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RESUMO - NOTAS / ABSTRACT - NOTES

This work had the objective to develop a methodology for the control process of gevernmental loans for agriculture with the support of aerial photograhs. The study area, named Irecê region, is located in Bahia State and comprises the municipal areas of Irecê, Lapão, Gabriel, and João Dourado. For monitoring the proper use of agricultural loans provided by "Banco do Brasil S.A." (Bank of Brazil), aerial photographs were used in a first phase after the plowing or at crop emergence stage and in a second phase just before harvesting. Vertical aerial photographs were obtained in color prints at the scales of 1:30,000 and 1:15,000, respectively for the first and second phases of this work. The farms with granted loans were outlined over the aerial photographs using cadastral maps at the scales of 1:5,000 and 1:25,000. The aerial photographs obtained in the first phase of the work were used to assess the area of soil prepared for planting and it was possible to assess 92 percent of the farms of the farms of the study area of which 27.2 percent presented area reduction when compared to the area agreed to be olanted in the loan contract. For the second phase the aerial photographs were utilized, both to identify the crop and to evaluate the planted area in accordance with the loan contract. In this phase, 50 percent of the loan contracts were analyzed of which 27.7 percent were in irregular situatio in relation to planted crop or area reduction. From the aircraft mission to th delivery of results to the local branch of the Bank 15 and 20 days were spent, respectively, for the first and second phases of the work. This experience has shown that both technically and economically the loan control can be done operationally using aerial photography in the region of Irecê.

OBSERVAÇÕES / REMARKS

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AERIAL PHOTOGRAPHY AS AN AID FOR AGRICULTURAL CREDIT CONTROL

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ABSTRACT

This work had the objective to develop a methodology for the control process of governmental loans for agriculture with the support of aerial photographs. The study area, named Irecê region, is located in Bahia State and comprises the municipal areas of Irecê, Lapão, Gabriel, and João Dourado. For monitoring the proper use of agricultural loans provided by "Banco do Brasil S.A." (Bank of Brazil), aerial photographs were used in a first phase after the plowing or at crop emergence stage and in a second phase just before harvesting. Vertical aerial photographs were obtained in color prints at the scales of 1:30,000 and 1:15,000, respectively for the first and second phases of

this work. The farms with granted loans were outlined over the aerial photographs using cadastral maps at the scales of 1:5,000 and 1:25,000. The aerial photographs obtained in the first phase of the work were used to assess the area of soil prepared for planting and it was possible to assess 92 percent of the farms of the study area of which 27.2 percent presented area reduction when compared to the area agreed to be planted in the loan contract. For the second phase the aerial photographs were utilized, both to identify the crop and to evaluate the planted area in accordance with the loan contract. In this phase, 50 percent of the loan contracts were analyzed of which 27.7 percent were in irregular situation in relation to planted crop or area reduction. From the aircraft flight mission to the delivery of results to the local branch of the Bank 15 and 20 days were spent, respectively, for the first and second phases of the work. This experience has shown that both technically and economically the loan control can be done operationally using aerial photography in the region of Irecê.

INTRODUCTION

The "Banco do Brasil" Foundation which is a scientific research funding organization, has supported several research projects aiming at the development of methodologies for control of agricultural credit applications through remote sensing techniques.

Irecê is one of the most important region for the production of edible beans and castorbeans in the northeast of Brazil. The costs of planting and cultivation are primarily financed by the government through agricultural credits provided by the "Banco do Brasil" usually with interest rates lower than the market to stimulate agricultural production in less developed regions. This credit is not given at once and, therefore it is necessary an inspection after each provision of credit to ascertain the appropriateness of the application of the loan.

