FEWS REPORT #3

DRAFT FINAL REPORT

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THEMATIC MAPPER DERIVED ACREAGE ESTIMATE OF THE 1985 MILLET/SORGHUM CROP IN WESTERN SUDAN

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CONTENTS

1 INTRODUCTION AND SUMMARY 1

2 FINDINGS 5

3 METHODOLOGY 7

3.1 STUDY AREA AND LANDSAT COVERAGE 7
3.2 FIELD DATA COLLECTION 7
3.3 DATA ANALYSIS AND SYNTHESIS 11

4 RESULTS 18

5 CONCLUSIONS AND RECOMMENDATIONS 25

APPENDIX A: BIBLIOGRAPHY 28

APPENDIX B: VALUABLE CONTACTS 37

1

INTRODUCTION AND SUMMARY

The Environmental Research Institute of Michigan (ERIM) was asked by AID/Washington (AID/W) to participate in a project to estimate Sudan's 1985 millet and sorghum grain production. Sudan has experienced poor production in the recent past and had not produced an annual crop sufficient for its population since 1981. Early 1985 season forecasts of rainfall were very encouraging, along with other market factors (e.g., 1984 end of season grain prices), and the AID Mission in Sudan was hopeful that 1985 might provide a bumper crop. Since the 1985 production would "direct" much of AID's food aid purchase and distribution plans, an accurate estimate of millet and sorghum production, at the earliest possible date, was required.

AID/W reached an agreement with USDA for their assistance in calculating millet and sorghum acreage for eastern Sudan, which is dominated by large field mechanized cultivation and state-run irrigation schemes. In the west, however, the millet/sorghum production (no distinction between the two crops was required for acreage estimation purposes) comes primarily from traditional rainfed areas, primarily from small fields (1-10 feddan) and often at a subsistence level, and from mechanized rainfed schemes in Southern Kordofan.

ERIM was asked, therefore, if it would generate an acreage estimate for Western Sudan (see Figure 1), the area bounded by the White Nile River on the east and Sudan's border with Chad on the west, and running from approximately 15°N to 10°N. This area encompasses that part of the country that receives from 250 to 800 mm of annual average rainfall and is, in "good" years, capable of supporting millet and sorghum cultivation.

Following two meetings in late October with AID/W, ERIM submitted a proposal and was given approval to proceed on 8 November 1985 (refer to Figure 1a).

FIGURE 1. THEMATIC MAPPER COVERAGE OF WESTERN SUDAN

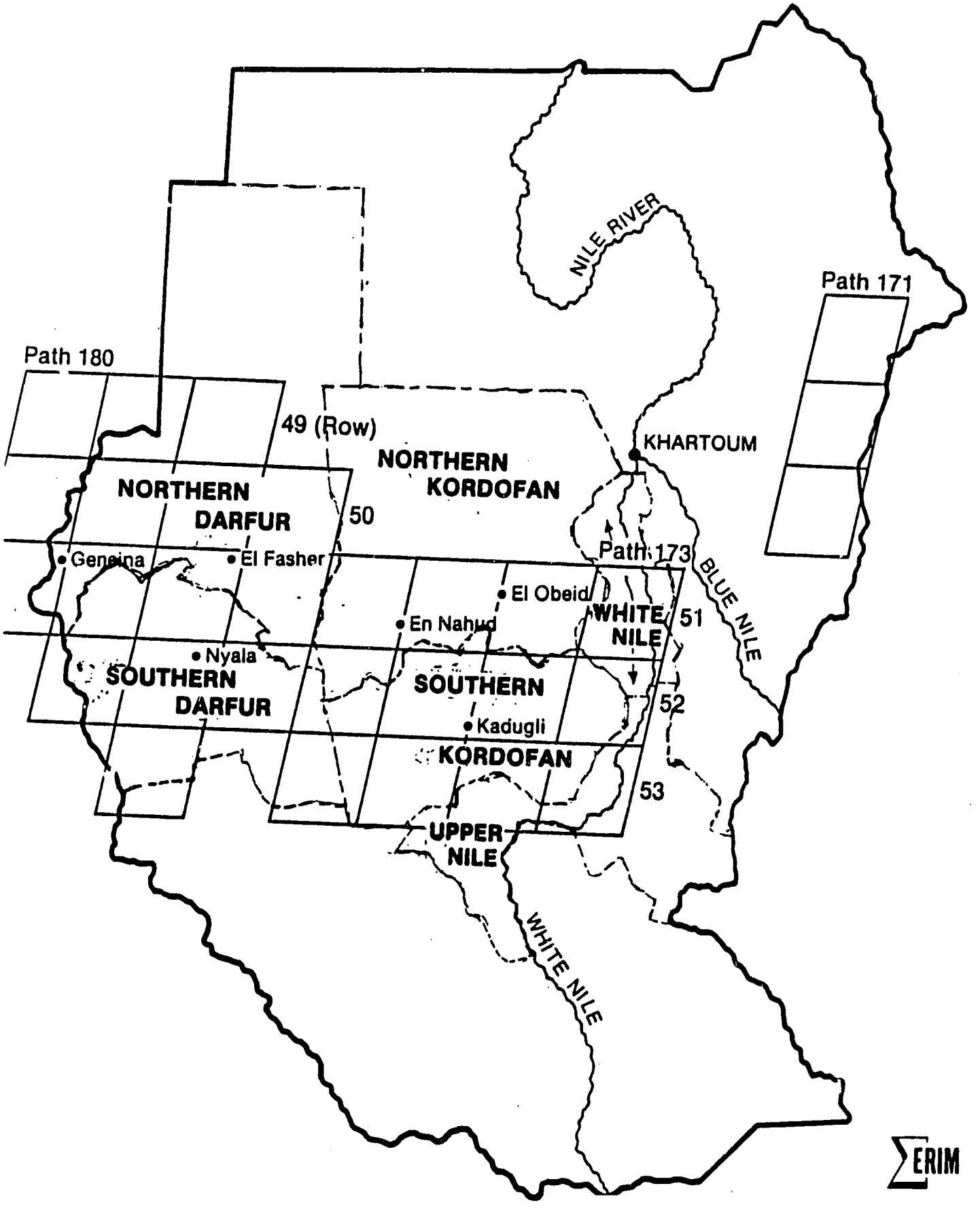
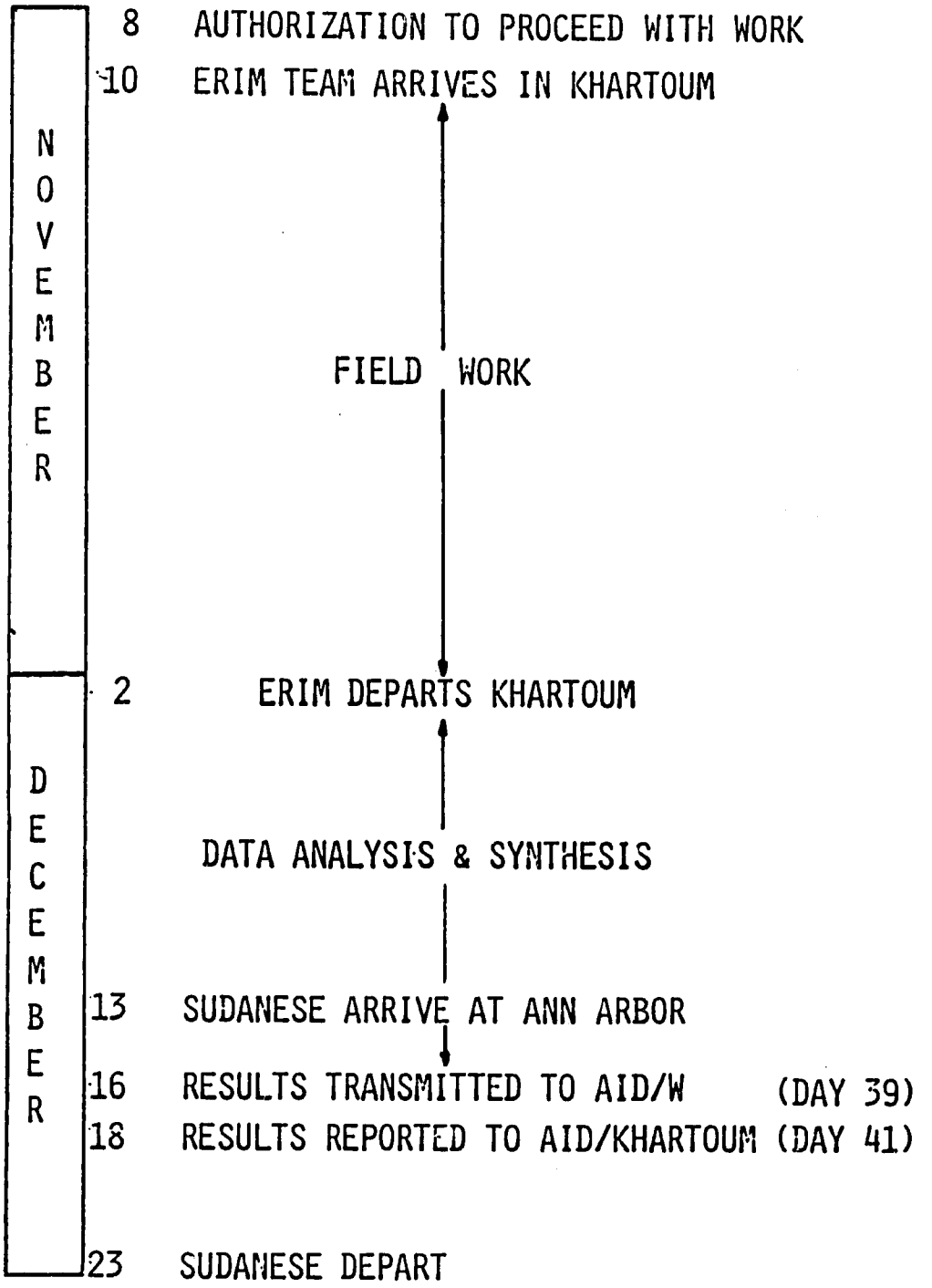


