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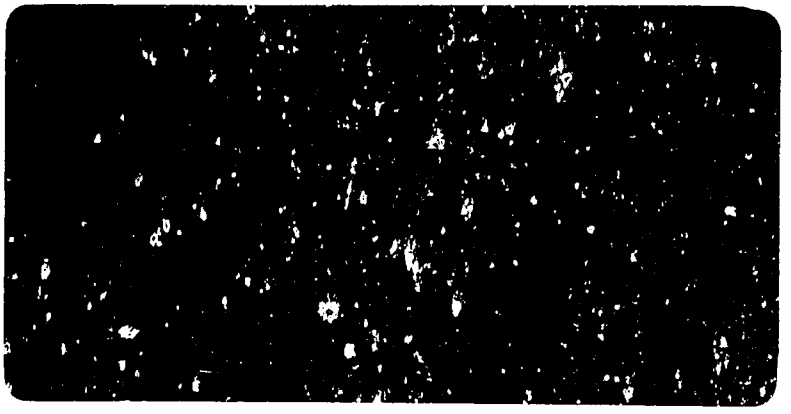

AGRICULTURAL DEVELOPMENT SUPPORT II
HAITI

University of Arkansas,
Fayetteville

AN IMPROVED SAMPLING SCHEME FOR ESTIMATING THE AREA AND YIELD OF SUGAR CANE IN HAITI

ADS-II
Agricultural Development Support II Project

AN IMPROVED SAMPLING SCHEME FOR ESTIMATING THE AREA AND YIELD OF SUGAR CANE IN HAITI

USAID CONTRACT # 521-0092

between

The University of Arkansas, Fayetteville/Winrock International
and
The Haitian Ministry of Agriculture (MARNDR)

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AN IMPROVED SAMPLING SCHEME FOR ESTIMATING THE AREA AND YIELD OF SUGAR CANE IN HAITI

The Problem - Terms of Reference

The University of Arkansas/Winrock International ADS II project is working presently with the Haitian Ministry of Agriculture (MARNDR) in developing and testing a National Agricultural Survey for annual crop production in Haiti. Initial results from trials in the Department de l'Ouest indicate that the open segment area frame sampling scheme used by ADS II may seriously underestimate crops growing at least in part on large farms, particularly if they are owned by absentee owners. From their initial trials, ADS II staff suspect that sugar cane is an example of this situation and have suggested that a multiple frame sample involving the present open segment frame for small farmers and a list frame for large, commercial producers might correct the distortion in the present system. With this in mind, the contractor has been asked to consider alternative sampling schemes and evaluate the most efficient means of estimating large sugar cane producer areas and production.

Questions and Objectives

There are several questions which must be considered before any recommendations of the most efficient sampling scheme can be made. Some of these are as follow:

1. Is there a list of large sugar cane producers with associated areas under cultivation for each on an annual basis?

2. Do the major commercial companies producing sugar have such information, and if so, will they be willing to make this information available?

3. If such lists aren't available, are there alternative methods of obtaining them?

4. Are there alternative sampling schemes that would be more effective and at least equally efficient in the estimation of crop area and yield?

5. If a new sampling scheme is used in combination with the existing open segment system, how can double count estimates of the same farms be avoided?

ADS II is supported by USAID Project 521-0092 funding.

With these questions and the terms of reference in mind, an attempt will be made to meet the following objectives:

1. summarize relevant past findings on sugar cane in Haiti

2. evaluate the availability of large producer information

3. consider alternative sources of data on large cane farms

4. design several alternative sampling schemes to estimate the area and yield of sugar cane produced on large holdings and then combine this with the existing open segment estimates for small holdings.

A Synopsis of Pertinent Results From Previous Studies

The USAID and UNDP Libraries in Port-au-Prince were searched for reference materials. While several documents were found in either library, USAID's contained three which give a reasonable overview of sugar cane production in the context of my objectives. The citations and their AID call numbers are given in the Literature Cited section of this report.

