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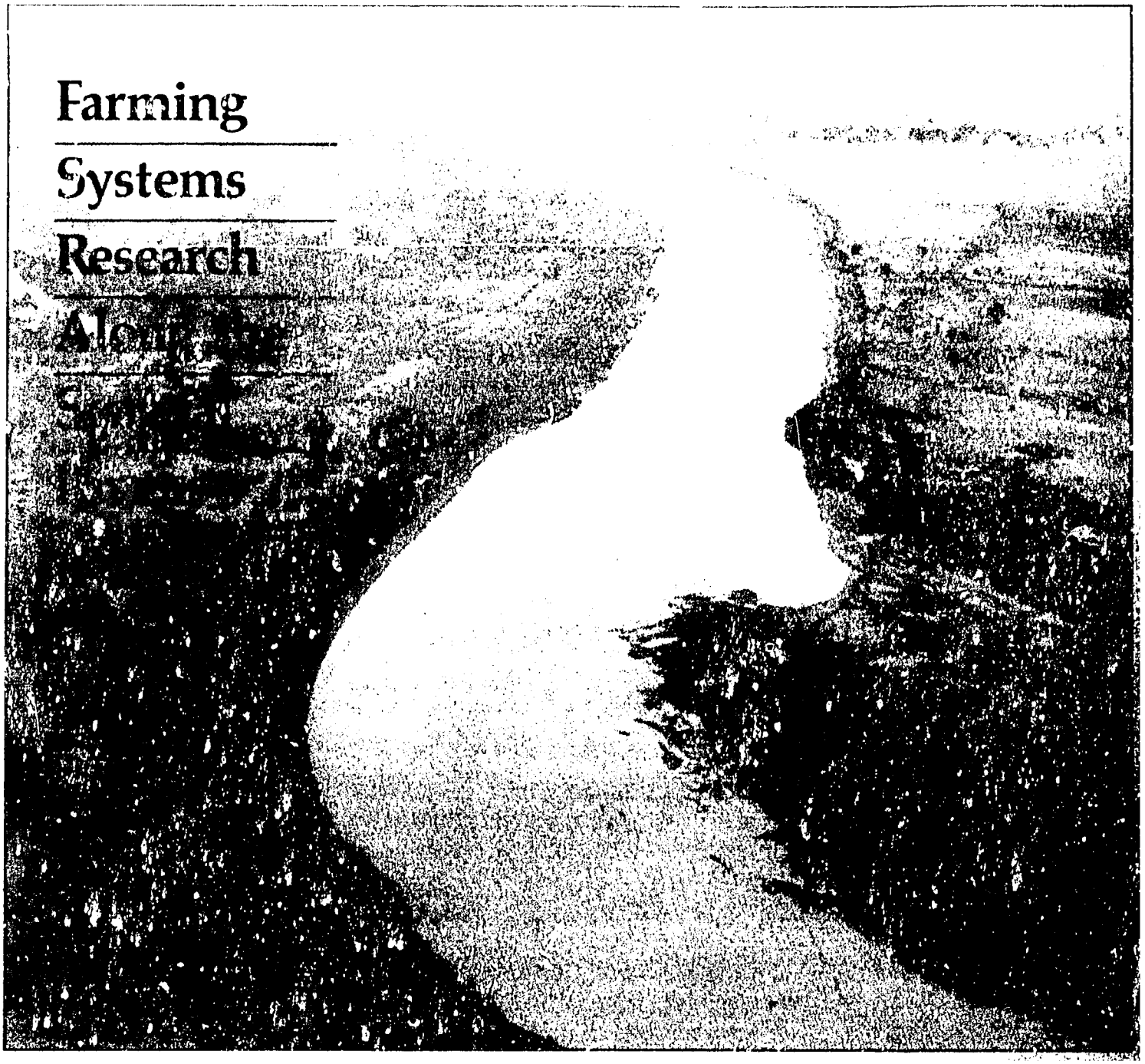
Report No. 4

Farming Systems Research Along the



An Aerial Survey in Guidimaka, Gorgol, Brakna, and Trarza Regions

Mauritania Agricultural
Research Project II

College of Agriculture
The University of Arizona
Tucson, Arizona
August 1986

Best Available Document

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DRAFT FOR REVIEW

FARMING SYSTEMS RESEARCH ALONG THE SENEGAL RIVER VALLEY

AN AERIAL SURVEY IN

GUIDIMAKA, GORGOL, BRAKNA, AND TRARZA REGIONS

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EXECUTIVE SUMMARY

This report describes a preliminary analysis of imagery acquired along the Senegal River Valley during two aerial surveys conducted in December 1985 and February 1986. The surveys were done in support of the Mauritania Agricultural Research Project II (AGRES II).

The primary objectives of the aerial survey were to provide: (1) general information on terrain and land use that could be used to plan the ground reconnaissance survey; and, (2) specific information on the nature of villages and agricultural practices to supplement the ground reconnaissance survey.

The secondary objective of the aerial survey was to determine how aerial 35 mm photography and color video imagery could best be used for reconnaissance surveys.

Summary of Findings

General Orientation

- Oblique video imagery was invaluable in selecting villages for intensive study at the planning stage of the reconnaissance survey.

Village Characteristics

- Several measures derived from 35 mm aerial photography proved to be useful indicators for determining: (1) tribal composition of a village; (2) level of institutional development within a village; (3) relative village wealth; and (4) the total village population.

  - Gross village area gives a general indication of village importance.

  - Proportion of area with a high density of structures is a sensitive indicator of the general village economy and suggests relative wealth.

  - Number of buildings can be used to estimate village population.

  - Building roof materials can be used reliably to: (1) identify the tribal character of a village, particularly Peul and Soninke tribes; and (2) estimate the relative wealth of a village.

  - Total garden area seems to be a general indication of village wealth.

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- No single feature serves as a reliable indicator in itself. The confidence with which villages can be characterized increases with the number of indicators used.

Field Characteristics

- Walo plot areas were consistent with measurements made independently by other researchers.

- Sorghum plant densities varied according to soil texture. This indicates that farmers understand the relationship between texture and water holding capacities and could adopt recommendations for variable plant spacings.

- Perimeter plot areas decreased upstream, and may suggest a number of things, including: (1) relative length of time irrigation has been practiced; (2) differences in land allocation practices; (3) consolidation of holdings over time; or (4) greater or lesser reliance on irrigation indicated by the size of plots.

Environmental Degradation

- Charcoal production was a dramatic indicator of failing agriculture and increasing environmental degradation as farmers find other sources of income in woodcutting.

Remote sensing can provide information about villages and their agriculture that cannot be easily acquired on the ground. The use of 35 mm aerial photography combined with oblique and vertical video imagery was an effective and inexpensive alternative to conventional aerial photography or satellite data.