Normally, the Bank delivers the credit in three phases of the crop season: the first at the contract signature to cover plowing and planting costs; the second to cover cultivation practices; and the third one for harvesting and commercialization support. Before any successive delivery the bank has to verify whether the credit of previous delivery has been applied properly. Conventionally, the only way the bank has to do that is by visiting the farm and

visually assess the crop areal extent what in some instances is very hard to accomplish due to hard-to-access farms (rainy season / non paved roads), inability of the human eye to estimate areal extent in hard-to-see situation. Interview with the farmer not always help, especially in non-regular cases. In situation where there might be irregularities, the bank is left with the alternative of contracting a topographic field survey which is always quite expensive and time consuming.

Remote sensing has been widely used for crop identification, areal extent estimation, and crop growing condition assessment (Batista et al., 1987; Myers, 1983; MacDonald and Hall, 1978; and Rudorff et al. 1986a; among others). Considering that there is a great number of farms to be checked in a short period of time, it is natural that remote sensing technique be evaluated in order to provide timely, costly, and accurate information for the credit application control.

Due to the peculiarity of the land system (large number of small farms) and of the planting system (intercropping of beans, corn, and castorbeans), the use of current orbital imagery with the spatial resolution limited at the best at 20 m (as in the SPOT HRV multispectral data) and cloud cover problems which limit the timeliness of the information, it is necessary the use of aerial photography for the

operational control. The analysis of the aerial photographs must be very efficient in order to provide the information back to the Bank in time for the delivery of the second and third payments of the credit in the process of control.

MATERIAL AND METHODS

Study Area

The study area, Irecê region, is located in the north of Bahia state (Figure 1) and comprises the municipal areas of Irecê, João Dourado, Gabriel, and Lapão, with a total area of 3,800 km^2, approximately.

This is a very intensively cultivated region with the predominance of edible beans, corn, and castorbeans. The mean annual precipitation is 550 mm with a mean annual temperature of 22^{o}C and a semi-arid climate. November and December are the most rainy months. It is a flat region with eutrophic cambisols (soils with incipient B horizon, equivalent to Eutropepts in the US soil taxonomy) with medium to high fertility (ENCO, 1983).

List of Farms Surveyed

The Irecê Land Survey System Project I and II ("Projeto Fundiário Irecê I e II") was carried out through an agreement between the INTERBA and the Secretariat of Agriculture both from the State Government of Bahia, INCRA (agency responsible for the national land system cadaster), SUDENE (Northeast Development Agency), and the Inter-American Development Bank, under the Federal Government coordination. From this survey, 579 charts at 1:5,000 scale with the boundaries of all farms associated with names, code numbers, and areal extent were available.

From this basic information obtained at the local office of INTERBA, a list in alphabetical order was derived with the following information: name of the farmer, number of the farm, number of the chart (1:5,000) which contains the farm, and number of the parcel where the farm is located. The area was subdivided into 10 parcels as can be seen in Figure 2. Thus, the farm code is given by the parcel number followed by the farm number.

Identification of Farmers

The identification of farmers was done by the time they went to the Bank to fill out the proposals for agricultural

credit. This task start on August and ended on December 18th, 1985. To accomplish this task, the farmers were asked to clearly identify the farms in which they intended to plant on the alphabetic list or over the available maps with the help of a trained banking of the local branch.

Identification of Farms on the Cadastral Maps 1:25,000

In addition to maps at 1:5,000 scale, maps at 1:25,000 available from INTERBA, containing basically the farm's boundaries and codes, were used to provide a synoptic view of the farms which received credit from the Bank. This highlighted map would indicate the concentration of financed agriculture fields in order to plan the aerial survey. The analysis of this map revealed that the fields were so spread throughout the study area that complete aerial survey was indicated.

Definition of the Dates of the Aerial Surveys

It was established that the crops planted with government credit be surveyed before the delivery of the second parcel of credit (to cover cultivation practices) and before the third one (for harvesting and commercialization) according to the operational flow shown in Figure 3. For the

Irecê region, the Central Bank ("Banco Central do Brasil") which is responsible for the overall coordination of the governmental credit, has established that the planting insurance called "PROAGRO", required for credit approval, would cover only those crops which were planted before December 15, in case of loss due natural disaster (in most cases associated with drought). Therefore, the first aerial survey was planned to begin on December 16, 1985 and the second flight should begin on February 10, 1986, following the expected growing cycle. However, due to unusual climate conditions the Central Bank postponed the planting period until December 31, for the 1985/86 crop year. Thus, the first flight was carried out from January 1st to January 7th, 1986 and the second one from February 25th to March 10th, 1986.