The Area of Sugar Cane Production

Lucie-Smith cited the 1950 Haitian census estimate of 85,000 hectares (Ha.) being used to grow sugar cane, one quarter of which was growing cane for commercial sugar (sucre centrifuge) production and the remaining three quarters for clairin (alcohol) and rapadu (a local form of raw sugar). Delatour, however, suggested that 40 percent of the cane area was used for commercial sugar purposes.

The major sugar cane growing areas as given by Lucie-Smith were the Cul-de-Sac, Plaine de Leogane, Plaine des Cayes, Plaine du Nord and the Grand Anse and Voldrogue Valleys. No source is given, but he estimates the amount of land supplying the commercial sugar producers as:

company	area (Ha.)
HASCO	
Cul-de-Sac	7,900
Leogone	2,100
Dessalines	
Les Cayes	4,500
Citadelle (now USN)	
Cap Haitian	4,200
	18,700

He also states that at any one time about 70 % of this area will

be actively growing cane, while the other 30 % will be in some stage of preparation for replanting. The usual cycle he gives for growing sugar cane is:

1. planting from nursery stock with a first cutting after 15 to 18 months (eg., plant March - Sept. in the Cul-de-Sac region or Aug. - Oct. in the Les Cayes region).

2. cutting of the regrowth after 12 months

3. repeated cutting on this 12 month cycle for 3 - 4 more years.

My own experience is that some small farmers will do the repeated cutting up to 8 years.

Delatour presents the latest and most comprehensive set of data on sugar cane production. His 1983 report compares the results air photo interpretations from 1956 and 1978 photos and presents pertinent data from many other sources to support his report. Delatour's study gave an estimated 31,000 Ha. in 1978 as is shown on the next page in the reproduction of his table 1. He essentially used the same major producing areas listed by Lucie-Smith, except that he excluded the Jeremie-Voldrogue area. He assumed that this area plus the Plaine de l'Arcahaie gave an additional 5,000 Ha. and cited his agreement with a 1980 SCET report giving an area of 9,000 Ha. of cane for the Central Plateau, thus giving his estimate (essentialy for 1978 - the date of his aerial photography) of the total sugar cane producing area as 45,000 Ha.

Delatour's 1978 results are significantly different from those of other sources. For example, in 1976 Lucie-Smith presented a total growing area estimate of 85,000 Ha., while the FAO 1976 & 1978 estimates were 80,000 Ha. Even when similar methodology, using the same data sources were employed, the results differed greatly. Delatour's air photo results from the interpretation of 1978 photos of the Plaine de Leogane illustrate this when compared with the results of the work by Damiscar and others. These are shown below.

Area Estimates (Ha.) From Interpretation Of The Same 1978 Aerial Photography Of The Plaine De Leogane

Damiscar		SOFRECO		Delatour	
Total	Cane Prod.	Total	Cane Prod.	Total	Cane Prod.
7,580	5,650	10,900	5,685	8,166	4,463

TABLE I

LAND USE IN FOUR MAIN CANE PRODUCING PLAINS

	1956			1978		
	Total Area (HA)	Cane Area (HA)	Cane % Total	Total Area (HA)	Cane Area (HA)	Cane % Total
Cul-de-Sac	34,342	11,948	34.7%	34,360	8,294	24.2%
Plaine du Nord	23,897	2,478	10.3%	32,000	10,690	33.4%
Ugrane	8,276	4,902	59.2%	8,166	4,463	54.6%
Plaine des Cayes	19,408	9,182	47.3%	19,252	7,089	36.8%
Total	85,923	28,510	33.1%	93,778	30,536	32.5%

Source: Aerial Photos of December 1956 (1/45,000) and February 1978 (1/40,000)

Sincere thanks to Ag. Paul Duret (Capital Consult) and Dalbert Claude for performing the photo interpretation and making the results intelligible to the author.

The Character of Land Use for Sugar Cane Production and Farm Size

The amount and trends of land use for sugar cane growing to produce commercial sugar, clairin, rapadu and other related products varies greatly between the different sources. As already noted, Lucie-Smith put the percentage of sugar cane growing land used to produce cane for commercial sugar at less than 25 %, while Delatour put it at 40 % Delatour noted that the data available from other sources differ substantialy from his and are contradictory in amounts and trends. He also noted that the amount of land being used for growing cane had decreased between 1956 and 1978. Unfortunatly, his calculations based upon air photo measurements probably illustrates differences in the determination of average photo scales between the two sets of photos (1956 and 1978), rather than real changes in cane producing area.