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I. INTRODUCTION

This report describes a preliminary analysis of aerial imagery of the Senegal River Valley taken during aerial surveys conducted in December 1985 and February 1986 in support of the Mauritania Agricultural Research Project II (AGRES II).

The overall objective of AGRES II is to improve the standard of living of farm households by: (1) increasing agricultural production, especially staple foods, and (2) arresting the deterioration of the valley environment. This objective will be achieved by establishing a vigorous and comprehensive research program for the Senegal River Valley that will be implemented by the Mauritanian Centre National de Recherche Agronomique et de Developpement Agricole (CNRADA). The project is conducted jointly by CNRADA and the University of Arizona College of Agriculture, and it is funded by the U.S. Agency for International Development (USAID).

As a preliminary step in developing a research program, a reconnaissance survey was conducted to characterize the farming systems found in the Senegal River Valley (Frankenberger et al., 1986). The information generated by the reconnaissance survey will be used to identify constraints on agricultural production from which an appropriate research agenda can be developed and implemented. The major part of the reconnaissance survey focused on farmer interviews and ground inspection of farmers' fields.

The aerial survey was designed to support the ground component of the reconnaissance survey by providing information that could not be gathered easily on the ground. The purposes of the aerial survey were to generate: (1) general information on terrain and land use prior to the ground reconnaissance survey that could be used for planning; and (2) more specific information on the nature of selected villages and general farming practices to supplement ground findings.

II. EQUIPMENT AND APPROACH

In addition to providing basic information in support of project objectives, the aerial survey was intended to demonstrate the combined use of two inexpensive imaging technologies. One was large-scale 35 mm aerial photography, which has been successfully used in many rural surveys in Africa (ILCA, 1981). The second was aerial video imagery, an emerging technology that shows great promise in lower cost, increased flexibility and ease of acquisition when compared to aerial photography (Vleck, 1983).

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A. Equipment

A Piper PA-28 aircraft was rented from the Aero Club Saint Exupery in Nouakchott for both photograpic missions.

Three camera systems were used in various combinations:

1. Canon AE-1 35 mm with motor drive and 28 mm lens using Fujichrome 100 film;

2. Canon AE-1 35 mm with motor drive and 135 mm lens using Fujichrome 100 film;

3. Hitachi VKC-1500 color video camera with 12.5 mm lens mated to a Panasonic NV-8420 portable VHS video cassette recorder, and Realistic five-inch portable monitor.

A portable camera mount had been fabricated previously by the Arizona Remote Sensing Center (ARSC). For this mission, the rear cargo door was removed from the Piper, and the mount was fixed to the floor of the aircraft so the cameras could be extended through the open cargo door (see Plate 1).

Color prints of photographs at scales of about 1:10,000 were interpreted manually at the University of Arizona. Features of interest were mapped on plastic overlays and their areas were measured using a Numonics 1224 electronic graphics calculator.

Video tapes were processed in two ways. For general orientation and reference, oblique and vertical images were viewed on a standard Mitsubishi 19" color monitor, using a Mitsubishi FX-4 video cassette player/recorder.

Area measurements were also made from vertical video tapes. A microcomputer-based Xybion Image Analysis and Capture system was used to digitize selected video frames. A line grid was electronically superimposed on the image, and area measurements were made for features of interest (see Appendix A).

B. Approach

The large-scale 35 mm photography and video imagery were used to gather two types of information. Medium and large-scale 35 mm images were acquired over selected villages and nearby fields to characterize village size, organization, land use patterns, field sizes, and agricultural practices.

The video camera system was operated continuously over the study area. In addition to providing useful material for referencing 35 mm photography, the data would be used to assess land uses in the areas between villages (Figure 1).

We planned to use the data generated by the aerial survey in two ways at different times in the reconnaissance. A single

Plate 1. Camera array installed in Piper PA-28 aircraft. The Canon 35 mm camera with 135 mm lens extends farthest from the plane. The Canon 35 mm camera with 28 mm lens is to the right; the Hitachi color video camera is to the left. Through the cargo door is the video monitor placed on top of the video cassette recorder. The camera array was retracted during ferry time and for film changes.