Film Development and Aerial Photographs

The aerial photographs were obtained with standard color film (Kodak Aerocolor Negative 2445) in a metric camera (Wild RC-10) with a focus plane of 88 mm aboard of a Brazilian aircraft (EMB-110-B1/Bandeirante) from the Institute for Space Research (INPE). From the negatives, contact print copies were obtained in the format of 23 cm x 23 cm which were used for fotointerpretation. The film

development and the copies were made at the photo lab of INPE.

For the first flight the scale of 1:30,000 was used for the assessment of the planted area and for the second flight the 1:15,000 scale was used for crop identification and area estimation. The selection of the scale for crop identification was based on results of previous work (Rudorff et al. 1986a), especially designed for bean identification in the study region.

Figure 2 shows the area covered by the two aerial surveys. In the first flight, practically the entire area of study was covered whereas, in the second, only about half of the area of interest was flown because of very dense cloud cover that prevail during practically all the appropriate period for the second flight. The trials made to take the photographs under conditions of several layers of dense clouds fail because there was not enough sun light to sensitize adequately the film. In order to overcome this problem in future missions, a test was made in São José dos Campos, SP, INPE's Headquarters, simulating all the conditions existing at the second flight of Irecê. The objective of this test was to verify the possibility of increasing the sensitivity of the film by increasing the duration of the development time. Several photographs over the same test site were obtained with different exposure

time (t^{-1}) and therefore, attributing different effective aerial film speed (EAFS). The film (Aerocolor negative 2445) was processed with different developing time for the frames taken with different exposure time. Table 1 shows the several sensitivities attributed to the film and developing times, as well. These values could be used in future missions to define parameters of this film that could be used under conditions of low illumination what frequently occur when photographing outside standard conditions for aerial photography or under clouds. This situation occur quite often for agricultural targets especially when timely information is required.

It should be pointed out that the use of TM Landsat at 1:100,000 scale acquired on July, 1985 was very useful for flight navigation. This image shows the conspicuous targets on the ground which allows the accurate positioning of the aircraft over the planned flight lines.

Control of Agricultural Credit through Aerial Photography

Initially, the farm's boundaries and codes were outlined over the aerial photographs using the planimetric charts at 1:25,000 and 1:5,000 scales. Then, the photographs obtained in the first flight (1:30,000 scale) were visually interpreted for the identification of the areas of soil

prepared for planting whereas, the photographs obtained in the second flight (1:15,000 scale) were photointerpreted for the identification of the effectively planted crops. For details on the use of aerial photography for crop identification refer to Bomberger and Dill Jr. (1960).

To evaluate the areal extent of the crops, 1 mm and 2mm overlaying grids were utilized for the 1:30,000 and 1:15,000 aerial photographs, respectively. An error of ten percent in area estimation is allowed by the Bank. Results were transferred to a list with the names of the farmers and codes of the financed farms and delivered to the Bank on January 15, 1986 for the prepared soil information purposes and on March 15, 1986 for the crop effectively planted.

Finally, archives containing a list of farmers, all the photographs, and 1:25,000 and 1:5,000 charts were organized and made available to the local branch of "Banco do Brasil". These archives allow for a quick and accurate location of a farm and it is an important tool for field check whenever necessary.

Training of Bankings

A total of 18 bankings from the local branch of the Bank was trained regarding the methodology of the use of

aerial photography for agricultural credit control. The training involved the following topics:

-Identification of farms over the aerial photographs;
-Legend of the farmer's list archive;
-Photointerpretation of soil prepared for planting and crop identification considering several planting systems;
-Areal extent evaluation.