There is one point of consistency through all of the reports. The majority of cane is produced by thousands of farmers having small farm areas, but the majority of cane for commercial sugar production comes from a relatively small number of land owners having large farm areas. Delatour cites several different reporting sources for the cane supply to the three major sugar mills. In summary:

HASCO (7,000 total suppliers)
- Cul-de-Sac: No data available
- Leogane: 79 % of growers have farms < 1/2 Ha. for 27 % of the total area being farmed
  - 1 % of growers have farms > 10 Ha. for 36 % of the total area being farmed

Dessalines (3,500 total suppliers)
- Cayes: 58 % of growers have farms < .64 Ha. for 16.6 % of the total area being farmed
  - 2 % have farms which avg. 18.4 Ha. for 28 % of the total area being farmed

USN (1300 total suppliers)
- Plaine du Nord: 54 % of growers have farms < 1.5 Ha. for 16.6 % of the total area being farmed
  - 2.7 % of growers have farms > 25 Ha. for 63 % of the total area being farmed.

Delatour's air photo work also shows a preponderance of large farms growing cane. His table XIV is reproduced on the following page. In that study farm fields having greater than 10 Ha. were defined as large, those with a lesser area as small.

TABLE XIV

SHIFTS IN CANE ACREAGE, 1956 and 1978
(Hectares)

	1956		1978	
	Small Holders	Larger Holders	Small Holders	Larger Holders
CUL DE SAC	4,860	7,088	2,734	5,560
PLAINE DES CAYES	3,588	5,594	1,695	5,394
LEOGANE	1,974	2,928	1,935	2,528
PLAINE DU NORD	342	2,136	3,772	6,918
TOTAL	10,764	17,746	10,136	20,400

Source: See Table I.

Yields of Harvested Cane

The estimates of cane harvest yields, like that of land area, vary greatly between reporting sources. However, it is generally agreed that yields per unit area are about one-half what they are in other cane producing countries. Lucie-Smith reported the following:

Source	Location	Yield(short tons/Ha.)
HASCO	Cul-de-Sac	49
	Leogane	46
Agronomes	Cayes	35
World Bank	Plaine du Nord	35

While Delatour reported:

HASCO	Cul-de-Sac & Leogane	37-49
Agronomes	Cayes	30-35
FAO		40
SOFRECO	Leogane & Plaine du Nord	40

Delatour concludes that 40 tons/Ha. is a reasonable average to use. It is unclear how he derived this average other than it seemed a reasonable upper limit on which to base his arguments about the maximum possible production that could have been taking place.

The yield estimates for commercial sugar produced from the rough cane was generally cited at between 10-14 tons of cane to produce 1 ton of sugar. Delatour presented data that indicates the percentage recovery had been going down steadily in recent years (report dated 1983, tables IV, V, and VIII) and that the yield in any year was subject to several producer related variables which change from year to year.

A Summary of What All This Means

In summary, the literature doesn't provide what appears to be a reliable measure of the small, large, or total land holdings in sugar cane production. However, the literature is convincing that a large proportion of the total cane producing area used for growing sugar cane to produce commercial sugar is in large holdings and that these are owned by a relative few.

The field harvest yields reported by Delatour are the latest available in the literature and can be used if no other data becomes available. It is worth noting that there are differences

in regional production rates and that any future changes in farm practices (eg., irrigation, fertilization, etc.) could make a substantial difference in yields.

Sugar yields from the field harvested cane won't be addressed further in this report. If these need to be derived, they can be obtained from mill data. It is important to remember that they can change significantly from year to year.

Information Available From The Commercial Sugar Producers

Some ADS II staff have suggested that the three major commercial sugar producers might have the needed area and yield information on the cane growers. With this in mind, the consultant has attempted to contact each of the sugar producers (HASCO, Dessalines and USN) and asked about the availability on an annual basis of;

1. a list of sugar cane producers for the region surrounding their mill,

2. the area of each farm producing cane for each of the above producers or the total area as a lump sum for each producer, if not available on a per farm basis estimate, and

3. the amount of cane produced by each of the above farms or producers.