FIGURE 1a

SCHEDULE OF ERIM'S EFFORT



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Our assignment, in its simplest terms, was (1) to generate an acreage estimate for millet/sorghum in Western Sudan by mid-December using Landsat Thematic Mapper data (refer again to Figure 1), (2) evaluate these data for town and village location and population, and (3) involve Sudanese nationals in all phases of the program where practical.

ERIM implemented a three week field data collection beginning on 10 November, when an advance planning team arrived in Khartoum to work with mission staff and counterpart officials of the Sudanese government. Additional ERIM staff arrived in Khartoum on 16 and 23 November and the field work was finished by 2 December.

The data analysis and synthesis phase of work continued at ERIM's headquarters in early December, and three of the participating Sudanese field staff (George Ghobrial of AID, Dr. Babakir Souleiman of the Soil Survey Department, and Dr. Ahmed El-Bashir of the University of Khartoum) arrived at ERIM on 13 December to participate in the final work phases and review procedures with ERIM staff. On 16 December, the crop acreage estimates computed for the district councils in Western Sudan were transmitted to AID/W and are reported in Section 4, and two ERIM staff travelled to Sudan to present the same results on 18 December 1985.

The remainder of this report summarizes the overall findings and recommendations, explains in greater detail the field survey and estimation procedures used, and provides supporting documentation on various project activities.

2

FINDINGS

A. While ERIM's job was limited to acreage estimates only, the initial computations of production in Western Sudan indicate that many of the district councils will be deficit areas again this year.

B. The Landsat satellite system is a reliable and useable data source for crop acreage estimation requirements as specified by AID/W and the Mission in Sudan. Specifically, the Thematic Mapper data were of sufficient quality to allow a direct measure of acreage planted to millet/sorghum in Western Sudan in 1985.

C. The presence of Sudanese counterparts was crucial to the success of the project. These individuals served as on-site authorities concerning agronomic, institutional and cultural issues and their participation in all facets of the project, including ten days at ERIM's facilities in Ann Arbor, could help pave the way for transferring the work with satellite data to Sudan in the future.

D. The methodology employed was the most appropriate given this years circumstances. It was chosen in order to ensure that (a) the results were delivered to AID within the available project time (6 weeks), (b) it was easily replicable and/or verifiable by others, and (c) an "appropriate technology" was designed and used in case AID wishes to transfer the task of annual acreage estimation work to Sudan. Given appropriate time to properly plan and implement an annual acreage estimate (8-10 months instead of 6 weeks), and also allowing for a more thorough definition of the ultimate information and products desired by AID, a different mix of techniques to derive an acreage estimate might be developed to take full advantage of satellite data systems.

E. The logistical support provided by AID in Sudan, especially the helicopter support, also proved crucial to ERIM's success in

generating the desired results. However, if planning for the 1986 crop year estimates could begin in March or April, and the ground truth teams could be on-site in Sudan at planting and throughout the growing season, field data collection requirements could be met using ground (four wheel drive) vehicles and readily available fixed wing aircraft.

3

METHODODLOGY

3.1 STUDY AREA AND LANDSAT COVERAGE

The study area, as shown in Figure 1, extends from approximately 10°N to 15°N and from the white Nile west to the Chad border. It incorporates part or all of the following provinces: Northern Darfur, Southern Darfur, Northern Kordofan, Southern Kordofan, White Nile and the Upper Nile. The area is covered by part or all of 27 Landsat Thematic Mapper images. Table 1 summarizes the Landsat Thematic Mapper data purchased by or made available to ERIM for the interpretation and enumeration phases discussed in this section.

3.2 FIELD DATA COLLECTION

The overall purpose of the field program was to obtain ground information as support to subsequent image interpretation and millet/sorghum acreage estimation. The field program was conducted over a period of 3 weeks (November 10 to December 2). This effort included a week of planning in Khartoum to map out field logistics, arrange aircraft support, make contact with prospective Sudanese counterparts and gather readily available ancilliary data (e.g., maps, climatic data).

