the sample villages, prepare written instructions and recording forms for the survey, and supervise the field work. The field work would be conducted by selected local agents of the Ministry of Agriculture, working in two-man teams, one team for each of the 22 villages. The sample villages would be selected at random and with equal probabilities from a complete list of villages in each region.

Necessary assistance from the United States would include providing major items of equipment needed for the survey, a vehicle for supervisory travel, and assistance with the tabulation of the survey. It would also be desirable if a survey specialist from the United States could assist with the supervision.

Specific items of equipment needed for the survey include compasses, 20 or 25 meter metric measuring tapes, and scales.

The procurement of 24 of each of these items is recommended. This would provide one set for each two-man team plus two spares. Detailed descriptions follow.

1. Compasses--should be hand-held, must read to the nearest degree, must be durable. Possible cost $100 each.
2. Metric measuring tapes in 20 or 25 meter lengths. Suitable tapes can be obtained from the Lufkin Rule Co., Saginaw, Michigan, models W224M (20 meters) or W225M (25 meters) at a cost of about $10 each.
3. Counter type scales having at least 20 Kgm capacity. A suitable scale manufactured by the Chatillon Scales Co., has a 25 Kgm capacity (25 Kgm x 100 gm) and would cost about $20 each.

In the absence of a specific statement of transportation requirements from Mr. Garvey, I would recommend budgeting the amount of $1,600 for rental of a Land Rover vehicle, for supervisory travel during the survey.

Tabulation of the survey results would require one man-week of technical assistance from AID. This could be hand-tabulation in the country or possibly concurrent computer processing with Niger. Survey results would include sampling errors and would be given both to the Ministry of Agriculture and to AID.

B. Future

Future assistance to the statistical programs in these countries could take the form of:

1. technical assistance in developing new and improved technologies and/or
2. financial and perhaps technical support of existing technology.

Considering the second option first, the two-stage cluster sampling procedure is technically sound and should produce reliable statistics if there is adequate motivation and supervision. Without these factors, nonsampling errors can become so large as to render the results meaningless. Also, all tabulation of survey results is by hand, and cannot be completed until the local officials find a way to get the completed survey forms to the capital city. I have recommended assistance of this sort for both countries for 1973. However, I would hestitate to recommend this as a long range program--unless AID develops as the major user of the data.

The major cost of the present two-stage cluster sample procedure now used is the time required to list all of the households in the sample villages. Not only is this a time-consuming operation, there is also a suspicion that the survey agents would be inclined to stop before they had quite finished canvassing the village. This would introduce an undertermined amount of nonsampling error. The amount of time required for this operation could be greatly reduced if a third, intermediate, stage of sampling was included in the survey. Under this modification, the villages would be selected as at present.. However, instead of listing all households in the village, the agent would, with

the assistance of the village chief or other knowledgeable official, block out the village into a number of sectors. Each sector would contain from 20 to 30 households. One sector would be selected at random from each village and only the households in this sector would be listed and considered for sampling. As before, all fields belonging to the selected households, regardless of their location, would be measured and sampled for yield.

The present procedure estimates the yield for a particular field from a single sample plot. I have noticed a considerable variation in (at least potential) yield within fields. Using 2 or 3 smaller plots per field should result in a considerable reduction in the overall sampling error, and with a minor increase in cost.

At present, Niger draws a completely new sample each year. Therefore, the survey estimates of acreage and production can be expected to bounce around because of the real difference found in the means of different subsamples from the same population. For example, if the relative sampling error of the direct expansion estimate was in the neighborhood of 10 percent, two independent surveys of the same population could produce estimates which differed by as much as 20 percent. The probability that such a large difference is small, approximately 5 percent, but it is there. If only, say, half of the sample was replaced each year, the other half could be used to measure the year to year differences so that a more stable set of indications could be obtained.

Another possibility would be to test the applicability of an area sampling frame. As indicated in Table 1 (Section II), the efficiency of such a frame for estimating crop acreage and production depends upon the proportion of cultivated land found in the cultivatable stratum. Initial research in this area then should investigate the possibility of divising a land classification system such that at least one-fourth of the land in the cultivatable stratum was actually in crops. Materials to be considered in such a program should include both Skylab and ERTS imagery, enlarged to as large a scale as practicable, and taken in both the dry and wet seasons.