They were also asked if maps were available which indicated the areas being used for cane production.

Unfortunatly, at the time of this consultancy two of the mills were closed (HASCO and USN) and their management couldn't be contacted. However, Mr. Roche, Chef de Bureau, for the Dessalines plant in Les Cayes was contacted and was very willing to provide whatever information he could. He was able to provide the names of those supplying the mill and the amount of cane they sold the plant. However, he was unsure if his company had records of the farm areas or had any maps of cane growing areas. If it is felt that his information would be of use, he should be contacted. (phone: 05-6-0351)

However, the problems that the domestic sugar producers are having now and into the foreseeable future make any dependency on mill data for the purposes of estimating sugar cane areas and yields on an ongoing annual basis very questionable. As will be mentioned again later, there is also a problem in using their area data (if Dessaline's response is representative of the other two mills) because there are likely many farms in their region which don't deliver their cane to that mill.

Potential Sampling Schemes to Improve Estimates of Planted Sugar Cane Area and Yield

There are several possible sampling schemes to improve upon the present open frame area estimates. Each of these has its own strengths and weaknesses, differences in cost, etc. While I will make a recommendation as to what I feel is the best scheme, the final decision must be made by the ADS II staff based upon their own mix of skills, the availability of needed data to support the alternative schemes, and the funds and time available for doing the work. The possible schemes discussed here are:

1. use of the present open frame for small farm production estimates combined with enumeration by the commercial sugar producers of large farm production

2. a modified open frame sample with the latest available aerial photos (1978) being used in the collection of additional information on the sample segments.

3. same as 2 above, except using supplementary aerial photography (SAP) taken on an annual basis.

4. Use of the present open frame scheme to obtain a production estimate for sugar cane growing outside of the major plaines areas, combined with line transect data collected by aerial observers for the plaines production

5. Use of the present open frame scheme to obtain a production estimate for cane growing outside of the major plaines areas combined with a point sample, aerial photo production estimate of the major plaines areas.

6. Use of satellite remote sensing surveys (either LANDSAT TM or SPOT) to obtain the area estimate.

Scheme 1: The Combination of Open Frame and Enumeration

At first consideration, this scheme appears to be a simple, cost effective means of obtaining a reliable combined estimate of the total area in cane production. The combined estimate would be obtained by using the present open frame system to obtain the estimated production for cane produced on small farms and this would be added to the producing area of the large farmers as provided by the major sugar producers or to a list sample of this mill listing, assuming that the sugar producers can provide the names and addresses of the individual landowners or their farm managers.

However, this scheme has several negative attributes. It is likely that the mill information will be only for those farms producing cane for their consumption and to the major plaines areas. Since 60-75 percent of Haitian cane goes for other

purposes, it is almost certain that some of the large holdings now being missed would also be missed in the mill information. Further, ADS II would have to segregate the data from the two components to assure that information wasn't collected over the same ground areas for overlapping farm sizes.

If this scheme is used, the combined total estimates would be obtained by summation. However, it is recommended that it be used only if ADS II feels that the mill information is complete for all large landowners. At present that doesn't seem a possibility.

Scheme 2: A Modified Open Frame With Aerial Photos

This scheme has the advantage of being done with relatively little change from the present open frame proceedure and methodology. The major modifications would be having the enumerators verify that the interview respondents only gave information on areas within the segment and that they include large farm area data on the base aerial photos when the farmer or land owner isn't available for interview. In essence, the segment will be broken into two subsegments.

There some problems foreseen with this scheme. The most serious would be having the enumerators determine accurately in the interviews which of the interviewee's gardens are in the segment and which are out. The enumerators would also have to have some skill in photo interpretation and be able to keep clear records of the photo location of farms where they didn't conduct detailed interviews. There would also have to be a modified data analysis program written to accommodate the combining of the two estimates for the subsegments and to calculate the error terms. One other concern would be that no exact yield or other farm data would be available usual interviews. However, this shouldn't be a significant problem as the regional averages provided by Delatour's mill data should be adequate.

