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EVALUATION REPORT

SUDAN CROP PRODUCTION ESTIMATES BASED ON LANDSAT MSS AND TM DATA

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LIST OF ACRONYMS

AVHRR	Advanced Very High Resolution Radiometer; a multispectral scanner on NOAA weather satellites with IFOV of one square kilometer directly under the satellite at the highest sampled rate.
CCT	Computer Compatible Tapes
ERIM	Environmental Research Institute of Michigan
FAS / USDA	Foreign Agriculture Service United States Department of Agriculture
FCC	False color composite, an image that looks like a color infrared photograph
GOS	Government of Sudan
HDT	High Density Tape
I^2S	International Imaging System, California Corp
MOA	Ministry of Agriculture
MSS	Multi-Spectral Scanner; a 59 by 79 meter resolution 4 band scanner on Landsats 1, 2, 3, 4 and 5
TM	Thematic Mapper; a 30-meter resolution, 7 band multispectral scanner on Landsat 4 and 5

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GLOSSARY OF TERMS

Cluster (spectral)
A group of picture elements (pixels) that have similar spectral signatures

Data
A collection of tables, estimates, figures or numbers either on tape, or paper. These data may or may not be useful for decision-making.

Digital data
Data from a satellite that is on a computer compatible tape (CCT)

Information
Data that can be used for decision making. The data are accurate, timely, objective, comprehensive, replicable, etc. In any case, decision makers can make decisions based on something they know - this knowledge is information.

Landsat
A series of five satellites that were launched starting in July 1972 for the purpose of Earth resource observations

Pixel
A picture element or resolution element

Resolution
The instantaeneous field of view (IFOV) or the smallest area of ground for which a sensor can measure reflected and emitted electromagnetic radiation

Spectral signature
The reflected and emitted energy from an object. The values of energy stored on the CCT's for each band

Subscene
A portion of a full satellite scene. The FAS divided the MSS images into nine approximately equal subscenes

Supervised classification
A process whereby a sample of pixels from known categories is used to set up rules to allot unknown pixels to categories by using spectral signatures of pixels

Unsupervised classification
A mechanical process of searching through data and grouping the pixels that have similar spectral signatures regardless of their location in the scene

EXECUTIVE SUMMARY

TO BE COMPLETED AFTER THE MAIN PARTS ARE WRITTEN

I. INTRODUCTION

On February 4, 1986 Price, Williams and Associates were requested to evaluate the methodology and crop estimates for Sudan that were obtained using remote sensing from ERIM in the West and from FAS/USDA in the East. It was agreed that this task would include several steps:

1. An accurate description of exactly how estimates were obtained for the eastern section by FAS/USDA and for the western section by ERIM,

2. an appraisal of the methodology used by the different contractors which resulted in estimates of harvested acres,

3. an appraisal of the area and yield estimates themselves,

4. A review of the NOAA yield procedures as they apply to the Sudan for this report, and generally for the rest of the FEWS countries.

II. DESCRIPTION OF FAS PROCEDURES

A. Objective

The objective of FAS/USDA work in the Sudan was to estimate planted sorghum/millet in eastern Sudan - east of the White Nile between 11 degrees and 16 degrees north latitude and the Ethiopian border. This acreage estimate was to be made using Landsat MSS computer compatible Tapes (CCT) and the I2S hardware /software system.

B. Data

1. Landsat MSS Data

Data was collected for 12 full pixel MSS scenes in High Density Tapes (HDT). Some areas are in the overlap areas of the scenes and covered twice. Figure 2.1 illustrates this point.

Figure 2.1

MSS scene areas of coverage in Eastern Sudan

The east-west sidelap is about 12 to 15 % of the scenes from 10 to 15 degrees North Latitude and the north -south overlap is about 5 %. When data are acquired, a strip of data is taken from north to south but during processing it is divided into scenes approximately 100 nautical miles or 113 statue miles long. In making scenes the last few lines of the previous scene are duplicated. This causes an overlap area both north south and east west.