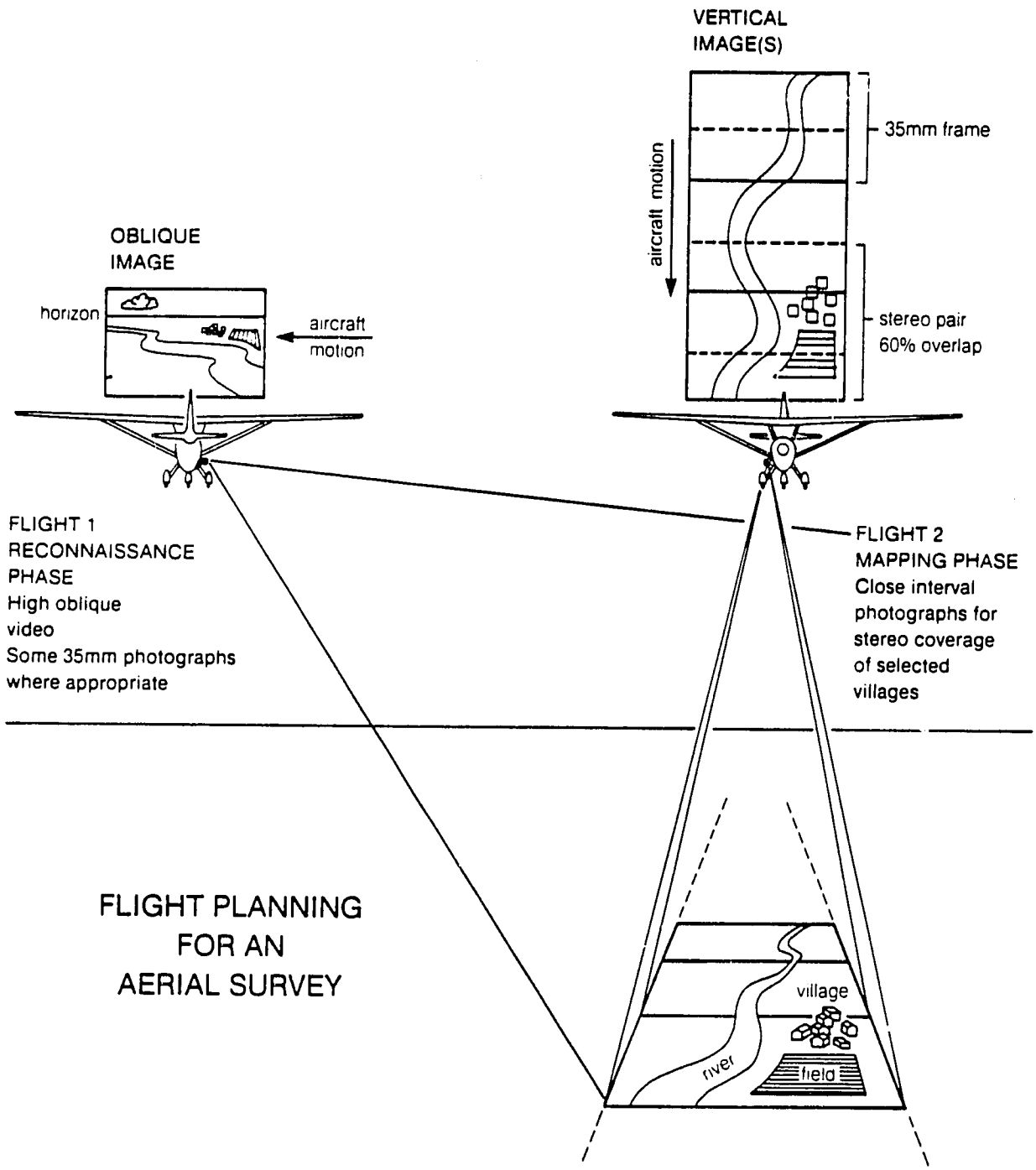

Figure 1. Flight planning for aerial survey.

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photographic mission was planned prior to the dispatch of the ground reconnaissance team. The video imagery acquired would be used first to identify villages for intensive survey during field orientation and planning. Secondly, large-scale 35 mm photography supported by video imagery would be interpreted by a remote sensing specialist accompanying the ground reconnaissance team to provide quantitative data on features of importance identified as the survey proceeded.

High winds, dust, and rain in December prevented the acquisition of vertical 35 mm and video images. However, an abbreviated mission over part of the study area was performed but only oblique, rather than vertical, video imagery was acquired. A second photographic mission was successfully performed in February and vertical 35 mm photographs and video imagery were acquired. Thus, the aerial survey was divided into two phases.

1. Phase I

Rain precluded the use of our external camera mount. The video camera was hand-held and oblique images were acquired out the starboard window of the aircraft. The initial pass extended from Boghe to somewhat south of Kaedi. On the initial leg, we flew between 1,000 and 3,000 ft. above the northern edge of the floodplain, providing a panoramic view of the walo areas along the river. On the return, the flight path was over the Senegal side of the river, looking into Mauritania. As we passed villages, the camera was zoomed-in to provide detailed images.

Members of the field team from the University of Arizona met in Tucson during January. Over a period of two days, the team reviewed the video tapes. First, the team established a set of criteria for selecting villages for field study. Some of the important features that were easily recognized on the video tape included:

1. relative village size;
2. number and relative abundance of various land uses near the village (e.g. walo, falo, dieri, irrigated perimeters, gardens, charcoal pits);
3. access to transportation (i.e. proximity to roads);
4. access to water (i.e. proximity to river);
5. evidence of nomads (i.e. encampments);
6. evidence of woodcutting (i.e. charcoal pits).

After establishing a set of selection criteria, the tapes were reviewed again with small-scale maps for reference, and a list was made of candidate villages for intensive ground survey.

2. Phase II

Using the criteria developed in Phase I and the input of the Mauritanian members of the field team, 34 villages between Rosso and Wompou were selected for study (see Figure 2). The final village selection was refined by the combined Mauritanian/U.S.

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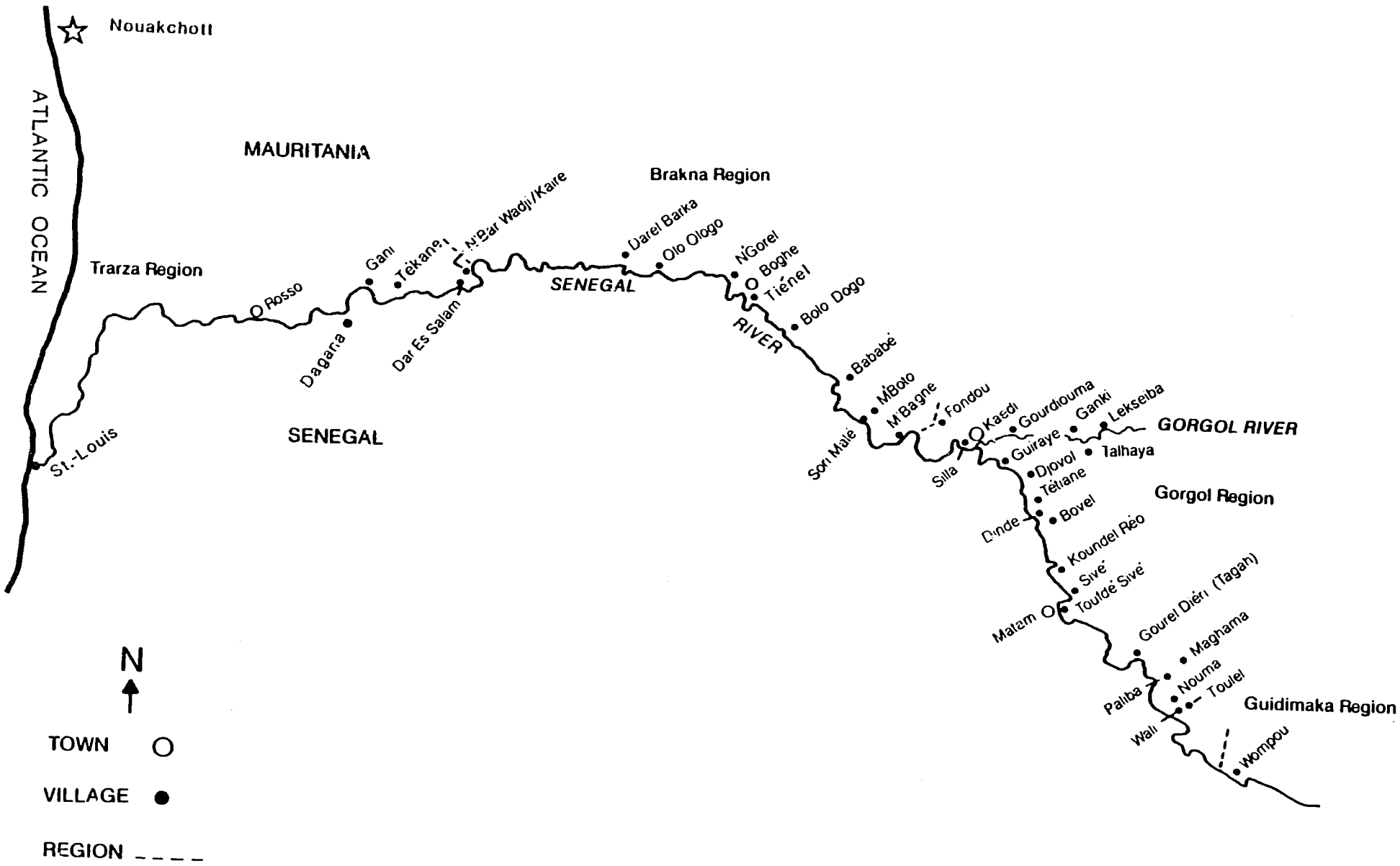

Figure 2. Location of villages visited during the ground reconnaissance survey.

survey team in Kaedi.