The proceedure for using this scheme would be as follows:

1. select segments within strata in the usual manner

2. conduct field interviews as usual within the sample segments, except that the enumerator would now have to verify that the gardens on which the farmer gave information were located within the segment boundaries

3. have the enumerator mark all large fields on the photos for those fields whose farm management wasn't available for interview. The choice of what constitutes a large field is left to ADS II, but it is suggested that this size be chosen such that it is of sufficient size to show up well on the photos (4 Ha. minimum) and wasn't enumerated frequently in the first pilot survey.

4. measure the areas of these fields from the photos using an average scale for the segment. Comparative photo and topographic measurements for at least four scale measurements dispersed over the segment should be done to determine this average scale. The scale should be quite accurate as the segments having large farm areas will generally be in the flat, intensively farmed plaines areas

5. calculate the segment statistics (areas, yields, etc.) for sugar cane on small and large farms where interviews took place using the usual proceedure, except that the expansion factor should now be recalculated using the segment area minus the area found in 4 above. You are making a subsegment within the parent

6. calculate the subsegment area for the large farms where interviews didn't take place by calculating the area sums for 4 above

7. calculate the yields per unit area for large farms using Delatour's mill data for that region or the average from interview data for that segment if five or more large farms had interview data taken on them

8. The estimate of sugar cane area for the segment would then be obtained by summing the areas in 5 and 6

9. The error estimates for the area total and yield have some theoretical problems associated with them. However, conservative estimates could be obtained by making the calculation of error using both sets of data and the open frame formula and would be obtained by summing the results of 5 and 7

This scheme might require an additional field person per segment team to verify the photo located boundaries. Other than this the only additional resources needed would be some personnel time to measure the photo areas and to enter the additional data into the survey data analysis system.

Scheme 3: A Modified Open Frame With SAP Photos

This is essentially the same system as outlined above. The difference is that small format aerial photos taken on an annual basis would be used by the field personnel to aid them in locating the sugar cane fields on the latest large format (1978) photos. This would involve the flying of 1:40,000 35 or 70 mm format photos of the segments before the enumerators commenced with their field work. SAP photos enlarged 2X would then be taken into the field with the presently used base photos (1978). The SAP photos provide a more recent photo overview of the farms to help in outlining the gardens on the base photos.

If the base photography is grossly out of date and the field patterns on them have changed greatly, this system has much to offer. However, it does mean that there will probably be a substantial increase in survey cost. Cameras, film, trained flight and photo personnel are but a few of the cost and personnel expenses that are added. Even if only the segments in the major plaines are flown, this additional photography could add several thousands of dollars to the annual cost of the survey. (6,000 - 8,000, not including the needed air photo cameras and photo related equipment)

Scheme 4: Combined Open Frame and Aerial Observer Line Transect Samples

The next two schemes involve the use of the present open frame sample for obtaining an estimate of the area and yield of sugar cane growing outside of the major plaines areas. This estimate will then be combined with the other sampling scheme's estimate of sugar cane in the major plaines.

The line transect sampling methodology has been used in several natural resource surveys over the past 50 years. It can be effectively used on the ground, by aerial observers and with various forms of remote sensing imagery (primarily aerial photos). The least expensive way to sample large areas is by using the aerial observation technique. The sample results in an estimate of the percent area over the area sampled which is the crop being studied. An error statement can be developed for this percent using formula for the standard error of a binomial probability.

The steps for making the line transect sample are:

1. outline the areas you want to sample (major plaines, etc.) on 1:50,000 topographic maps and measure the area in hectares of each

2. next make the flight map to be followed by the pilot and observer. First, mark and measure the magnetic compass direction of the proposed flight lines for each plaine on the 1:50,000 topo. sheets at a spacing of 0.5 km apart, paralleling the longest dimension (length or width) of the plaine. To help the pilot in his navigation, the direction should be to the nearest whole 5 degrees (eg., 214 degrees would become 215 degrees)

3. note prominent land marks (road junctions, streams, etc.) which can be used to guide the pilot onto the flight lines