RESULTS AND DISCUSSION

A total of 2,173 contracts of agricultural credit were financed by Irecê's branch of "Banco do Brasil" for supporting planting in the crop year of 1985/86. In connection with those contracts, 2,503 farms were identified in the INTERBA's list. This number was greater than the number of contracts because some farmers have more than one property and the specific farm where he intended to plant, unfortunately, was not indicated. Only the contracts of beans, corn, castorbeans, or intercrops of beans and corn, beans and castorbeans, and all three crops planted in the same field i.e. beans, corn, and castorbeans were investigated in this work. Some of the castorbean fields

were eliminated from the inspection task because they were in the second year of production.

Finally, 1,886 contracts in 1,805 farms (one farm may hold more than one contract for planting in different fields) were identified for inspection. Table 2 shows the number of contracts and the area of each crop that were subject of funding from the local branch of the Bank. This table also shows the number of contracts that were inspected in both, the first phase (soil prepared for planting) and the second phase (crop effectively planted).

Results of the First Inspection - Survey of the Area of Soil Prepared for Planting

In the first inspection using the aerial photographs obtained during the first fortnight of January, the areas of soil prepared for planting were evaluated. A special list containing the farmers' names, the area financed, the area actually prepared for planting, and the number of the photograph which contains the investigated farms was delivered to the Bank as the result of this first phase of inspection.

The results of the first inspection are summarized in Table 3. The regularities or irregularities either in

absolute or relative terms are given in relation to the size of the financed area grouped into eight class intervals. A contract is considered in regular situation when the area prepared for planting is within at least 10 percent of the agreed area in the contract. It can be noticed that 27.2 percent of the total number of financing contracts are in irregular situation and that the majority of the contracts (85 percent approximately) are for small planting areas (equal to or smaller than 30 ha). In relative terms the irregularity increases with the increasing in the size of the financed area in other words, for those contracts with over 150 ha of financed area, 73.9 percent were in irregular situation as opposed to only 20.9 percent for contracts of 10 ha or smaller.

Results of the Second Inspection - Survey of the Crop Effectively Planted

The second inspection using aerial photographs obtained in the first fortnight of March had the objective of identifying and evaluating the areal extent of crops effectively planted according to the financing contracts. Some crop fields had been already harvested by the time of the second aerial survey, especially those of beans. Therefore, a field check was performed whenever there was doubt in the photointerpretation.

The results of this inspection are summarized in Table 4. The regularity and irregularity of the financing contracts are given for each crop category and classes of size. Similarly, it can be noticed that about 27 percent of the financing contracts were in irregular situation and that the trend of irregularity to increase with the size of the area persists.

SUMMARY AND CONCLUSIONS

A list of farmers as the one provided by INTERBA is essential for the successful application of remote sensing for the control of agricultural credit because it allows the precise location of farms. Even though the list used was not recent (it was elaborated in 1982/83) it was easily updated during the contract interviews.

The outlining of boundaries of the farms was obtained from the planimetric charts at 1:5,000 and 1:25,000 scales.

The aerial color photographs (1:30,000 scale) were perfectly adequate for the identification and areal extent estimation of soil prepared for planting. However, the 1:15,000 scale for the identification and areal extent

estimation of crops effectively planted were adequate only for those crops which were in good vegetative conditions covering almost completely the soil; therefore, requiring additional field work to obtain reliable information.

The dates of the second flight were not adequate to identify some of the crops because they were in harvesting stage.

In the second phase of the inspection, it was not possible to obtain aerial photographs for the entire area of interest (only 50 percent) because of low luminosity due to dense layers of clouds which prevailed during the indicated period for photograph acquisition.

The method of inspection using aerial photography is quite simple and was easily assimilated by the bankings of the local branch of "Banco do Brasil" with one week of training.

It was possible to meet the planned schedule for the delivery of results of the two inspections using a team of 7 people, not including the aircraft crew, during 30 days of work.

From the total number of inspected contracts, about 27 percent were in irregular situation in both the first and second phases of the inspection.