2. Ground Data

Two FAS/USDA employees and six Sudanese nationals collected ground data in Sudan over a nine day period. Seven of those days were spent in the field flying various routes and hiring trucks at airfields to go see crops and talk to local farmers. The schedule of events in Sudan was as follows:

Nov. 15, 1985	Arrived in Khartoum
Nov. 16, 1985	Discussed project with mission
Nov. 17, 1985	Chartered two airplanes for field work
Nov. 18, 1985	Left Khartoum for Damazin in two planes. The first plane flew down between the Blue and the White Nile to the same latitude as Kosti and then took a straight course to Damazin. The second plane flew to Wad Madani straight south to the latitude of Damazin and then into Damazin. Took trucks to the Epyptian-Sudan joint venture farms. Three trucks were available for this exercise.
Nov. 19, 1985	Left Damazin and flew west to Rank, north to Kosti and refueled. Then flew back to Damazin. Had lunch in Kosti, then first plane flew east toward Ethiopia and in a heart shape flew south and back to Damazin. Second group took trucks to visit scheme management around Damazin.
Nov. 20, 1985	Left Damazin in two planes, one headed north along the Ethiopian border over El Gedaref and back to Sim Sim Scheme. The other flew over Singa and then looped east to the Sim Sim Scheme. Some of the flight was only 1500 feet off the ground. Some of the crew talked to the Scheme administration while on the ground.
Nov. 21, 1985	Flew another heart shaped flight in two planes and landed at El Gedaref. Trucks were there, drove to talk to the scheme management.
Nov. 22, 1985	Left El Gedaref for Wad Madani then straight North to the same latitude as Khartoum and then West into Khartoum. Spent two days in Khartoum.
Nov. 24, 1985	Left Khartoum for Kassala and returned. Most of the trip was over desert.
Nov. 25, 1985	Took trucks to Wad Madani and returned. (16 hour day)
Nov. 26, 1985	Talked to USAID Mission, return to Washington.

Figure 2.2 shows the flight paths for each day.

Figure 2.2

Map showing flight paths for each day in the field

C. Analysis

1. FAS Data Handling

The I^2S monitor can hold 512 by 512 picture elements (pixels) and this is called a subscene. The full MSS scene was subdivided into nine subscenes and each was sampled in one of the following ways: every fifth column and every fifth row; every second column and every second row; or in some cases, every pixel was used. These pixels were then reconstructed to make a subscene for analysis. These subscenes were then studied to estimate the percentage of sorghum/millet on the subscene. Figure 2.3 shows this procedure for the 5 by 5 sampled subscene procedure listed above.

Figure 2.3

Full Pixel Image Mapped Into a Subscene

Analysis of each subscene was then started by using the I^2S clustering algorithm, a nearest neighbor procedure, that is provided with the system. FAS analysts usually utilized three bands (1, 2 and 4) and the nearest neighbor clustering algorithm that groups pixels into similar spectral classes after placing pixels in 3-space. Figure 2.4 shows the clustering algorithm and how the procedure is employed in two space.

Figure 2.4

Nearest Neighbor Clustering Algorithm

There is a maximun of 40 clusters that can be constructed using this clustering analysis. Data in each subscene are divided into groups of pixels with similar spectral reflectances or values in all three bands even though pixels may be from different parts of the scene.

Once the pixels in the subscene are grouped into spectrally similar groups - that is, groups of pixels which have similar reflectances - then the spectral classes are given colors and combined so that the scene looks reasonable to the analyst. For example, subscene 1 might have four fields that contain 40 pixels each. The analyst puts the cursor on a pixel in a field and makes that pixel and all the pixels in its spectral cluster one color, say yellow. The field may now have 9 pixels that are yellow; that is, there were eight other pixels in the field that were in the same class as the identified pixel and perhaps 50 other pixels outside the field. Next, the analyst moves the cursor to another pixel in the field that is not colored yellow and colors this pixel and all other pixels in its spectral class yellow as well. Thirteen more pixels might turn yellow in the field and a larger group of pixels across the entire scene would turn yellow. Now 22 pixels are yellow in the field but 18 pixels within the boundaries of this field are still not colored. The analyst continues through the field, coloring uncolored pixels yellow and simultaneously changing all other pixels in the MSS scenes in these same spectral classes yellow. He would then proceed to the next field, if necessary, and continue labeling pixels yellow. The analyst does this best when he has visited the field and knows that certain fields are sorghum. Logically, it is assumed that the pixels in analyzed sorghum fields will be similar to pixels in other sorghum fields in the area. When all pixels within the boundaries of a field are yellow, then the analyst might look at the subscene and realize that there are "too many" yellow pixels. At this point, he is able to remove pixel groups from the yellow category by putting the cursor on an individual pixel and decoloring it and all those pixels in the same spectral cluster.