The field survey work was carried out by 2 teams consisting each of two ERIM staff and two Sudanese counterparts (one geographer and one agronomist).

The specific objectives of the field activities were as follows:

1. to develop a familiarity with land cover/use features and local agronomic practices in order to relate them to TM image characteristics,
2. to obtain photographic records of agricultural activity in various representative settings,

TABLE 1. LANDSAT THEMATIC MAPPER IMAGERY USED IN THE STUDY

Path/Row	Date
173/51	20 Oct 85
173/52	20 Oct 85
173/53	20 Oct 85
174/51	28 Nov 85
174/52	28 Nov 85
174/53	28 Nov 85
175/51	3 Nov 85
175/52	3 Nov 85
175/53	19 Nov 85
176/51	10 Nov 85
176/52	10 Nov 85
176/53	10 Nov 85
177/50	1 Nov 85
177/51	1 Nov 85
177/52	1 Nov 85
178/49	4 Aug 85
178/50	4 Aug 85
178/51	4 Aug 85
178/52	1 Aug 84
178/53	23 Oct 85
179/49	15 Nov 85
179/50	30 Oct 85
179/51	30 Oct 85
179/52	30 Oct 85
180/49	21 Oct 85
180/50	21 Oct 85
180/51	21 Oct 85

3. to confirm the presence or absence of agricultural activities in areas which were initially ambiguous via photointerpretation,
4. to determine the extent of "confusion crops" (e.g., groundnuts, sesame),
5. to obtain crop yield information from local farmers,
6. to establish contact with local authorities on agriculture, geomorphology, weather conditions and other factors related to cultivation of sorghum and millet,
7. to introduce Sudanese counterparts to field data collection techniques.

Following extensive image observation and analysis, a number of typical sites were selected for subsequent field visits. The site selection was made via a "mental stratification" based on observable landforms like wadis, slopes, pediments, alluvial fans, eolian features (dunes, sand sheets, interdunal corridors), and general image characteristics (tone, texture and pattern), as well as observable terrain features such as naturally vegetated regions, variability of cultivated fields caused by varying soil conditions, harvested or unharvested crops, variation in plant density, or fallow status. Representative sites for each of these conditions were selected for field checking.

A majority of the sites were reached using Boeing Vertol 107 helicopters in the far west and one fixed wing aircraft in Kordofan. Navigation to sites was accomplished by "dead reckoning" between landmarks that were easily identified on Landsat images and on the ground. Frequently, it was possible to locate individual cultivated fields on the ground and on the images.

Upon approaching a pre-selected site (Figure 2) a photo was taken of an identification card containing information on the site number, Landsat path/row number, and film roll number (Figure 3). An oblique

Figure 2. Study site marked on Landsat TM image.

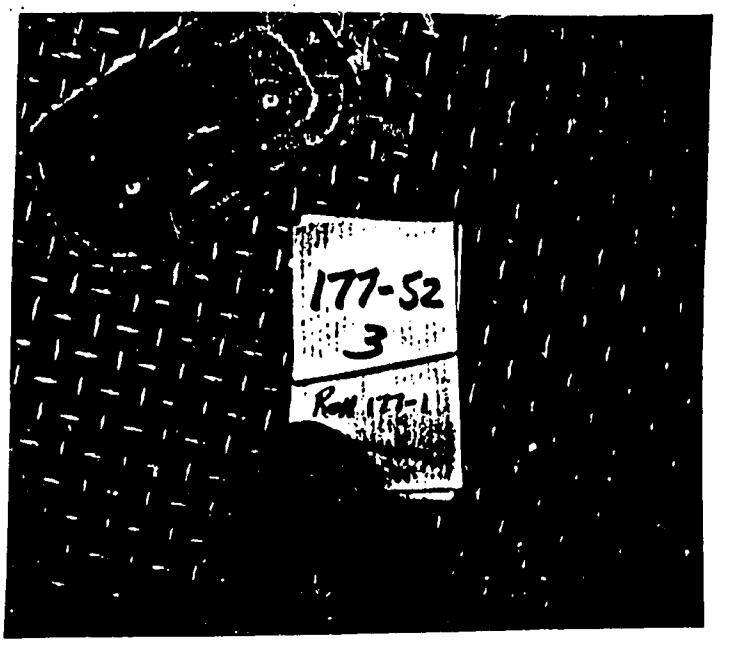


Figure 3. Study site ID card showing path/row, site number and film roll number.

igure 4. Aerial oblique photo of study site (2,000').

Figure 5. Aerial oblique photo of study site (1,000').

photo was then taken of the site at 2,000 feet, another taken at 1,000 feet and then two or three taken upon landing (Figures 4,5,6, and 7).

At almost every site curious local farmers would gather, and the team took advantage of their curiosity and interviewed them concerning crop yields, recent weather conditions, crop pests, etc. (Figure 8). Through personal observations and these interviews, standardized forms were filled out at each site (Figure 9).

The time spent at a site usually amounted to about 30 minutes, and together with travel time about 8 sites could be visited each day. Owing to the difficult nature of the terrain, the fixed wing aircraft could not make any landings; at preselected sites, the pilot reduced the planes altitude to 2000 feet, banked sharply to permit a vertical photograph to be taken, then reduced altitude to 1,000 feet for a similar photograph, and finally flew at low level (50 feet) for crop identification and a general observation of field conditions.

Within the constraints of aircraft range, time allocation and manpower availability, a total of 118 sites were visited. The location of these sites is shown on Figure 10.

3.3 DATA ANALYSIS AND SYNTHESIS

A standardized procedure was used to estimate planted crop acreage, but owing to unique circumstances the procedure was modified if required. Broadly, the sequence of procedures were as follows (refer to Figure 11):

1. A 1:250,000 scale uncontrolled mosaic of Landsat False Color Composite (FCC) images was prepared.
2. Political boundaries of the provinces and the district councils were transferred to the 1:250,000 scale FCC mosaic using transparencies made from avilable 1:250,000 topographic maps.