From this experience it may be concluded that remote sensing technique is effectively useful for the control of agricultural credit for the region of Irecê, Bahia and that aerial photography has great potential of utilization whenever the situation is serious enough to justify the investment in spite of limitations that might occur for the actual acquisition of data. The methodology used in this work provided acceptable accurate results even though no geometric corrections of raw photographs were done.

FINAL REMARKS

The control of agricultural credit in regions where the predominant farm size is very small (smaller than 10 ha) is not an easy task, especially when a great number of contracts have to be verified in a short period of time. The experience obtained in this work indicated that aerial photography can be used to successfully accomplish this task. The uses of the photographs are not just to furnish the characterization and accurate areal extent estimation of crops but they also show the growing conditions of a field

pointing out spots of non germination or poor growth and the best accessing routes to the fields.

The major limitation of this technique is the acquisition of data at appropriate time especially due to rains and clouds bellow flight altitude. Therefore, it is essential a good communication link between the local branch of the Bank and the aircraft crew in order to take advantage of any flight opportunity. Also, the increasing in exposure and development time during low illumination conditions for aerial photography should be tryed following the results of tests reported in the Material and Methods section of this paper.

The areal extent estimation which is hard to accomplish in the field can be easily estimated from the aerial photographs. However, there is a limitation concerning the interpretation of crops with low vegetative development and therefore not detectable on the photographs. To overcome this problem, field work is necessary and it is important that the data be obtained in a period that the majority of the crops is covering most of the soil to minimize field check. Even though the end of planting date is fixed by the Central Bank, the crop calender is quite flexible in this region and therefore it is difficult to establish a specific flight period that enables a reliable identification of all crops. From this experience, it seems sufficient that only

one flight when the majority of the crops are between the vegetative and grain filling stages be carried out. The aerial photographs obtained in this flight would allow the areal extent estimation of all crop fields and the crop identification of the fields which had a poor vegetative development would be accomplished by field work. This certainly would result in a decrease in cost of the credit control.

At the end of this experiment a detailed cost analysis was conducted. The costs of inspection per farm (assuming that 2,000 farms were inspected) and per hectare (40,000 ha were financed in the 1985/86 crop year) were investigated. The cost of the control using this methodology corresponded to 3.0 percent of the total investment made by the Bank in the Irecê region in the agricultural credit for the 1985/86 crop year. To perform the inspection in only one phase the cost would be about 1.7 percent of the investment. A detailed description of this cost analysis can be found in Rudorff et al. 1986b.

For most of the Northeast region of Brazil there is a graphical cadaster of the farms available which is essential for the delineation of the farm's boundaries over the aerial photographs. For those regions where this cadaster is not available, it is necessary an additional task which is described in Batista et al. 1984.

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CAPTIONS

TABLE 1

Speed of the developing machine 1811 (INPE's Lab) for different effective aerial film speed of the Aerocolor negative film 2445

TABLE 2

Number and area of the contracts financed by the Bank and inspected through aerial photography for each crop system

TABLE 3

Summary of the first inspection (area prepared for planting) showing the absolute and relative numbers of regular and irregular contracts for eight class intervals of financed area

TABLE 4

Summary of the second inspection (crop effectively planted) showing the number of regular (R) and irregular (I) contracts for each crop system and eight class intervals of financed area

FIGURE 1

Location of the study area - Irecê Region

FIGURE 2

Subdivision of the study area into parcels and the coverage of the first and second aerial surveys

FIGURE 3

Operational flux of the agricultural credit control using aerial photography

TABLE 1

EAFS	t^{-1}	SPEED OF 1811 DEVELOPER (ft/min)
50*	140	5.4**
75	200	4.4
100	240	3.4
150	340	2.4

EAFS = Effective Aerial Film Speed;
t^{-1} = Exposure time of the RC-10 camera;
* = Standard sensitivity of the Aerocolor negative film 2445;
** = Standard speed of the 1811 processor to develop the 2445 film.