When the analyst colors the scene the way he/she likes it, this phase of the analysis ends. The analysis is completed by

requesting that the computer first count all pixels labeled yellow and then calculates the percentage of pixels of this color to the total pixels in the subscene by dividing the total number of pixels in the subscene into the total number of pixels labeled sorghum (yellow). The analysis for one subscene can take as little as 30 minutes if the the anayyst feels data are correct and much longer than 30 minutes if he feels that there are problems.

The same procedure is completed for each subscene on the MSS image and for the rest of the 12 MSS scenes. Some parts of the MSS scenes are left out of the analysis if the analyst feels that there is little or no sorghum present.

Because of the way the Landsat images are framed, there are areas of land that are in two images. FAS has not determined a way to mosaic Landsat images so instead of using pixel counting techniques, they estimate percentages of each subscene identified as a particular category (sorghum) and then use an arithmetic average of the percentages applying this percentage to the entire area of interest. The estimates that were obtained using this technique seemed too high to the analysts so estimates were reduced by 25% to get the present estimates of 14,371,000 acres of sorghum/millet planted in Eastern Sudan in 1985. The 14,371,000 acres obtained were multiplied by the GOS MOA Statistics Division estimates for yields to obtain a total production figure of 4.57 million (M) metric tons - the largest estimates ever and half again larger than the 3.1 M metric ton estimate in 1981.

III. DESCRIPTION OF THE ERIM PROCEDURES

A. Objective

The objective of the ERIM work was to estimate planted sorghum/millet in western Sudan - between the White Nile and the Chad border and 10 and 15 degrees North Latitude. This acreage (feddan) estimate was to be made using Landsat Thematic Mapper (TM) Data with a completion date of Mid-December.

B. Data

1. Landsat TM Data

TM data were collected for 27 full pixel Landsat scenes on standard EOSAT format. Figure 3.1 from the ERIM report lists the coverage of TM products. Although TM CCTs were obtained, ERIM decided to use False Color Composite (FCC) photographic like image products with photo interpretation (PI) techniques to estimate the area planted to sorghum/millet. The standard products used were 1:250,000 and 1:100,000 scale FCCs. These products were not available until after field trips to Sudan were completed.

2. Ground Data

ERIM employees spent three weeks in Sudan organizing and collecting ground data. Two field teams, each consisting of two ERIM employees and two Sudanese Nationals worked in Sudan for this period. The first week was spent in Khartoum selecting field sites, planning aircraft missions and ground support, and hiring ground personnel. The last two weeks were spent in the field collecting data in western Sudan from 118 ground sites marked in figure 3.2. Both fixed wing aircraft and helicopters were used for this mission.

These 118 field sites were subjectively selected to provide a variety of ground crops and situations for training and calibrating photo interpreters. Ground sites were selected to provide ground information across the entire western Sudan area of interest. They were selected before Landsat imagery was available so ground site selection was not integrated into the Landsat imagery analysis.

At ground data landing sites, farmers often gathered around the aircraft. When this happened, farmers were asked to report yields for harvested fields that year that could be seen from the landing site. This yield data was collected by farmer recall methodology and was requested for specific fields which belonged to farmers close to the landing site. Neighbors were not asked about the yields of fields of others. Since field site selection was subjective, crews landed only where there were things to observe.

Figure 3.2

Map showing 118 field sites

C. Analysis

1. Sampling Frame and Sample Selection

After observing the imagery, a two-layer stratification was carried out with the first layer being Districts within Provinces. Within Districts, a second layer of stratification was set up using land use strata taking into account landforms, variability of soils and cropping conditions. This stratification was done on a piece of mylar that was placed over the 1:250,000 TM scenes. FCCs were mosaiced to cover the entire area of interest. There were six possible land use strata within Districts as shown below:

1. Randomly Distributed Traditional Agriculture describes agriculture that is spread somewhat evenly across the area.

2. Clumped Traditional Agriculture describes agriculture that is clumped together rather than spread evenly across an area. There are areas of non-agriculture but when agriculture is located, fields of crops will be close together.

3. Mechanized Clumped Agriculture for fields spread across land but prepared by tractors. Fields from this stratum were larger than fields in traditional areas.