The second photographic mission was performed concurrent with the ground reconnaissance survey, and the imagery was analyzed subsequently at the University of Arizona.

As explained, the purpose of the reconnaissance aerial survey was to provide general information on villages and farming practices in the Senegal River Valley. Fourteen of the 34 villages along the Senegal River between Rosso and Wompou which were ground surveyed were selected for aerial analysis.

Most of the village analyses were made on 5x7 inch color prints of the 35 mm wide angle photography with a scale of approximately 1:10,000. The camera with the 135 mm lens provided large scale detail within the 28 mm field-of-view. Larger scale color prints (1:2,070) were used for plant density and field size measurements and as an aid in the interpretation of the smaller scale photography.

The boundaries of villages, fields, gardens and charcoal pits to be measured were outlined on 5x7 inch (1:10,000) color prints of the 35 mm wide angle aerial photography flown at an altitude of 4,600 feet and areas were measured. Image characteristics of all camera systems at 4,600 feet are listed in Table 1.

TABLE 1. IMAGE CHARACTERISTICS AT 4,600 FEET ALTITUDE

camera lens	ground image height	ground image width	contact scale	5"x7" print scale*
28 mm	3,937'	5,906'	1:50,000	1:10,000
135 mm	817'	1,225'	1:10,370	1:2,074
video with 12.5 mm		3,281'		

* images of Tekane were flown at 6,000 feet and the 5x7 inch prints of the 28 mm lens photos have a scale of about 1:13,000.

It was not always possible to maintain a constant flying altitude, and photo scales vary accordingly. Although topographic maps were not always available to compensate for scale changes, we feel that the error factor of all area measurements is within plus or minus 10 percent.

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III. FINDINGS

A. General orientation

Often, a survey team is placed in a new environment with only small scale topographic maps to describe local terrain or land use. The oblique video images gathered in late December proved to be highly useful for planning the ground reconnaissance survey.

The oblique video images gave a view of the study area as seen from the window of a low-flying aircraft. Team members were able to examine and discuss the tapes as a group. They were able to pause the tape to discuss significant features, or reverse the tape to compare different localities. In this way, the team was able to reach general agreement on what the nature of the landscape was, and what features were important. A similar analysis could not be performed by sending the same team aloft in an aircraft.

B. Village area measurement

Village areas are difficult to measure on the ground due to their indistinct boundaries and irregular shapes. However, the areal extent of villages is a useful descriptive measure and it is necessary for estimating population densities.

Gross village area gives some indication of population and also general economy. Small villages tend to be oriented toward agriculture or herding. However, in examining the range of village areas and comparing it with total population or relative significance (e.g. Bolo Dogo vs. Ganki) gross village area is misleading (Plate 2).

In more complex settings, such as towns and cities, it is desirable to measure areas devoted to various types of land uses (e.g. industrial, commercial, residential, agricultural). This type of information can give an indication of the economic and sometimes social nature of the city and its parts.

In villages, the organization is structurally simple but significant in its implications. Areas with a high density of structures suggest a population that has achieved a higher level of institutional development; areas with a low structural density point to an economy organized around subsistence agriculture or herding.

We mapped two types of villages areas. High density contained a high concentration of structures per unit area with few or no yard areas. Low density included areas with comparatively fewer structures per unit area and most of these structures had enclosed yards. The two densities of village structures were mapped and their areas measured (Table 2).

Plate 2. Medium scale (1:10:000) print of 35 mm wide angle photography of Ganki. These types of photographs were used to measure village area. Ganki is a good example of a predominantly low density village. See Plate 6 of Wompou for an example of a high density village area.

14x

TABLE 2. VILLAGE AREA
(hectares)

village	high density	low density	percent high density	total
		Lower middle valley		
Tekane	4.9	5.1	49%	10.0
		Central middle valley		
Tienel	5.7	10.2	37%	15.9
Bolo Dogo	3.7	2.4	60%	6.1
M'Boto	6.1	16.2	27%	22.3
Foundou	11.7	7.9	60%	19.6
Gourdiouma	0.0	2.9	0%	2.9
Ganki	0.5	5.1	9%	5.6
Talhaya	0.0	12.2	0%	12.2
Tetiane	0.0	7.5	0%	7.5
Dinde	0.0	3.1	0%	3.1
		Upper middle valley		
Sive	6.3	4.0	61%	10.3
Gourel Dieri	0.0	6.6	0%	6.6
Nouma	0.0	5.6	0%	5.6
Wompou	15.7	0.5	97%	16.2

The proportion of high density area within a village may indicate several things. First, it gives some indication of the ethnic nature of the village. Wompou has the largest proportion of high density area. The village is Soninke, a tribe which prefers to live in large extended families.

Second, the proportion of high density area in a village indicates the level of its institutional development and its relative wealth. Relatively large villages with a high proportion of high density area tend to be: (1) important markets or transportation nodes, such a Sive; (2) relatively wealthy villages receiving substantial remittances from abroad, such as Wompou; or (3) traditional centers of economic and political importance, such as Bolo Dogo. Conversely, villages with no high density areas may be oriented exlusively toward subsistence agriculture or herding. This is true even of villages, such as Talhaya, that are generally regarded as being relatively prosperous.

The proportion of high density area within a village is a sensitive indicator of a village's economic status and its ethnic nature.

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C. Field area survey

Large-scale aerial photography was especially useful for measuring field areas (see Plate 3). Other figures tend to be inaccurate because farmers tend to estimate the size of their fields by the amount of seed they sow (Frankenberger et al.,1986).

Suitable sample photography of fields was limited but provides a reasonable estimate of the mean field areas for two parts of the study area (Table 3.)

TABLE 3. FIELD AREAS

location	number of fields	mean area (ha)	std. deviation
Dieri or nambu fields in in the vicinity of Wompou	16	0.17	0.05
Walo fields in the vicinity of of Gourdiouma	10	0.12	0.02

The estimate of mean walo field area is comparable to the 0.17 ha. reported by others (RIM, 1979). These figures seem somewhat low, but they represent the area farmed by individuals. A family or household may work several individual fields.