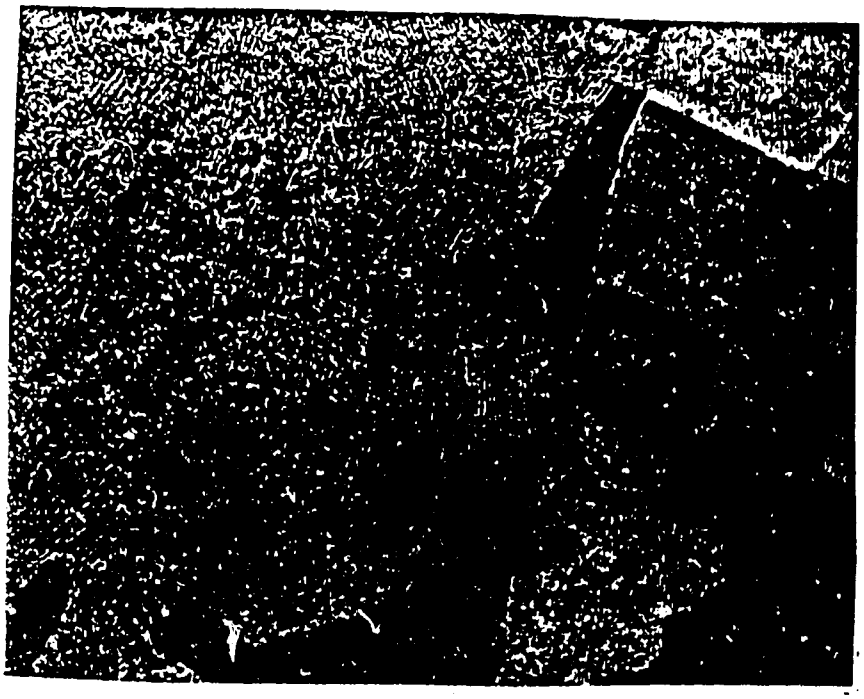


Figure 6. Near vertical photo of study site (1,000').

Figure 7. Millet stalks and study site ID card.

Figure 8. Field team members interviewing local farmer.

TM PAIH/ROW 177/52
SITE # 3

DATE	22 November 1985
TIME	10:30 am
TEAM	A
ROLL #	177-1
SHOTS #	23-29
COORDINATES	12.068N 25.444E

COVER

SITE TYPE	Flat dunes
SOIL COLOR	Light greyish brown
DRAINAGE	Well drained
VEG TYPE	Grasses with scattered bushes

SURROUNDING VEGETATION TYPE: Same as above; concentrated along drainage channels.

ADJACENT DOMINANT LANDFORMS: Complex terrain of dunes & numerous wadis

AGRONOMIC FACTORS

LIFE CYCLE STAGE	Millet mature, harvested
PLANT DENSITY	Spacing 2 x 2 m; 8 to 10 heads per hole
YIELD	2 sacks/feddan*
CROP MIX	Millet, watermelon
GENERAL FIELD CONDITION	Plants tall, average condition, weeded twice

COMMENTS: Rain season good; but farmers reported that due to food shortage there was insufficient energy to properly manage fields.

*One feddan = 1.03 acres.

Figure 9. Standardized form for Site 3.

FIGURE 10. LOCATION OF FIELD SURVEY SITES (10 November-2 December 1985)

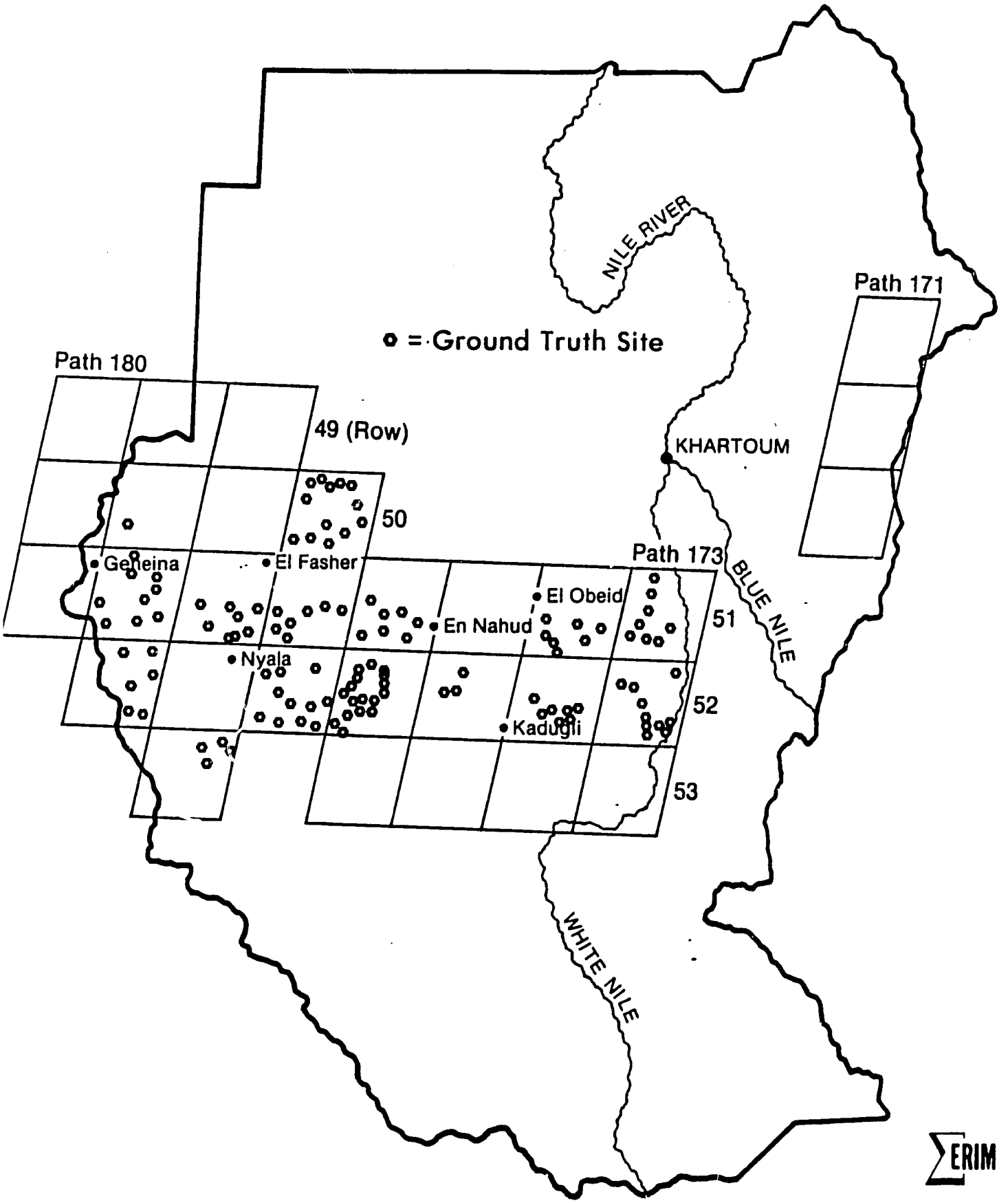
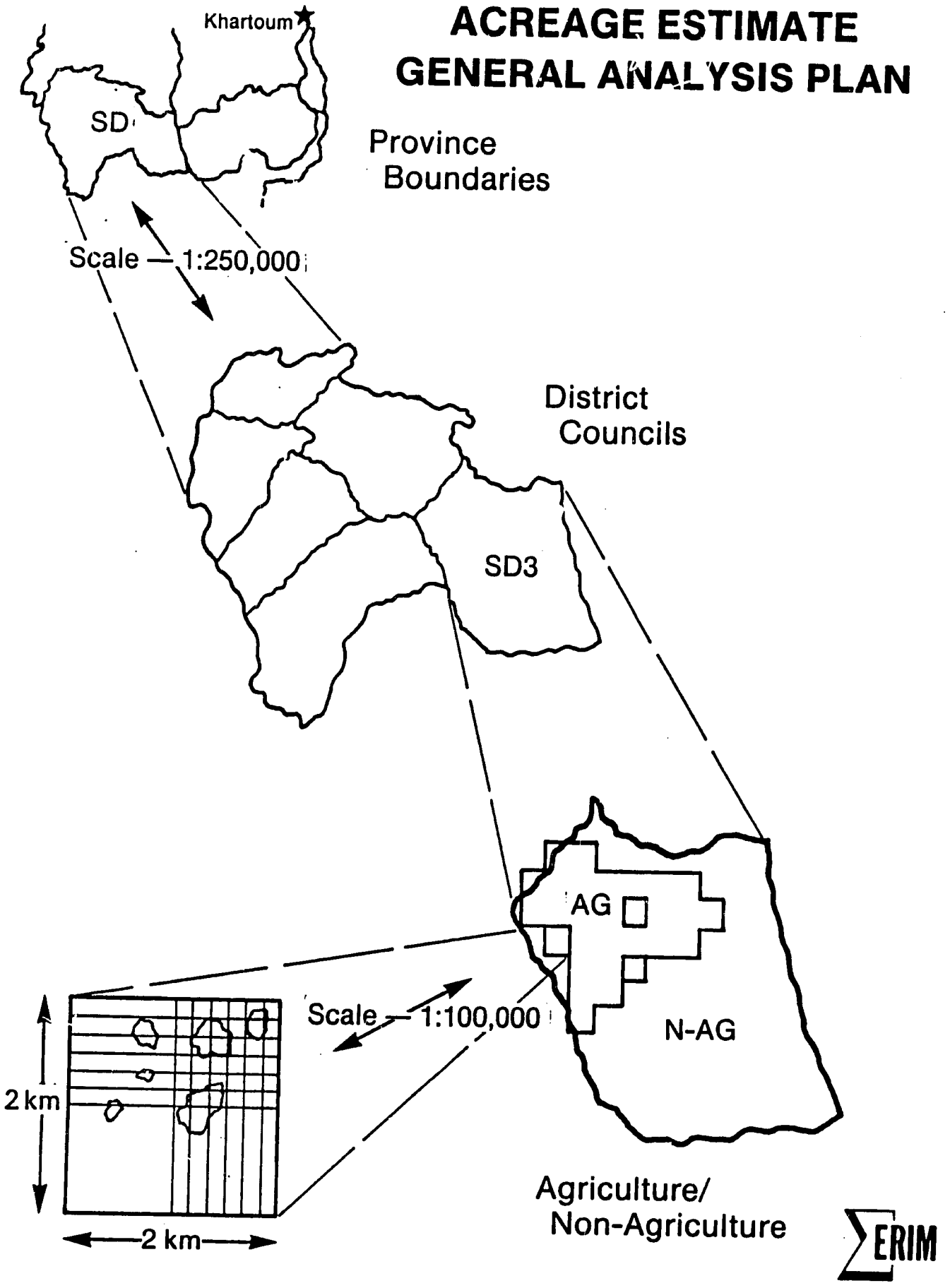