4. once the above have been done, the actual flying can be undertaken. The flight should be at about 1,500 to 3,500 feet AGL, with an airspeed of about 90 m.p.h. The exact elevation and airspeed choice is left for the observer to decide, based upon what gives him the best view of his flight line and allows him the time to accurately note the cane producing areas

5. during the flight the observer should put the topo. map covering the area being sampled (with the flight lines marked on it) in his lap and look out the side window of the aircraft and down as near vertical as possible. As the line is flown, he should keep track of his location on the topo. map and mark the start and ending of each cane field as it is crossed by the flight path

6. the total length of flight lines and the length of line covered crossing cane is then measured off the topo. maps. This is done in the office

7. next the percent area in cane for each plaine is calculated by dividing the total length of all the lines into the sum of the lengths for the cane. in that plaine. The error for this percent is then calculated using the binomial formula

8. the percent area and its error are converted to area units by multiplying the results in 7 by the total area of the plaine

9. yield estimates are obtained by multiplying the results of step 8 by Delatour's yield (per Ha.) for the particular region. A substitute for Delatour's data may be used if a better set becomes available

10. The combined open frame and line transect estimates are obtained by summation of the final results of the two samples.

To gain some understanding of the effort and cost involved to making a transect sample, the data below were developed. It was assumed from past experience that the spacing between flight lines and the flight speed cited above would result in a relatively low set of sample and non-sample errors. It was also assumed that all flights would originate and be completed in Port-au-Prince.

Site Area	Avg. Width (km)	Avg. Length (km)
Cul-de-Sac	14	28 (needs to be verified, may be less)
Leogane	12	12
Plaine des Cayes	15	16
Plaine du Nord	14	31 (needs to be verified, may be less)

Site Area	No. of Flight Lines	Km. Of Line
Cul-de-Sac	26	728
Leogane	22	264
Plaine des Cayes	28	448
Plain du Nord	26	806

Site Area	Flight Time (hrs)	Est. TT (hrs)
Cul-de-Sac	4.85	5.5
Leogane	1.76	2.75
Plaine des Cayes	2.99	5.00
Plaine du Nord	5.37	7.4
TOTAL		20.65

The cost of the flights for this sample is obtained by multiplying the expected total flight time by the hourly rate for the aircraft and pilot. One recently quoted rental for a Cessna 206 (high wing, single engine aircraft) with pilot was 150$ per hour. (Call Bruce 7-0919)

The combined estimate for the this sample and the open frame results would be derived by adding the totals of each scheme for area and yield. Again, there are some theoretical problems in obtaining the error statements for the combined estimates. I suggest simple addition in the absence of any more easily achievable, better way of obtaining these.

Note: Essentially the same technique could be employed by replacing the aerial observer transects with photo interpretation of the same transects drawn on air photo coverage (1978) of the area being studied. This can give reliable estimates if good quality, representative vertical aerial photography is available. If one has to pay for new photography, the cost for covering the major plaines areas would be several thousands of dollars (20,000$ +).

Scheme 5: Combined Open Frame and Aerial Photo Point Sample

The aerial photo point ample part of this scheme is based upon the same theory as the line transect sampling described above and results as did the line transect in a percent area for the crop being studied. However, the recording of a continuous line will now be replaced by observations of what is on the ground at a given set of points.

The point sample is taken as follows:

1. make a flight plan as outlined in steps 1 - 3 for the line transect sample.
2. fly the flight lines at an altitude to achieve a scale of 1:40,000 (depends upon camera focal length), using black and white panchromatic film and a minus blue filter. If such a filter isn't available, fly the photos at a 1:20,000 scale.

3. take a stereo triplet (60 percent forward overlap) every kilometer. This will require coordination between the photographer and the pilot to assure that the timing between photo sets is synchronized with the aircraft's ground speed.

4. make two time enlargements of the photos if the camera had a format of less than 9 in.

5. interpret all sets of photos and record if there was sugar cane at the principal point of the center photo of each stereo triplet.

6. the percent of area in sugar cane is then computed by dividing the number of points having cane by the total number of stereo triplets. As before, an error statement can be calculated using binomial theory.

7. the area and yield estimates are then obtained following steps 8 - 10 for the line transect sample.