Our estimate of mean dieri field area is considerably lower than the 0.27 ha. reported by RIM (1979). The substantially smaller size of these fields suggest that they may not be true dieri. The close proximity of the fields to the village may mean that they are managed more like gardens and used to produce vegetables or quick-maturing crops. This type of field is called nambu (nambeli), and is managed by women.

D. Sorghum plant density survey

Plant densities can be more easily determined from aerial photography than ground sampling.

Walo sorghum is normally planted in hills of three to five plants spaced approximately one meter apart (Gannett et al., 1978). In our survey, plant density (hills/hectare) was calculated by counting the number of hills per unit area on large scale (1:2,070) 5x7 inch color prints of the 35 mm aerial

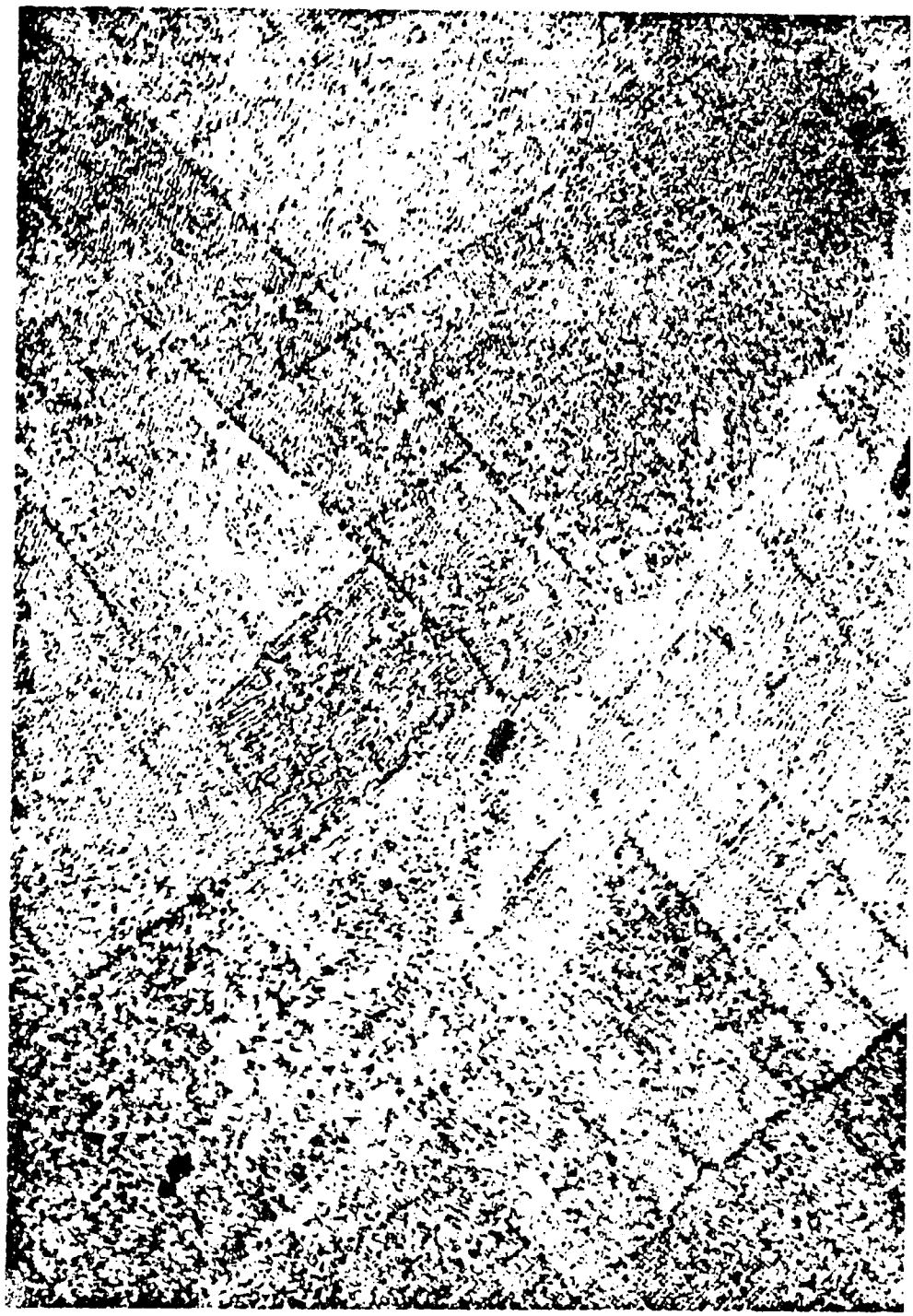

Plate 3. Walo sorghum fields in the vicinity of Ganki. Large-scale (1:2,070) prints of photographs acquired with the 135 mm lens were used to measure field areas and plant densities. Plant density is between 2,000 and 2,500 hills per hectare. Note the distinctive soil boundary marked by the lighter tone in the lower right corner of the photograph.

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telephoto photography. Plant densities of four fields within each photo area were calculated (see Plate 3).

The sample was virtually random due to the limited number of large scale aerial photos available of walo sorghum and the lack of pre-selection of areas to be photographed by the survey crew. Where variability of plant density existed, an attempt was made to sample the entire range of densities observed.

TABLE 4. WALO SORGHUM PLANT DENSITY

location	walo sorghum plant density (hills/ha)
Walo in vicinity of Gourdiouma	2780 3125 3610 3770 ---- mean = 3,320 hills/ha
Walo in vicinity of Ganki	2244 2450 2900 3230 ---- mean = 2,710 hills/ha
Walo in vicinity of Fimbo	1436 1510 1525 1560 ---- mean = 1,510 hills/ha

The main factor affecting planting density in walo is the moisture holding capacity of the soil. Sandy soils have lower moisture holding capacities than heavier textured clay soils and can support fewer plants per unit area. Planting density was observed to decrease away from the river towards the upper edges of walo areas where soils become lighter textured.

The systematic variation in plant densities indicates that farmers are aware of the relationship between soil texture and moisture holding capacity. This further suggests that farmers will be able to adopt recommendations for different planting densities for new crops with different water requirements.

E. Perimeter plot area survey

Areas of a number of plots within four perimeters were calculated for those perimeters with complete photo coverage (Table 4: see Plate 4).