4. Wadi or Stream Bed Agriculture for areas following the stream.

5. Irrigated Land in intensively and diversely cropped areas.

6. Non-agricultural Land where no agriculture can be viewed on Landsat images.

Not all Districts had all six strata, only those land use categories which could be identified on imagery were marked. The non-agriculture strata were not sampled in any District. In the first three strata, samples were drawn using a large grid of 2 square centimeters representing 5 by 5 kilometer squares on the ground. This grid was overlaid onto the 1:250,000 FCC images. Squares were numbered from 1 to N, the total number of samples in each stratum, and 10 to 20 sample squares were selected at random, approximately equal to 10% of the total stratum cells. The wadi and the irrigated strata were not statistically sampled. In wadi strata, sample squares were selected in a subjective way on the 1:250,000 FCCs and estimates were generated of total sorghum/millet within the Wadi strata by multiplying the total number of squares in the strata by the average percentage of sorghum in the sample squares.

$2\ cm^2 \approx 25\ km^2$

D. Sample Enumeration

In the Irrigated strata, the total areas were photo interpreted square by square to decide whether or not the

$\frac{2\ cm^2}{25\ km^2 \times \frac{(10^5\ cm)^2}{km^2} \times \frac{(10^2\ cm)^2}{m^2}} = \frac{2\ cm^2}{25 \times 10^{10}} = \frac{1}{12 \times 10^{10}}$ $\frac{1.4\ cm}{5 \times 10^5\ cm} = \frac{1}{400,000}$

vegetation was sorghum/millet or not. In most cases, everything that reflected EMR like vegetation was called sorghum/millet. A grid was laid on the 1:250,000 scale images. Each square with half or more vegetation was counted as totally sorghum. Each square with less than half was counted as not having any sorghum.

Once the sample squares were selected, 1:100,000 scale enlargements were made of the selected areas and a "small" grid was placed on the 5 by 5 kilometer sampled squares. The sample square was transfered onto the 1:100,000 scale map as accurately as possible without scientific procedures to register the image. The small grid then divided this sampled plot into 4 hectare squares (200 meters by 200 meters on the ground) that were photo interpreted to determine whether or not the square contained half or more vegetation.

Although it was known that different crops were also grown in the area, most vegetation could not be separated visually. The possible crops which could have caused confusion were ground nuts, sudan grass, watermelons, sesame, garden vegetables and mixtured crops.

Estimates of the total amount of sorghum/millet were calculated on a stratum by stratum basis by multiplying the total number of squares in the stratum by the average amount of sorghum/millet in the sample. The estimate of sorgum/millet in Western Sudan was obtained by adding strata estimates. Variances were not calculated using this methodology.

III. CRITERIA OF A GOOD AGRICULTURAL INFORMATION SYSTEM

To support decision-making by planners, an information system must have certain characteristics. Criteria used to evaluate an information system are listed below and the description of how both FAS/USDA and ERIM systems support the criteria are stated in Section IV.

- Accuracy

Survey errors are of two types, sampling errors and non-sampling errors. Non-sampling errors are the most important and result from lack of an adequate sampling frame, poor data collection procedures, and improper data handling. Once non-sampling errors are controlled, then sampling errors are computed to establish accuracy.

- Timeliness

Timeliness refers to the length of time required from the beginning of data collection to when the data is available to the users. A system that can assess and supply reports of a changing situation within weeks after the change is better than one that takes months or years. Agriculture is demanding since it is dynamic; the situation can change drastically in a short time. Decisions that affect the food supply are crucial to the stability of a government.

- Objectivity

An objective procedure produces data that do not depend on a person or group's point of view. In statistical terms, sampling errors and nonsampling errors are known and can be stated, and estimates of target values follow the laws of probability. An objective procedure is absolutely essential if the data are to have credibility with the user community and solid methodology is what creates objectivity and establishes credibility.

- Comprehensiveness

An agricultural information system must provide data on all aspects of the agricultural sector to support decision making. Knowing planted crop area without knowing harvested areas and yields will not support decision-making about total food production. Likewise, certain foods can be substituted for others, so having information about one crop may not be sufficient to evaluate food policy alternatives or establish food aid requirements. It is equally important to have statistics at all levels of administrative planning. For example, National data, Provincial data, and District data are needed if these levels are designed into the system. Data may be needed to not only to obtain supply side data but demand side data as well.

- Expandable

An expandable information system can have new technologies and requirements incorporated into it without massive costs. For example, can yield data be added to the information system or multiple frame methods be introduced without massive revision of methodology.