The cost of this sampling scheme will depend upon several variables. The availability of a trained photographer, trained photo interpreters and camera and photo interpretation equipment (2 - 4 power stereo scopes). Assuming that all of these are available, ADS II can assign a cost for them. The cost of the interpretation could be considerable as there would be more than 2000 stereo triplets to collect data from.

Aside from this there will be the cost of the film and its processing. This will depend upon the film format used, but would require about 2,000 feet of 70 mm format film (20 rolls, each 100 ft. in length) or a total of 850 feet of 35 mm format film. Since the prices of purchase and developing change frequently on these, no estimate is given here other than to say that in total they will probably cost at least 1,000$ US. Another consideration is that this whole scheme shouldn't be considered unless good quality developing and enlarging can be done locally. My experience from having small batches of film processed in Port-au-Prince is that it can be.

Note: As in the last scheme, a series of points and sample could be observed on existing aerial photography, if there is a representative set available (1978 ?).

Scheme 6: A Satellite Survey

The use of multispectral scanners on satellite platforms to make crop surveys has become common with the advent of the LANDSAT and SPOT satellite systems. Such systems have several advantages. Among them is that the area estimates for crops can be automated when using the systems' computer compatible tapes (CCT's). However, making a sample survey with the CCT's assumes that you have or will contract with someone who has the computer, software, and trained personnel to do the survey from the computer imagery.

Some of these requirements can be avoided by requesting photographic imagery of the areas you want to survey. However, this will also require a skilled interpreter, a few pieces of equipment (eg., transfer scope) and will probably reduce the accuracy of the result by some unpredictable amount (accuracy will depend upon average garden size for the crop of interest and its contrast from the other species surrounding it). These samples (CCT's or photo. imagery) will also produce only an area estimate and additional fieldwork must be done if an error estimate is desired.

All of this aside, the base cost of CCT's or photographic imagery produced from them is shown below. This information is from the recent MARNDR briefing by SPOT representatives. A copy of the material used in this briefing is available in ADS II files (see Mark Maguire). It is assumed that it will require between 20 & 28 SPOT scenes to cover Haiti, depending upon the exact orbit path followed by the satellite. Further, for cost purposes it is assumed that 6 FF ="1$ US.

A. CCT

CCT's with standard corrections (product 1b) cost 10,300 FF (1,717$)
for a total cost before sampling of between 34,333$ and 48,067$ US.

B. 3 band CIR film positives (transparencies) at a scale of 1:200,000.

These are made from CCT's having standard corrections and cost 6,300 FF (1,050$) each
for a total cost before sampling of between 21,100 and 29,400$ US. Note: If the CCT's for any of these scenes haven't already been what is termed preprocessed, then the cost of having this done by SPOT's representatives will have to be added. No cost for this is cited.

The cost and problems associated with using this sampling scheme may seem great. However, they would become much less if there were other projects using the same tapes and sharing all of the costs. This has been the case in some other countries where several agencies have shared many of the basic costs while having the processing done for their particular interest.

Recommendations

Several potential sampling schemes have been presented so that alternative schemes will be available for consideration as the acceptability of a given scheme's accuracy, its cost effectiveness, and the survey staffing expertise change. If one had recent aerial photography, the accuracy of the area estimate from any of the first five schemes would probably be about the same. The accuracy of a satellite survey would probably be less because a large percent of small farms would be missed and there would be missed cane area where mixed crop (sugar cane growing with other crops) signatures would not be correctly recognized for what they were.

Another consideration in the factors which will determine the accuracy of the sampling scheme will be the timing of the survey overflights, aerial photography, or satellite acquisitions. One would want these obtained when the sugar cane to be harvested in that survey year is most visible. This isn't an easy thing to do because cane is cut over much of the year. However, to minimize the chances of cloud cover problems and to maximize the chances of observing newly planted cane, it is suggested that these be 6-8 months after each region's major rainy season.

However, assuming there is a modest budget available, I would suggest using either scheme 2, 3, or 4. Scheme 1 isn't practical at present. Scheme 5 (unless the 1978 photos are used) and scheme 6 are probably too expensive.

References

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