FIGURE 11

SUDAN — 1985 MILLET/SORGHUM ACREAGE ESTIMATE GENERAL ANALYSIS PLAN



3. Stratification within the political boundaries was done to divide the areas into areas of uniform ecophysical characteristics (as visible on the image), uniform cropping density and practices. Additional strata were created by a crop condition line as drawn on the Landsat mosaic (in the northern part of the mosaic) to separate areas which were planted but not harvested due to insufficient yield. This line was based on field observations and interviews, as well as appearance on the Landsat FCC image and an AVHRR vegetation index image. This line was an approximation and, therefore, could cause some error in the relative amount of harvested/non harvested areas determined. Non-agricultural strata were created so as to exclude them from measurements and analysis. Since there was probably some small amount of agriculture in these strata, their omission produced some conservatism in the area estimates.
4. The fundamental strata on which individual measurements were made (i.e., measurement strata) were the smallest units created by the interaction of ecophysical, political (district council) and harvest/non-harvest stratum lines.
5. Sampling or census procedures were followed based on cropping density and distribution patterns within each of the delineated measurement strata. For sampling, a sampling frame of 25 km^2 sampling units (2 cm x 2 cm at mosaic scale of 1:250,000) was established within each stratum. All the sampling units within a stratum were numbered suitably and a sample of approximately 10% in each stratum was selected using random number tables. The number of sampling units selected was based on stratum size and expected importance of the stratum to crop production (a combination of crop area and crop yield). Each selected sampling unit (25 km^2) boundary was transferred to a 1:100,000 scale Thematic Mapper image,

and was overlaid by a fine grid of 25 x 25 (= 625) square (each fine square = 1/25 sq km or 4 hectares) for interpretation and measurement. For census, a complete enumeration was made on the 1:250,000 scale mosaic using a coarser grid.

6. Interpretation keys were developed based on available field and photographic data. Image interpreters were calibrated against each other, and against the person considered to be most knowledgeable about the area, so as to ensure consistent and accurate interpretation and measurement of crop area. The interpretation and measurement were kept conservative. That is, if there were doubts in interpretation, or differing values between interpreters, lower values were accepted. This procedure resulted in a potentially negative bias in the estimates. Fine squares having less than 50% of the agricultural area was ignored and squares having greater than 50% of the agricultural land were counted as full squares. This should balance the errors of over and under estimation although our impression is that it generally resulted in a conservative estimate.

7. For the sampling-based procedure which was applied to most of the traditional Goz and mechanized strata, the mean value of agricultural area per sampling unit ($\bar{x}$) over the n sampling units selected was computed from the sample of the stratum. The total agricultural area of the stratum was then estimated by multiplying this mean value ($\bar{x}$) by the total number of potential sampling units in the stratum (N). Thus $X_{total} = N\bar{x}$ gave an estimate of agricultural land within the stratum sampled. A similar procedure was followed for the unharvested crop strata.

8. For a patchy stratum (i.e., that in which crop area tended to be clumped) a total census was carried out on the 1:250,000

scale mosaic itself using a coarser grid of 100 squares per 25 sq km sampling unit. This estimate, though based on coarser scale measurements, had no sampling error.

9. For wadi areas in the western sector, the area of wadi was marked and measured on the 1:250,000 mosaic. A judgemental sample representing the range of conditions present within these wadis was made on the 1:250,000 scale mosaic using a coarse grid. The agricultural area was then estimated in the same way as was done for the random sample, i.e., $X_{\text{total wadi}} = N_{\bar{x}}$.

10. Based on the above estimates per measurement stratum, the total crop area for each district was computed and designated as harvested or non-harvested, and categorized as to whether it was traditional, mechanized, or irrigated agriculture. The results of this procedure are presented in Section 4.