- Replicability

Surveys run at different times should reflect changes in the target population rather than changes in the sample or methodology. Value and utility of statistical data increase when

current and past results can be compared. Statistical control procedures must be utilized to effectively ensure replicability of the survey results.

- Cost-effectiveness

An information system must compete with other information systems cost wise. Thus if two survey methods produce identical information, but one can be implemented with less cost, then it is more cost-effective. By being careful in the set-up, the operational costs are reduced.

Some of these criteria above obviously look beyond the scope of this evaluation. However, some of these items must be considered even on a narrow evaluation such as this. Accuracy and objectivity are what this evaluation is really about. The other criteria are less important even though for the future design though they too might be important.

IV. METHODOLOGY AND ESTIMATION EVALUATION

A. General

The criteria listed above are general criteria for evaluating any information system rather than evaluating a specific system in Sudan, nevertheless; data without these attributes are not useful for decision-making and therefore should not be considered information. Since USAID needs to make decisions about food aid, a perfect opportunity exists for decision makers to ask if these data are useful information.

Another point is that both supply and demand side information are needed for making food aid decisions. Data must be comprehensive. Certainly the demand side is in great flux. Political refugees are pouring into Sudan from Ethiopia, Uganda and Chad. Refugee influx is so dynamic that it is difficult to know refugee counts. Demand side grain needs are a function of total population, seed requirements and feed requirements. If information about deficit grain is needed, then reasonable estimates are required on major aspects of the food deficit equation. Supply side grain is a function of production (area and yield), harvest and post harvest loss (15 to 22%), grain stored, grain smuggled into Sudan, grain smuggled out of Sudan. equation.

Everyone agrees that more time was needed to set up an information system than was allowed for the exercise in Sudan. But, a useful question for consideration is whether or not additional time would have made a difference in the methodology and in the estimates.

B. Evaluation of FAS Methodology

- Accuracy

As far as accuracy assessment is concerned, FAS methodology does not support estimating survey errors. Certainly, non-sampling errors dominate the total survey errors. The methodology of classifying all vegetation as sorghum/millet supports the idea that the estimates are too high. As far as procedures, there was no selection based on probabilities, no expansions to totals, and no specific methodology that would justify computing sampling errors. Non-sampling errors are produced in the estimation process in several specific ways, the largest being a classification bias with no built-in means of error assessment or correction.

- Objectivity

The FAS estimates are subjective in that they definitely depend on the analyst's point of view. To make this point clearer: After the estimates were completed, the analysts judged them too high and reduced the estimates for sorghum/millet by 25 %. Although the tools used to make the estimates were

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objective, the methods used were not and depended on the individuals doing the work. They used sophisticated tools and electronic equipment to enhance their judgement.

- Cost-effectiveness

The cost of an information system and its effectiveness must be compared with alternative systems. Unfortunately there are few alternative systems operating that are able to obtain planted area of specific crops in the Sudan. The cost of 12 MSS Landsat scenes used was approximately 12 @ $ 1100 or $ 13,200. This criteria is not useful at this time.

- Timeliness

The data were timely. Reports were available to the user in time and shortly after the raw data were acquired.

- Comprehensiveness

The estimates provided to Sudan are not comprehensive. No additional estimates were made available except a sorghum/millet mixture. In fact, there are many crops grown in eastern Sudan but none could be separated using the methodology established by FAS.

- Replicability

The FAS procedure is not replicable. It is too subjective to be replicable when an analyst manipulates colors representing crops to get them to "look right". One way to answer this question is to sit down with the analyst and ask him to repeat an analysis for one MSS scene (9 subscenes). If the answer obtained is the same each time, then the analysis is somewhat replicable. Another question would be to have a second person do the same analysis and compare results. These two exercises can be done easily.

C. Evaluation of FAS Estimates

I have been critical of the methodology used by FAS in the previous section. In my opinion, clustering algorithms do not effectively use spectral data in an effective way to differentiate between spectral groups. On a personal note, the FAS personnel are sincere, honest, genuine and energetic people trying to do good work on this topic. They are excited to be involved in such an important project. Their task at USDA is to produce qualitative judgements rather than to supply quantitative estimates of crop acreage.

As I stated in the previous section, dominate the FAS methodology and the total system is subjective. It is difficult to assess accuracy of the estimates produced subjectively. Nevertheless, USAID has asked that this be done.