Table 4. PERIMETER PLOT AREA

village	number of samples	average plot size (ha)	std. deviation
		Lower middle valley	
Tekane	30	0.16	0.07
		Central middle valley	
Dinde/Bovel	40	0.12	0.23
		Upper middle valley	
Sive	50	0.02	0.01
Wompou	50	0.02	0.01

Although the samples were limited in their distribution, the analysis shows a distinct trend toward smaller plots in the upper part of the valley. There is a corresponding reduction in perimeter age from the lower to the upper part of the valley. These two facts suggest several explanations.

One is that SONADER has made smaller plot allocations in newer perimeters where farmers are unfamiliar with irrigation practices. Another is that, as perimeter management matures, successful farmers may come to manage more than one individual plot.

Finally, it can be argued that differences in perimeter plot sizes reflect fundamental differences between total farming systems in the lower and upper parts of the valley. Rainfed agriculture tends to be more productive in the upper part of the valley, so that there is more diversity in these systems and farmers are less reliant on irrigation.

In addition to providing quantitative data, aerial imagery proved useful for assessing perimeter crop status and general perimeter activity. For example, the village of Belane between

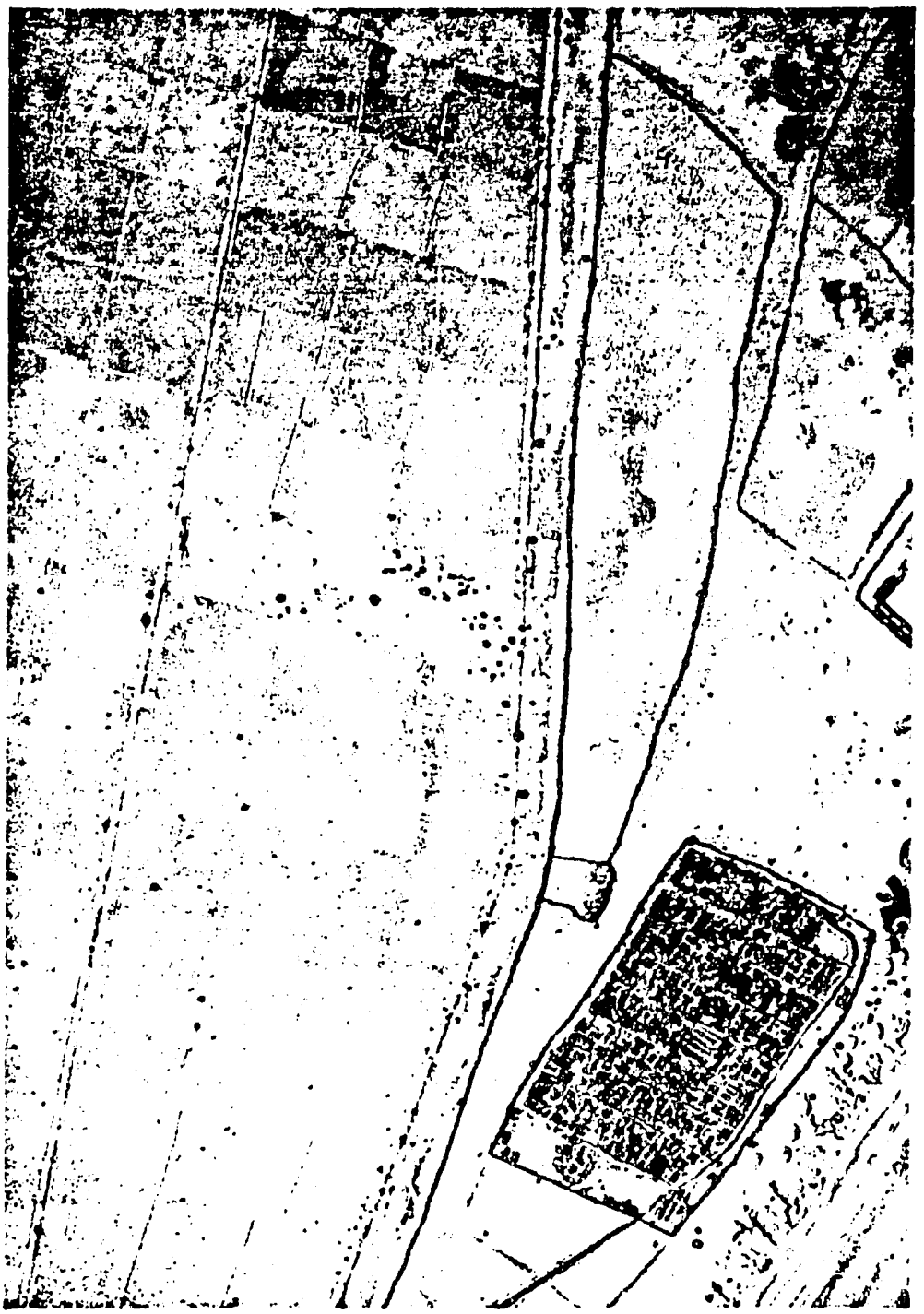

Plate 4. Irrigated perimeter and cooperative garden near Wali. Perimeter plots have an average area of about 0.08 hectares. The garden is approximately 0.5 hectares in area. Photo scale is about 1:2,070.

Olo Ologo and Darel Barka has a perimeter which appears to have been inactive at the time of the reconnaissance survey due to a pump failure.

F. Village garden area survey

The number of gardens within and around each village was counted and the total area in gardens calculated. Gardens were distinguished from field crops by their close proximity to the villages and by the smaller size of plots within a field (Table 5; see Plates 4 and 5).

This inventory, while not exhaustive, is useful in that it appears to reflect two things. First, the wide range in the number of gardens may indicate those villages where Peace Corps volunteers have been active recently. We did not have information on Peace Corps activity, so we could not verify this.

Second, total garden area per village seems to be a general indicator of relative village wealth, or its institutional development. Those villages with the largest areas in gardens also are highly ranked in other indicators (e.g. percent high density area; percent manufactured roofs). However, the apparent absence of gardens in some important villages, such as Bolo Dogo and Sive, shows that garden area may not always be a reliable indicator of wealth or institutional development.

Plate 5. Community garden in Maghama. The total fenced garden area is about 1 hectare. Note the small size of the garden plots and the different roof types in the village. Photo scale is about 1:2,070.

TABLE 5. VILLAGE GARDEN INVENTORY

village	number of gardens	total area of gardens (ha)	notes
Tekane	1	0.5	cooperative garden on river
Tienel	1	3.6*	cooperative perimeter garden
Bolo Dogo	0	0	no identifiable gardens
M'Boto	2	0.5	0.45 hectare cooperative garden
Foundou	1	1.1	large cooperative garden
Gourdiouma	2	<0.1	gardens on outer edges of village
Ganki	1	<0.1	cooperative garden
Talhaya	6	0.4	several cooperative gardens
Tetiane	1	0.2	cooperative garden on edge of village
Dinde	0	0	possible village gardens accross river in falo area
Sive	0	0	possible village gardens accross river
Gourel Dieri	5	<0.1	small gardens grouped together on edge of walo
Nouma	0	0	no identifiable gardens at scale of photography
Wompou	12	0.8	all gardens near edge of lake Wompou

* estimated due to incomplete coverage

G. Village building census

Buildings in each village were counted to help: (1) describe the relative size of the village; and, (2) develop a population estimate. In addition, each building was classified by roof type (see Plates 5 and 6).