TABLE 2

CROP	FINANCING CONTRACTS		No. OF INSPECTED CONTRACTS			
			1ST INSPECTION		2ND INSPECTION	
	No. OF CONTRACTS	AREA (ha)	No. OF CONTRACTS	AREA (ha)	No. OF CONTRACTS	AREA (ha)
BEANS	126	5,651	119	5,550	75	2,965
CORN	66	2,418	59	2,217	32	1,531
CASTORBEANS	99	2,427	90	2,160	28	735
BEANS & CORN	323	8,517	302	8,033	161	4,581
BEANS & CASTORBEANS	490	12,262	468	11,717	276	7,193
BEANS, CORN, & CASTORBEANS	782	8,794	701	8,046	362	4,372
TOTAL	1,886	40,069	1,739	37,824	934	21,377

TABLE 3

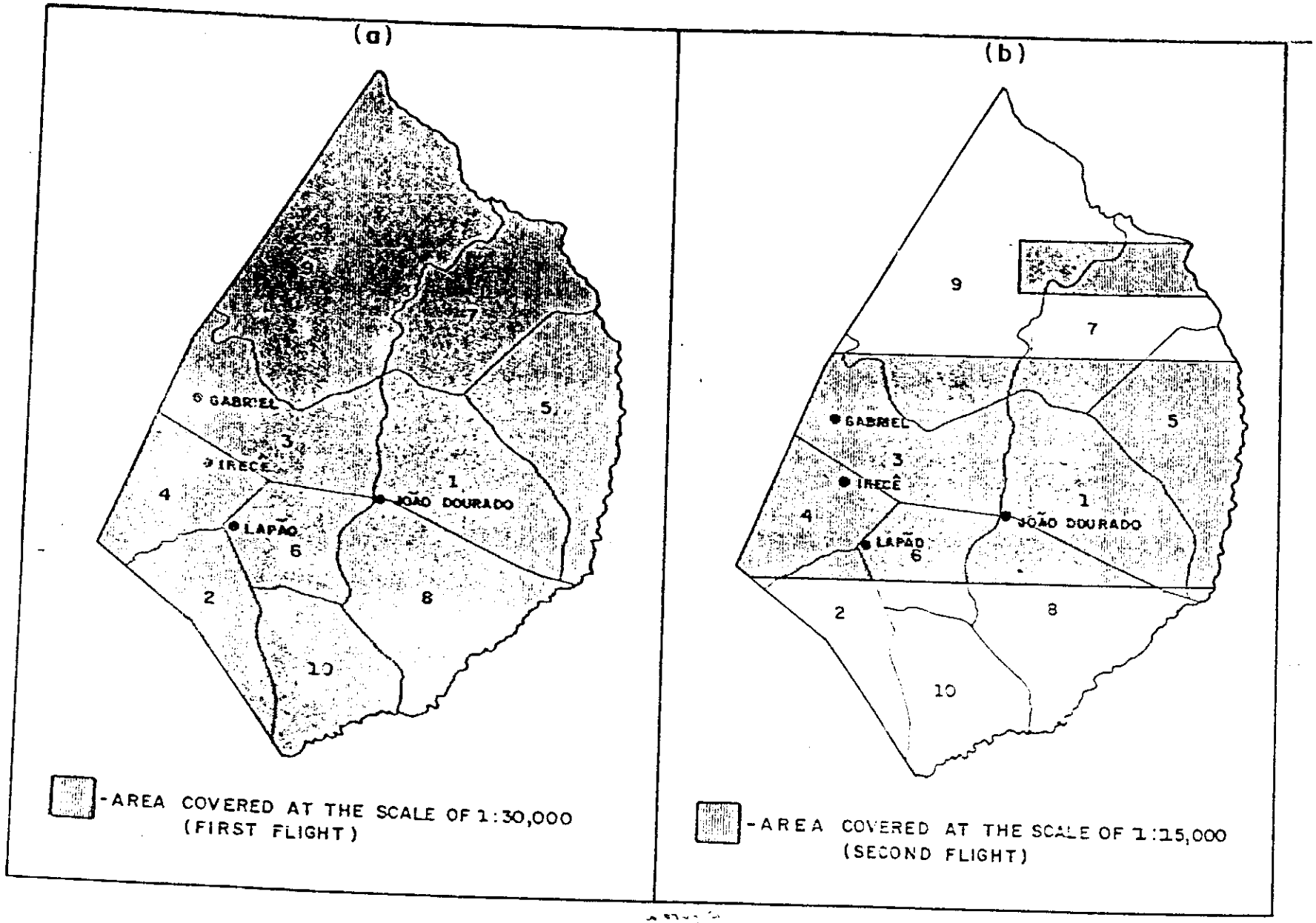
CLASS INTERVAL (ha)	ABSOLUTE		RELATIVE (%)	
	REGULAR (A)	IRREGULAR (B)	REGULAR (A/A*B)*100	IRREGULAR (B/A*B)*100
0-10	685	181	79.1	20.9
10-20	273	107	71.8	28.2
20-30	152	61	71.4	28.6
30-40	30	29	56.7	43.3
40-50	33	23	58.9	41.1
50-100	65	40	61.9	38.1
100-150	14	15	48.3	51.7
> 150	6	17	26.1	73.9
TOTAL	1.266	473	72.8	27.2