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It is very obvious to most persons that the 1985 crop year was good compared to previous years. As a matter of fact, one can observe from AVHRR data that 1985 was better than all three years since 1981 and looks very similar to 1981. When 1985 AVHRR data (showing accumulated biomass) are subtracted from the comparable products for 1981, the difference shows that 1981 had more total biomass accumulation in Eastern Sudan. Normally one could assume that much of the difference would be native vegetation. No scientific studies have established a relationship between native vegetation and cultivated vegetation.

In any type of subjective assessment of the production of crops in Sudan, one must also consider the significant price differences between 1981 and 1985.

D. Evaluation of ERIM Methodology
(UNEDITED)

o Accuracy

ERIM tried sampling methodology eventhough it was poorly executed. Sampling errors were not computed and would not reflect true survey errors. The problem with the methodology is in sample enumeration or data collection. With survey methodology, the survey designer must develop a sampling frame, select a representative sample, collect data from the sample without error or provide a way to measure errors, and expand the data to the strata totals. Any reasonable attempt to measure P.I. errors in a scientific way using the ground data would have been useful. In the P.I. process, errors are made that can not be estimated. These data are then multiplied by the expansion factors so they are expanding unknown extensive errors - an inappropriate design. Some of the P.I. procedures produced consistent biases which are expanded and accumulated when strata are added. In most cases, the ERIM procedures underestimates the true totals. For example, in the P.I. procedure using the half or more rule, and not sampling all strata consistently underestimates the actual area. The half or more rule

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underestimates because only a very small percentage of the total land is planted to sorghum/millet and most fields are less than four hectares in the traditional sector. The distribution of crops would have many squares with less than half rather than an equal number of squares with over half an under half. In the case of not sampling the non-agricultural stratum, the problem is that the date of the imagery was such that much of the sorghum was not observable on the dates when the imagery was taken. Thus large areas were set up where it was assumed that no sorghum was planted and in fact there was no way to catch this in the data collection or ground truthing process.

o Objectivity

ERIM tried to be objective, at least in principle. The sampling frame and selection were objective although it was not possible for them to retrace the procedures exactly from frame construction to sample selection, I feel that it was adequate considering the rush required to complete the work. They built a frame by first stratifying the population of interest. The next step was to subdivide strata into sampling units. Samples were selected in all strata where agriculture was thought to be and samples were enumerated using P.I.s who were trained. Expansions were carried out according to the reciprocal of the probability of selection and the total for the area was obtained by adding strata totals. If the P.I.s were told by management to be conservative then objectivity is violated. I assume that they were not told to be conservative. One statement was made in a presentation that they did not want to be responcible for people starving in the West. This statement leads one to believe that

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the estimates were kept low to ensure that an error of being too high was not committed. If this was the case, then again the procedures were not objective. On the surface, it looks objective.

- Timeliness

The estimates and reports were timely, and provided soon after data collection.

- Comprehensiveness and cost effectiveness

These criteria do not apply at this point in time. The methodology was not comprehensive but USAID did not request comprehensive data. Cost effectiveness has to do with comparison with other methods. The only comment here is that TM CCTs were ordered at a cost of $ 4900. US and FCC images were used. If FCC images were ordered even if priority service and custom service had been requested, the costs would have been $ 2400 US thus a savings of $ 2500. for 27 TM scenes is over $ 65,000 US. The biggest problem was that they ran out of time.

- Replicability

To the extent that ERIM was objective, their procedures are replicable. ERIM did calibrate P.I. against each other and against the ground data.

E. Evaluation of ERIM Estimates

I have been critical of the methodology although there are some positive aspects. As far as the crop estimates themselves, the data do not lend themselves to accuracy assessment. AVHRR data shows that more accumulated biomass in 1981 than in 1985. We know that the 1985 crop year had much stronger economic

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incentives than 1981 but in the West, seed may have been a problem. The weather in 1981 and 1985 look comparable.

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NOTES

1.
Feb. 7, 1986

Very good meeting with FAS/USDA. Talked to Kevin Haley, Bobby Speirs, Pat Ashburn, and Frank David. Spent 3 1/2 hours with them going through procedures and getting material. They had me in front of the Equipment for 2 hours.

2.
Feb. 13, 1986

Bill Trayfors and I had a very good meeting at ERIM in Ann Arbor Michigan. Talked to Don Lowe, John Colwell, Norm Roller and Buzz Sellman. We spent from 9:30 A.M. to 6:00 P.M. going through materials, discussing methodology and looking at computer analysis of special areas.