4

RESULTS

As described earlier, ERIM transmitted the millet/sorghum acreage estimates down to the district council level to AID in mid-December. These results (Tables 2-7) are presented here, unchanged by ERIM. These estimates have already been used by various AID analysts and may have also been "adjusted" based on other sources of information.

TABLE 2
SUDAN
1985 MILLET/SORGHUM
SATELLITE ACREAGE ESTIMATE

PROVINCE	PLANTED AREA (FEDDAN)	
NORTH DARFUR	355,800	
SOUTH DARFUR	923,635	
NORTH KORDOFAN	920,778	
SOUTH KORDOFAN	802,746	626,138 MECHANIZED 176,608 TRADITIONAL
	3,002,959	
WHITE NILE	161,968	ONLY PARTIAL SATELLITE COVERAGE OF AGRICULTURAL ZONES FOR THESE TWO PROVINCES
UPPER NILE	24,480	
	3,189,406	

3,192,365

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TABLE 3

SUDAN

1985 MILLET/SORGHUM

SATELLITE ACREAGE ESTIMATE

NORTH DARFUR

(ALL TRADITIONAL RAINFED)

DISTRICT	STRATUM	AREA
ND1	ND1A	0
ND2	ND2A	0
ND5	ND5A	28,025*
ND6	ND6A	42,025*
ND4	ND4A	15,200
	ND4B	21,000
ND3	ND3A	186,525
	ND3B	49,525*
	ND3C	13,500
		355,800 TOTAL

*"FAILED" CROP BUT COUNTED IN TOTAL ACREAGE...
YIELDS ARE 1/2 SACK/FEDDAN OR LESS

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TABLE 4
SUDAN
1985 MILLET/SORGHUM
SATELLITE ACREAGE ESTIMATE

SOUTH DARFUR
(ALL TRADITIONAL RAINFED)

DISTRICT	STRATUM	AREA
SD1	SD1A	19,635
	SD1B	115,217
	SD1C	19,068
SD2	SD2A	61,585
	SD2B	76,812
SD3	SD3A	73,482
	SD3B	162,115
SD4	SD4A	128,935
	SD4B	53,228
SD5	SD5A	91,325
SD6	SD6A	122,230
		923,635 TOTAL

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TABLE 5
SUDAN
1985 MILLET/SORGHUM
SATELLITE ACREAGE ESTIMATE

NORTH KORDOFAN
(ALL TRADITIONAL RAINFED)

DISTRICT	STRATUM	AREA
NK1	NK1A	0
NK2	NK2A	107,580*
NK3	NK3A	73,068*
NK4	NK4A	210,232*
NK5	NK5A	493,050
	NK5B	36,848*
		920,778 TOTAL

*"FAILED" CROP BUT COUNTED IN TOTAL ACREAGE...
YIELDS ARE 1/2 SACK/FEDDAN OR LESS

ERIM

TABLE 6
SUDAN
1985 MILLET/SORGHUM
SATELLITE ACREAGE ESTIMATE

SOUTH KORDOFAN

DISTRICT	STRATUM	AREA
SK1	SK1A	170,608
SK2	SK2A	231,228 (M)
SK3	SK3A	133,170 (M)
	SK3B	239,360 (M)
	SK3C	6,000
SK4	SK4A	22,380 (M)
		802,746 TOTAL

(M) = MECHANIZED

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TABLE 7
SUDAN
1985 MILLET/SORGHUM
SATELLITE ACREAGE ESTIMATE

WHITE NILE

DISTRICT	STRATUM	AREA
WN1	WN1A	40,920 (I)
	WN1B	15,045 (M)
	WN1C	17,280
	WN1D	44,268 (M)
WN2	WN2A	44,455
		161,968 TOTAL*

UPPER NILE

DISTRICT	STRATUM	AREA
UN1	UN1A	24,480 (M)*

(I) = IRRIGATED
(M) = MECHANIZED
*Note: The province was not completely covered with satellite data, so the acreage totals are not province totals.

5

CONCLUSIONS AND RECOMMENDATIONS

ERIM readily accepted a difficult and complicated assignment when it agreed to generate a millet/sorghum acreage estimate for AID in six weeks time. Our acceptance was based upon our previous experience, a fundamental faith in the quality of the primary data source to allow such an undertaking, a belief that supporting data, services and insight would be forthcoming from the mission in Khartoum (it was), and an understanding that we might need some measure of just plain luck! We contacted as many people as we could for information and encouragement, and many people were particularly helpful via long distance telephone calls. Drs. Jim Hensen, and Trend Bunderson at Washington State University and Dr. James Riley at the University of Arizona and Dr. John Yohe at the University of Nebraska immediately come to mind. There were many others. If, then, an evaluation determines that the 1985 ERIM numbers were both qualitatively and quanitatively an "accurate" portrayal of this years situation, we will indeed have to share the outcome with many other people. Hopefully most of them are listed in the Appendix.

It is correct to point out, however, that owing to the six week period of performance (there was no room for seeking a "no-cost" extension...either the results were ready in mid-December or we simply failed), the usual standards and conduct for a project of this complexity were necessarily bypassed.

ERIM has been understandably queried by many interested persons as to why they did or did not do certain things in this project. To many of these well-meaning inquiries the answer must simply be "six-weeks". Fortunately, for ERIM, AID staff and analysts in Washington and Sudan are aware of this salient point, and have graciously accepted, for the moment, the caveats which must accompany this years effort.

ERIM is hopeful that we will be a partner in future years activities in Sudan, and look forward to an opportunity to present a more thoughtful proposal than was possible this year. While all the points cannot be adequately summarized here, a few lines of departure are listed here for those who must struggle with this years results while keeping a close eye on the 1986 crop year.

1. Begin planning now if there is going to be a satellite-aided crop acreage program in Sudan in 1986.

2. Define very precise goals and desired outputs and outcomes. For example, is it clearly a goal of the Famine Early Warning System that there will be an annual grain production estimate for Sudan? If so, who ultimately, will be responsible to generate the estimate...Sudanese nationals, a U.S. contractor, another Federal agency, or others? The cost and procedure employed will vary considerably depending upon the answer to the question, "Who's in charge of generating the estimate"!

3. There are many data sources that could improve the quality of results achieved (no matter who works the problem in future years), if these data are collected, corrected, organized and properly formatted now. For example, ERIM is convinced that a digital cartographic base map at the district council level should be generated and distributed to all interested parties so that unambiguous and spatially reliable data are available and comparable in future years. This will be initially an additional expense, but will save far more money (via improved efficiency) and measurably improve the quality of results in future years.