TABLE 4

CLASS INTERVAL (ha)	BEANS		CORN		CASTORB.		BEANS & CORN		BEANS & CASTORB.		BEAN,CORN & CASTORB.		TOTAL			
													ABSOLUTE		RELATIVE (%)	
	R	I	R	I	R	I	R	I	R	I	R	I	R	I	(A/A*B)*100 Reg.	(B/A*B)*100 Irreg.
0-10	11	5	8	8	9	4	33	12	95	9	185	47	341	85	80.1	20.0
10-20	9	6	1	1	5	2	38	11	41	16	53	23	147	59	71.4	28.6
20-30	6	4	3	3	2	1	20	9	35	13	23	11	89	41	68.5	31.5
30-40	7	1	1	1	2	0	7	4	7	5	6	1	30	12	71.4	28.6
40-50	4	2	0	2	1	0	6	1	10	3	4	3	25	11	69.4	30.6
50-100	6	9	0	1	1	0	7	5	18	15	4	1	26	31	53.7	42.3
100-150	1	1	0	2	0	0	2	3	2	4	0	0	5	10	33.3	66.7
) 150	1	2	1	0	1	1	1	2	2	1	0	1	6	7	46.2	53.9
TOTAL ABSOL.	45	30	14	18	21	8	114	47	210	66	275	87	679	256		
TOTAL REL(%)	60.0	40.0	43.8	56.3	72.4	27.6	70.8	29.2	76.1	23.9	76.0	24.0			72.6	27.4


BRAZIL
PIAUÍ
10°
IRECÊ
BAHIA
SÃO FRANCISCO RIVER
GOIÁS
SALVADOR
13°
45°
MINAS GERAIS
37°30'
ATLANTIC OCEAN
42°00'
41°30
11°00'
GABRIEL
IRECÊ
BA-052
LAPÃO
JOÃO DOURADO
JACARÉ RIVER
11°30'
BA-433

FIGURE 1


(a)
GABRIEL
IRECÊ
LAPÃO
JOÃO DOURADO
1
2
3
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10
-AREA COVERED AT THE SCALE OF 1:30,000
(FIRST FLIGHT)
(b)
GABRIEL
IRECÊ
LAPÃO
JOÃO DOURADO
1
2
3
4
5
6
7
8
9
10
-AREA COVERED AT THE SCALE OF 1:15,000
(SECOND FLIGHT)