Three roof types were differentiated: manufactured; mud/wood; and thatch. Manufactured roofs are made of imported materials such as metal or tile which have a metallic or pinkish photo tone. Wood/mud roofs have a tan photo color, and thatch roofs are conical in shape and are found largely on round buildings.

One objective of the roof material survey was to obtain an indicator of village wealth. Imported manufactured roofs are more expensive than other roofs and the ratio of manufactured to local roof types should be an indicator of village wealth.

TABLE 6. VILLAGE BUILDING CENSUS
number (percent)

village	roof types: manufactured	mud/wood	thatch	total
		Lower middle valley		
Tekane	69 (28%)	177 (71%)	2 (1%)	248
		Central middle valley		
Tienel	30 (15%)	165 (83%)	3 (2%)	198
Bolo Dogo	5 (8%)	57 (92%)	0	62
M'Boto	50 (24%)	162 (76%)	0	212
Foundou	75 (26%)	210 (71%)	9 (3%)	294
Gourdiouma	2 (4%)	0	50 (96%)	52
Ganki	20 (24%)	53 (64%)	10 (12%)	83
Talhaya	8 (5%)	166 (95%)	0	174
Tetiane*	4 (4%)	8 (7%)	96 (89%)	108
Dinde	1 (3%)	0	33 (97%)	34
		Upper middle valley		
Sive	26 (18%)	95 (65%)	25 (17%)	146
Gourel Dieri	31 (24%)	7 (5%)	93 (71%)	131
Nouma*	3 (4%)	11 (13%)	68 (83%)	82
Wompou	153 (53%)	91 (31%)	46 (16%)	290

*count may be unreliable due to low contrast between buildings and soil.

Plate 6. Large-scale photograph of Wompou. Note the large size of buildings and the predominance of metal roofs. Excavations near the bottom right of the photo are borrow pits for building material. Photo scale is about 1:2,070.

Wompou had the highest percentage of manufactured roofs (53 percent). Wompou is by far the wealthiest village of the fourteen surveyed due in part to high emigration and remittances back to the village. Wompou also had considerably more large buildings than any other village surveyed.

Another significant roof materials grouping seems to be those villages with less than four percent manufactured roofs: Dinde (2.9 percent); Tetiane (3.7 percent); Nouma (3.7 percent); and Gourdiouma (3.9 percent). Possible reasons for the low percentage of manufactured roofs in these villages are:

1. small size (Nouma, Dinde, Gourdiouma)
2. isolation (Tetiane, Dinde)
3. low village incomes (all)
4. tribal preference for thatch roofs (all)

Villages with a high percentage of thatch roofs (Nouma 83 percent, Tetiane 89 percent, and Dinde 97 percent) are Peul villages with a distinct livestock orientation. These villages have substantial accumulations of manure on the soil surface which are easily observed on the aerial video and the 35 mm color photography. Peul villages are easily mapped on aerial photography because of these distinctive features.

Building materials seem to be another fairly reliable indicator of relative village wealth and, as with the Peul villages, tribal composition.

H. Population estimates

The village building census was used to develop an estimate of village populations. All buildings (shops, clinics, schools etc.) listed for each village reported by Frankenberger et al. (1986) were subtracted from the total building count to yield a number of buildings that might be inhabited.

The average number of persons comprising a household (poy) can be estimated from the 1977 census (RIM, 1977). Recent work by Park et al. (1986), indicates that this relationship may have remained constant over the past ten years in Dirol Plain.

It is more difficult to develop an estimate of the average number of households that may occupy a building. Generally, these have been reported by galle, or the number of poy living together as a unit, either in a single building or a compound. Park et al. (1986) found an average of three poy per galle on the Dirol Plain. However, there is no comparable information on the average number of buildings occupied by a galle.

To estimate the number of families per village, we assumed that all buildings with mud/wood or thatch were occupied by one family. Because they tend to be larger, we assumed that buildings with manufactured roofs were occupied by two families.

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The number of persons per family was derived from the 1977 census. This figure was multiplied by the estimated number of families to yield an estimate of village population (Table 8).

TABLE 8. VILLAGE POPULATION ESTIMATES

	air photo		ground*		1977 census**	
village	families	pop.	families	pop.	households	pop.
			Lower middle valley			
Tekane	277	2264	350	2200	138	1128
			Central middle valley			
Tienel	226	1647	391	3970	115	838
Bolo Dogo	63	456	76	410	64	463
M'Boto	240	1277	250	2500	185	984
Foundou	353	2089	450	3-4000	242	1432
Gourdiouma	54	308	156	600-1100	72	412
Ganki	95	678	300	1000	92	657
Talhaya	176	1260	120	1000	118	845
Tetiane	104	627	168	1000	108	651
Dinde	33	223	100	1050	25	169
			Upper middle valley			
Sive	162	1092	300	1000	104	701
Gourel Dieri	156	920	200	1040	10	59
Nouma	81	751	80	400	32	297
Wompou	411	3371	360	3300	142	1165

*Frankenberger et al., 1986.
**RIM, 1977.

Although the building count is assumed to be within ten percent of the true number, there are two sources of considerable probable error in the population estimate derived from aerial photography.

First, it was assumed that, after adjusting for public buildings and shops, all other village buildings were occupied. In that this makes no allowance for buildings used for storage, or abandoned buildings, the number is undoubtedly too high.

Second, the number of households occupying each building was assumed to be one, or two for buildings with manufactured roofs. This may prove to be too low. Moreover, this relationship was assumed to hold throughout the valley, and some variation should be expected between villages.

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Further research on the use of buildings and the number of families occupying buildings, combined with more detailed interpretation of the photographs, would significantly improve the accuracy and reliablity of results.

I. Charcoal production assessment

Both video imagery and aerial photography proved to be valuable tools for documenting the destruction of limited wood resources due to charcoal production. Evidence of charcoal production is very distinctive on aerial photography (see Plate 7). Charcoal pits are very dark circular features. Generally, though not always, they are located in wooded areas, with evidence of recent tree cutting (e.g. disturbed soil surface).