4. As an outgrowth of early planning and coordination, many potential benefits immediate arise;

- area and yield estimates can be linked spatially (if a common and unambiguous map base is prepared in advance), temporally and functionally (e.g., planted area and yield/planted area, or harvested area and yield/harvested area),
- resources can be allocated to the most variable factor (acreage in Western Sudan),
- an accuracy assessment task can be built in (AID should not fund any future work unless the process is capable of generating a verifiable measure of accuracy of the estimates),
- calibration sites for evaluating accuracy (e.g, Habila as a double-sampling opportunity) and new methodologies (e.g., computer assisted classification) could be selected,
- future surveys could more adequately benefit from other remote sensing data (e.g., AVHRR data sets),
- crop condition assessments as a gauge on expected yields could also be performed if analysts are given time to evaluate the through-the-season performance of the crops of interest.
- direct and more workable linkages to various Government of Sudan Ministries could be put in place,
- satellite data adequate to the timing of events can be ordered in advance,
- countless other efficiencies and improvements to procedures are possible with early planning.

5. Finally, future year efforts should have a single, responsible technical home (Washington or Khartoum) and spokesperson to define what AID wants. This years program understandablay was a shared effort between Washington and Khartoum but there is time to coordinate and unify AID's goals and consequently the dirction it wants to go with the program.

APPENDIX A

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APPENDIX B

VALUABLE CONTACTS

Due to shortness of time and hurried nature of our initial planning activities we may have misspelled some names, and we apologize for this shortcoming.

Khartoum Contacts

KEN LYVERS - Agricultural Development Officer, USAID, Khartoum. He is a key link to many of the persons listed below. (Referred by Dr. John Yohe, see U.S. contact list.)

ELIZABETH MARTELLA - Project Officer, USAID, Agricultural Office. Second link to persons listed below. (Referred by Dr. John Yohe.)

ED LIPPERT - Agricultural Statistics Head, USAID, Agricultural Statistics and Planning Project, Ministry of Agriculture. He has access to yield data on sorghum and millet, and is in charge of the USAID-Ministry of Agriculture effort to develop a method for estimating annual yield data. The project publishes an annual report on area, yield/hectare and total production of sorghum and millet for all provinces of Sudan. Most recent report was published in 1984. (Referred by David Howes, Eastern Kentucky University, and by Brian d'Silva, USDA. See U.S. contact list.)

HASSAN EL SHEIKH - Ministry of Agricuture. Works with Lippert. Expert on sorghum/millet yields. (Referred by Brian d'Silva, USDA.)

BRIAN D'SILVA - Agricultural economist who recently published an important document on the status of agricultural recovery efforts in Sudan. Previously spent 2 years teaching at the University of Khartoum. Reached through USAID.

DAFALLA AHMED DAFALLA - Director, West Sudan Agricultural Research Project at Shanbat in Khartoum North. Near campus and agricultural research farm of Khartoum University. This is a joint USAID/World Bank sponsored project. He can provide possible access to a Dehavilland Twin Otter aircraft which flies regularly to agricultural research stations at Kadugli, Al Obeid, Al Fashir and Ghazalla Gawazat. He is an authority on agriculture in Western Sudan. Could be useful in familiarizing us on distribution of three types of cultivation in Western Sudan. (Referred by Dr. James Riley, University of Arizona. See U.S. contact sheet.)

MAHMOUD AHMED MAHMOUD - Agronomist/Plant Breeder with the Agricultural Research Corporation on loan to the Mechanized Farm Corporation. Dedicated. Graduate of Oklahoma State. Authority on rain fed sorghum agriculture. The Mechanized Farm Corporation is an independent agency which has large operations in South Kordufan near Dilling. (Referred by Dr. James Riley, University of Arizona.)

DR. JAIN - International Sorghum/Millet (INTSORMIL) and Western Savannah Agricultural Research Project (WSARP). c/o Alastair Scott-Villiers, CARE/SUDAN, P.O. Box 2702, Khartoum, Sudan. He is an expert on millet breeding, millet varieties and can provide specific information on millet phenology for Sudan, particularly the El Obeid area. Can be contacted through Alastair Scott-Villiers.

WILLIAM BATESON - Member of Agricultural Statistics and Planning Project. Developing yield estimation techniques. Familiar with crop conditions in South Kordufan Province. Familiar with remote sensing technology. (Referred by Brian d'Silva, USDA, Dr. James Riley, University of Arizona.)

KAREN TWINING - OXFAM, Assistant Field Director, The Sudan, P.O. Box 29799, Khartoum, Sudan (Phone: 41972). Field Operations Address: P.O. Box 35, El Fasher, Sudan (Phone: 2375). Knowledgeable on the role of OXFAM in the agricultural development process of western Sudan. Has access to current agricultural yield information obtained through field interviews.

PETER WOOD - League of Red Cross and Red Crescent Societies, Sub-Delegation, Darfar, Sudan Delegation, P.O. Box 25560, Khartoum, Sudan (Phone: 41393, Telex: 24238 LRCSD). Good source of information on food supply situation in western Sudan.

IAN SMITH (CARE) - ALASTAIR SCOTT-VILLIERS (BANDAID) and PATTA SCOTT-VILLIERS (CARE), c/o CARE/SUDAN, P.O. Box 2702, Khartoum, Sudan. These individuals are particularly knowledgeable on food production and agriculture in north and south Kordofan. Ian Smith has conducted an extensive survey of agricultural production in Kordofan through head of household interviews in 300 villages. Patta has considerable experience in interpretation of agricultural data on Landsat images.

EMILE STEINKRAUS - CARE representative. Can provide information on private volunteer organizations in Western Sudan (Catholic Relief Services, Oxfam, etc.) which are involved in agricultural projects with data that may be of value. (Referred by Robert Craig, USDA, Washington. See U.S. contact list.)

SASCO AIR CHARTER - Tel. 43362, Telex 22048 NURCO, P.O. Box 8260, Al Amarat, Khartoum. Have several light aircraft for supporting field operations. (Referred by Dr. Chris Justice/NASA. See U.S. contact list.)

KEVIN HALEY and BILL BOYD - USDA. Conducted ground truth exercise E. of Nile

BOB BROWN - USAID, Mission Chief/Khartoum

HUME HORAN - Ambassador to Sudan

DR. AHMED EL-BASHIR - Faculty of Agriculture, University of Khartoum - Agronomist - member of 1985 survey team. Authority on sorghum/millet.

MR. GEORGE GHOBRIAL - USAID/Khartoum, Agronomist - member of 1985 survey team. Authority on sorghum/millet. Well known and respected throughout agricultural community of Sudan.

DR. BABAKIR SOULEIMAN - Soil Survey Department, Ministry of Agriculture - experienced remote sensing specialist with emphasis on soils and landforms. Member of 1985 survey team.

IBRAHIM ADAM - Agricultural Economist, Ministry of Agriculture, Khartoum. Member of 1985 survey team.

ASSIM AHMAD - Agricultural Economist, Ministry of Agriculture, Khartoum. Member of 1985 survey team.

MR. JOE GOODWIN - USAID/Khartoum. Will coordinate future surveys.

AL-OBEID CONTACTS

MR. BILL ASTLE - FAO, range management specialist. Very familiar with field conditions in western Sudan. (Referred by Dr. Chris Justice/NASA.)

KADUGLI CONTACTS

TAREKE BEHRE - Working on AID funded Collaborative Research Support Program (CRSP). From the University of Kansas. Authority on sorghum/millet. (Referred by Dr. John Yohe, University of Nebraska.)