FIGURE 2

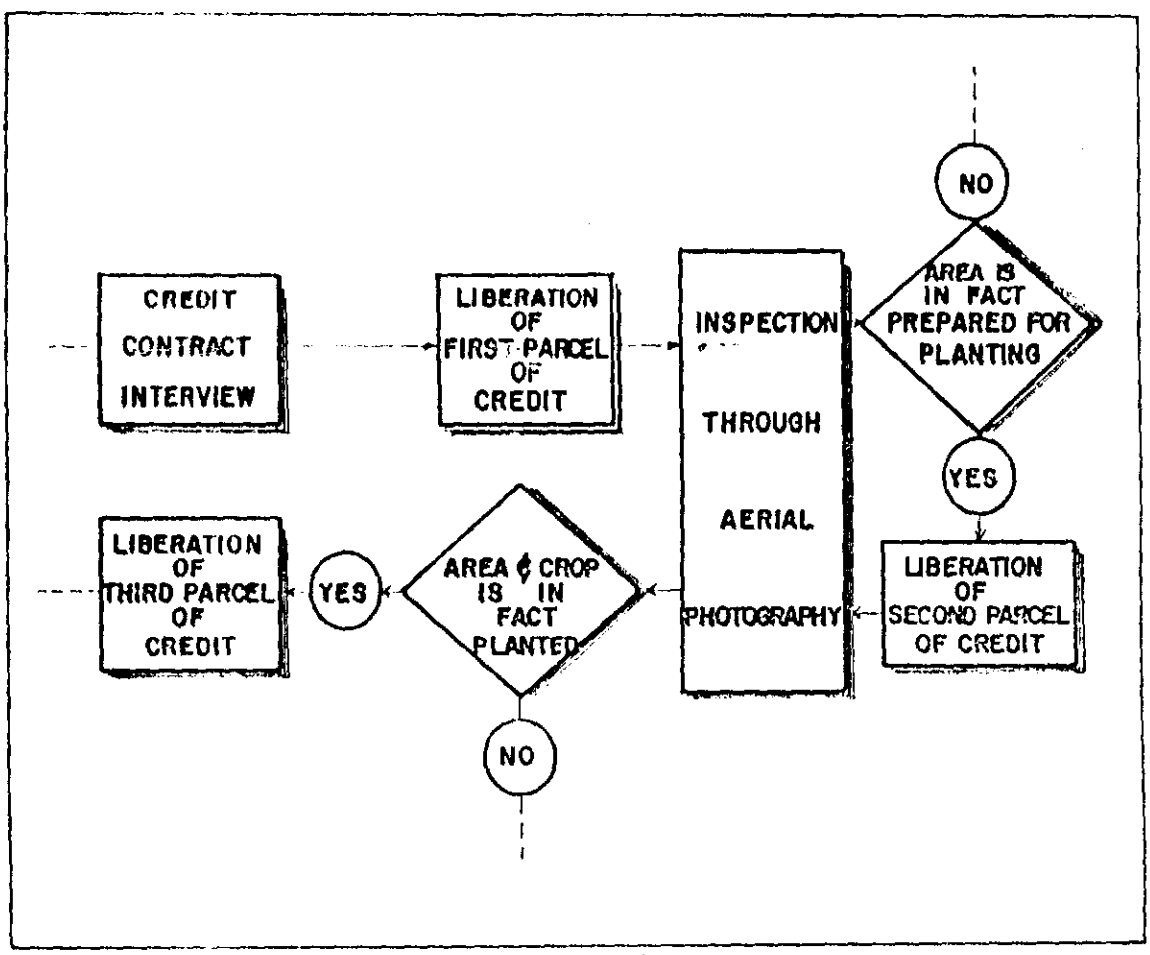
CREDIT CONTRACT INTERVIEW
LIBERATION OF FIRST PARCEL OF CREDIT
INSPECTION THROUGH AERIAL PHOTOGRAPHY
AREA IS IN FACT PREPARED FOR PLANTING
NO
YES
LIBERATION OF SECOND PARCEL OF CREDIT
AREA & CROP IS IN FACT PLANTED
YES
LIBERATION OF THIRD PARCEL OF CREDIT
NO

FIGURE 3