We were able to document forest destruction due to charcoal production in the Lower Middle Valley between the villages of Olo Ologo and Darel Barka. From a sample of 45 charcoal pits, we found that pits averaged nine meters in diameter, with an area of 70 square meters. In the small study area, pits occurred at about nine per hectare.

Beyond its considerable environmental significance, results of the ground reconnaissance survey confirm that charcoal production reflects local economic conditions. The farmers in this region are exploiting their forest resources at an accelerated rate due to pump failures which have prevented crop production on irrigated parcels (Frankenberger et al.,1986).

Ideally, reconnaissance flights over the same areas should be flown annually or biannually to : (1) identify areas that may be in need of immediate economic assistance; and (2) to document longer term rates of fuelwood conversion to charcoal.

Plate 7. Deforestation between the villages of Darel Barka and Olo Ologo (Senegal side of river). Note the scattered circular charcoal pits on the right side of the photograph. Charcoal production has increased because of perimeter pump failures. Farmers have turned to charcoal production as a source of income. Photo scale is about 1:2,600.

29x

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APPENDIX A

VILLAGE AREA MEASUREMENTS FROM DIGITAL VIDEO IMAGERY

Areas of seven villages were measured using video images acquired at 4,600 feet. The images were digitized from video tape using a Xybion Image Analysis and Capture System installed in a Compac IBM PC-compatible microcomputer.

Once the images were in digital form, a 96 pixel grid was superimposed onto the images. Grid squares which overlayed village areas were counted, and the total number of pixels calculated. The size of the pixels was calculated based on the camera lens focal length and flying heights using the following equation:

$$Sg = Si * (H/f)$$

Where Sg = ground distance
Si = image distance
H = flying height (AGL)
f = camera focal length

The video camera had a macro lens which was set at a focal length of 12.5 mm. The imaging chip is 6.6 mm by 8.8 mm, divided into 92,928 picture elements, or pixels, each 0.0229 mm vertical by 0.0273 mm horizontal. Using the above equation for a flying height of 4,600 feet the pixels have a representative ground size of 3.05 m by 2.57 m.

TABLE A-1. VIDEO GEOMETRY AT 4,600 FEET

f	Rh	Rv	Ch	Cv	Pa
12.5	3.05	2.57	1000.4	616.8	7.8

f = focal length, mm
Rh = horizontal pixel dimension on ground, m
Rv = vertical pixel dimension on resolution, m
Ch = horizontal frame dimension on ground, m
Cv = vertical frame dimension on ground, m
Pa = ground pixel area, m x m

3/x

TABLE A-2. COMPARISON OF VILLAGE AREA MEASUREMENTS

village	flying height	# pixels	area measurement video	area measurement photo	% diff.
Bolo Dogo	4,600	4,704	6.2	6.1	1.6
Gourdiouma	4,600	3,744	2.9	2.9	0.0
Ganki	4,600	6,240	4.9	5.6	12.5
Talhaya	4,600	6,320	12.8	12.2	4.9
Sive	4,600	12,384	9.7	10.3	5.8
Gourel Dieri	4,600	8,094	6.4	6.6	3.0
Wompou	4,600	19,296	15.1	16.2	6.8

There was good agreement between area measurements using digitized video images with an internal dot grid and digitized area measurements made on 1:10,000 scale prints of the wide angle 35 mm photography. The average area difference was approximately five percent which is reasonable considering that two different interpreters made the measurements independently.

APPENDIX B

RECOMMENDATIONS FOR SUBSEQUENT SURVEYS

This was the first attempt to use a combination of video with 35 mm aerial photography, and the strategy employed proved to be sound. However, several improvements in technique can be incorporated in the next aerial survey scheduled for August 1986.

OPERATIONS

Personnel

1. Navigator/observer. There are problems in relying solely on a pilot and camera operator because they are occupied with their own set of tasks. A third person, or navigator-observer, should be seated with the pilot and equipped with a map of the area and the microphone for the video tape recorder. Using the audio portion of the video tape, he/she would provide a running commentary on ground features, landmarks, altitude and compass heading changes. In addition, he/she could plot the flight on the map.

Flying heights and scales

The following section lists suggested optimum flying heights for different aerial image interpretations using both the video and 35 mm cameras. This assumes 35 mm cameras equipped with 28 mm and 135 mm lenses, and a video camera equipped with a 12.5 mm lens.

1. Village inventories. The suggested flying height for village surveys (buildings count, roof types, gardens etc.) is 3,500 to 4,000 feet above ground level (AGL). The initial reconnassance survey flew most of the villages at an altitude of 4,600 feet. The 1:50,000 contact scale photography from the 28 mm lens which resulted was usable for the above interpretations but a slightly larger scale would be preferable.

2. Charcoal production/environmental degradation assessment. The suggested flying height for monitoring environmental change is 5,500 feet. This could be lowered to 4,000 to 5,000 feet if a smaller telephoto lens (80 - 100 mm) was used in tandem with the 28 mm wide angle lens. The initial aerial mission flew over a charcoal producing region between Darel Barka and Olo Ologo at a flying height of approximately 6,000 feet. Deforested areas and charcoal pits were discernable on the 28 mm photographs with a contact scale of 1:81,650, but a larger scale would be preferable. The camera with the telephoto lens produced photos which had a good scale (contact scale 1:16,950) for

observation of the forest destruction and charcoal pits; increasing the telephoto coverage scale would not be beneficial.

3. Field inventories. The suggested flying height for field inventories such as plant density and field size measurements is 3,500 feet. All of the plant density measurements in this report were made on 1:2,070 scale 5x7 inch prints of 135 mm photographs taken at a flying height of 4,600 feet. While it was possible to make the measurements a larger scale would be preferable.

4. Landscape interpretations. Regional viewpoints necessary to observe general relationships between the landscape and agricultural land use practices require higher flying heights (9,000+ feet AGL) to acquire the small image scales required. The need for a wider perspective may be met, in part, by oblique video taken in conjunction with lower altitude vertical coverage.

For any measurements to be taken of regional land use practices (e.g. area in walo agriculture) high altitude vertical imagery would be preferred. This may necessitate the use of a larger aircraft and/or additional flights.

VIDEOGRAPHY

1. Color monitor. It is necessary to have access to a color video monitor to adjust the camera color balance because automatic color balance systems are not always reliable.

2. Character generator. A character generator within the video system would be useful to provide an internal reference for tape location and/or elapsed time.

35 MM PHOTOGRAPHY

1. Separate photo intervals for each camera. The two 35 mm cameras have been operated in tandem. This ensures that the the large-scale 135 mm frame is contained within the small-scale 28 mm frame. However, this creates large gaps in large-scale coverage that is especially critical over villages. The two cameras might be decoupled over village areas and the 135 mm coverage increased to about three frames for every 28 mm frame.