DR. RICHARD COOK - Chief of Party at agricultural research station being developed by Washington State University. (Referred by Dr. Jim Hensen, WSU. See U.S. contact list.)

TOM BYERS - Agricultural economist at agricultural research station. (Referred by Dr. Jim Hensen, WSU.)

NYALA CONTACTS

ALLEN LONSLOW - Cartographer with Hunting Technical Services working at Western Savannah Development Corporation in Nyala. Presently working on southern Darfur mapping project being funded by Overseas Development Administration. Knowledgeable on the topic and Sudan mapping.

RODNEY TUCKER - Image Analyst also working with Hunting at Western Savannah. Good source of information on landscape change in Western Sudan.

W.B. KERR - Soil Scientist at Western Savannah. Knowledgeable on development projects and changing agricultural land use in southern Darfur.

The three Nyala contacts can be contacted through: Hunting Technical Services Ltd., Elstree Way, Borehamwood, Herts, England WD6 1SB, Phone: 01-953 6161, Telex: 23517.

OTHER CONTACTS IN KHARTOUM

JIM BOLL - FAO representative in Khartoum, Project Manager, Fuel Resources, FAO Project Forest Department. Potential source of information on natural resource inventory work in Sudan. Can be contacted through Paul-Gerhard Reichert. (See U.K. contact list.)

MOHAMMED ABDULLAH - Acting Director, GOS National Remote Sensing Center, Khartoum (Building just completed, but equipment has been lost. About 20 Sudanese have remote sensing experience, only a few are adequate.)

ZIN AL ABDEEN AL OMAR AL SHAREEF - Cartographer, Soil Survey Department. Member of 1985 survey team.

SUDAN SURVEY DEPARTMENT, KHARTOUM - Will sell 1:250,000 scale maps published by the British in the 1930's. These maps contain planimetric data only.

DR. SOUMANI - Director of Remote Sensing section in the Department of Geography at the University of Khartoum, Khartoum, Sudan. Potential source of information on remote sensing programs that have alrady been undertaken in Sudan.

MAHMUD AL KHALIFI - Director, Institute of Environmental Studies, Khartoum (has used MSS data for past studies in Sudan).

CHRIS HOWES - Hunting Technical Surveys, Khartoum - currently using Landsat data for a project at Jabal Mara. Provided access to HTS acreage estimate study in the Jabal Mara area.

FATHI EL SADIG JAMIL, Settlement Officer, Western Savannah Development Corporation (WSDC), P.O. Box 9025 (K.T.1), Khartoum, Sudan. Useful and helpful contact regarding settlement schemes in southern Darfur - Knowledgeable on agricultural land use, agricultural practices and migration patterns.

CONTACTS IN THE UNITED KINGDOM

MICHAEL E. DAW - Senior Agricultural Economist, Agricultural Economics Division, North of Scotland College of Agriculture, School of Agriculture, 581 King Street, Aberdeen, Scotland, UK AB9 1UD (Phone: Aberdeen 40291). Good source of information on current agriculture in Sudan, especially the El Obeid area. Knowledgeable on Local Private Volunteer Organization (PVO's).

HUGH MACKAY - Director, Overseas Development, The Save the Children Fund, Mary Datchelor House, 17 Grove Lane, London, England SE5 8RD (Phone: 01-703 5400, Telex: 892809). Potential contact for information

on food programs and activities in the Darfur region. MacKay is based in London but frequently visits SCF fielld offices to assess field operations. He works closely with Mike Dick and Christine Eldridge (Operations Director). Both are experts on food distribution problems. They work in Nyala office but can be reached through MacKay. Mike Dick is interested in our Landsat image processing capabilities. Mike MacRae, Arkel Taleb Transport (trucking firm) in Nyala direccts grain hauling operations to food deficit areas in Darfur. He is helpful and can also be reached through Hugh MacKay or Mike Dick.

CONTACTS AT UN/FAO - ROME

PAUL-GERHARD REICHERT - Remote Sensing Officer, Forestry, Remote Sensing Center, Research and Technology Development Division, FAO, via delle Terme di Caracalla, 00100 Rome, Italy (Phone: 57974513, Telex: 610181FA01. Paul is active on forestry projects in Sudan and is currently planning forest/rangeland inventory by density class that would cover western and eastern Sudan. TM imagery would be used for this classification. He is a useful contact for persosns having questionsn on forests/fuelwood as they relate to agriculture.

U.S. CONTACTS

DR. CHRIS JUSTICE/NASA - (301) 344-7282 Recently returned from a TDY in Sudan. Identified Astle/FAO and many contacts in Khartoum.

JIM HENSEN - International Agricultural programs Office at Washington State University (509) 335-2541. WSU has set up 4 agricultural stations in Sudan, 2 in Darfur and 2 in Kordufan. They have been conducting crop yield studies for the last 7 years. They are interested in cooperating with ERIM. (Identified Trent Bunderson/WSU as a potential consultant in the U.S.)

TRENT BUNDERSON - International Agricultural Programs Office, WSU (509)335-3282. Recommended as consultant in U.S. Spent four years in Western Sudan as a range ecologist.

Dr. JAMES RILEY - Environmental Research Lab, University of Arizona (602) 621-7962. Agronomist who is a leading authority on agriculture in Sudan. (Identified Mahmoud Ahmed Mahmoud, Dafalla Ahmed Dafalla, and William Bateson.)

BRIAN D'SILVA - USDA (202) 786-1680

DAVID HOWES - Department of Geography, Eastern Kentucky University, Richmond, KY 40475 (606)622-1427. 1985 Survey team member. (Identified by Dr. James Riley, University of Nebraska.)

DR. JOHN YOHE - Department of Agriculture, University of Nebraska (402) 472-6032. Authority on sorghum/millet in Sudan. Primary contact regarding the Collaborative Research and Support Program (CRSP) for sorghum/millet. He calls is SORMILCRSP. Claims to have access to "98%" of the authorities in the U.S., mostly in universities, on sorghum/millet in Sudan. (Identified Dr. James Riley; Ken Lyvers and Elizabeth Martella.)

BOB CRAIG - USAID/Washington (202)632-2978. Authority on private volunteer organizations (PVO's) associated with agriculture and health in Sudan (Identified Emile Steinkraus.)

ALLEN REED - USAID/Washington (202)632-9762. Sudan Desk Officer.

LOREN SCHULZE - USDA/Washington (703)235-1497. Authority on CRSP. (Identified Dr. John Yohe).

DOUG LACOMPTE - NOAA (202) 634-1822. Generated a 1985 yield estimate for agriculture in Sudan using AVHRR data.

WILLIAM WRIGHT - Oklahoma State University

STEVEN MARPLES - World Bank. Range management/livestock specialist on Sudan.

DAVID STROUP - Columbia helicopters (503)657-1111. Very familiar with the nature of our work. Flew one of the helicopters used in the 1985 survey. Navigates using Landsat images with uncanny ability.