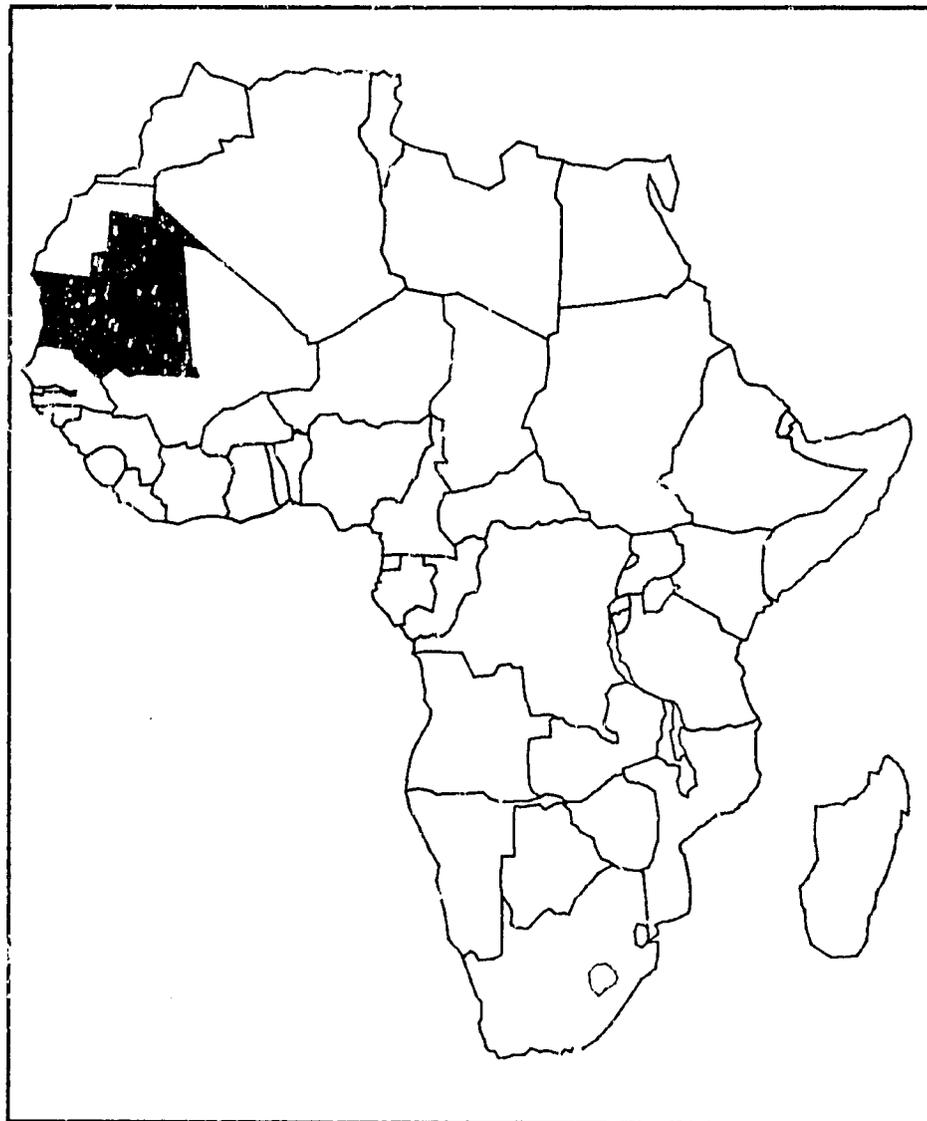


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5/1 1989

MAURITANIA

VULNERABILITY ASSESSMENT

FAMINE EARLY WARNING SYSTEM



FAMINE EARLY WARNING SYSTEM

The Famine Early Warning System (FEWS) is an Agency-wide effort coordinated by the Africa Bureau of the U.S. Agency for International Development (AID). Its mission is to assemble, analyze and report on the complex conditions which may lead to famine in any one of the following drought-prone countries in Africa:

- Burkina
- Chad
- Ethiopia
- Mali
- Mauritania
- Niger
- Sudan

FEWS reflects the Africa Bureau's commitment to providing reliable and timely information to decision-makers within the Agency, and among the broader donor community, so that they can take appropriate actions to avert a famine.

The FEWS system obtains information directly from FEWS Field Representatives assigned to six USAID Missions. In addition, FEWS relies on information it obtains from a wide variety of sources including: USAID Missions, host governments, private voluntary organizations, international donor and relief agencies, and the remote sensing and academic communities.

This is the final report prepared under FEWS Phase I. The vulnerability assessment was completed for USAID's Africa Bureau by Price, Williams & Associates, Inc.

Under Phase I, the work of the FEWS Field Representatives was coordinated by Tulane University's School of Public Health and Tropical Medicine.

NOTE: This publication is a working document and should not be construed as an official pronouncement of the U. S. Agency for International Development.

MAURITANIA

Vulnerability Assessment

June 1989

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MAURITANIA

Vulnerability Assessment

Executive Summary

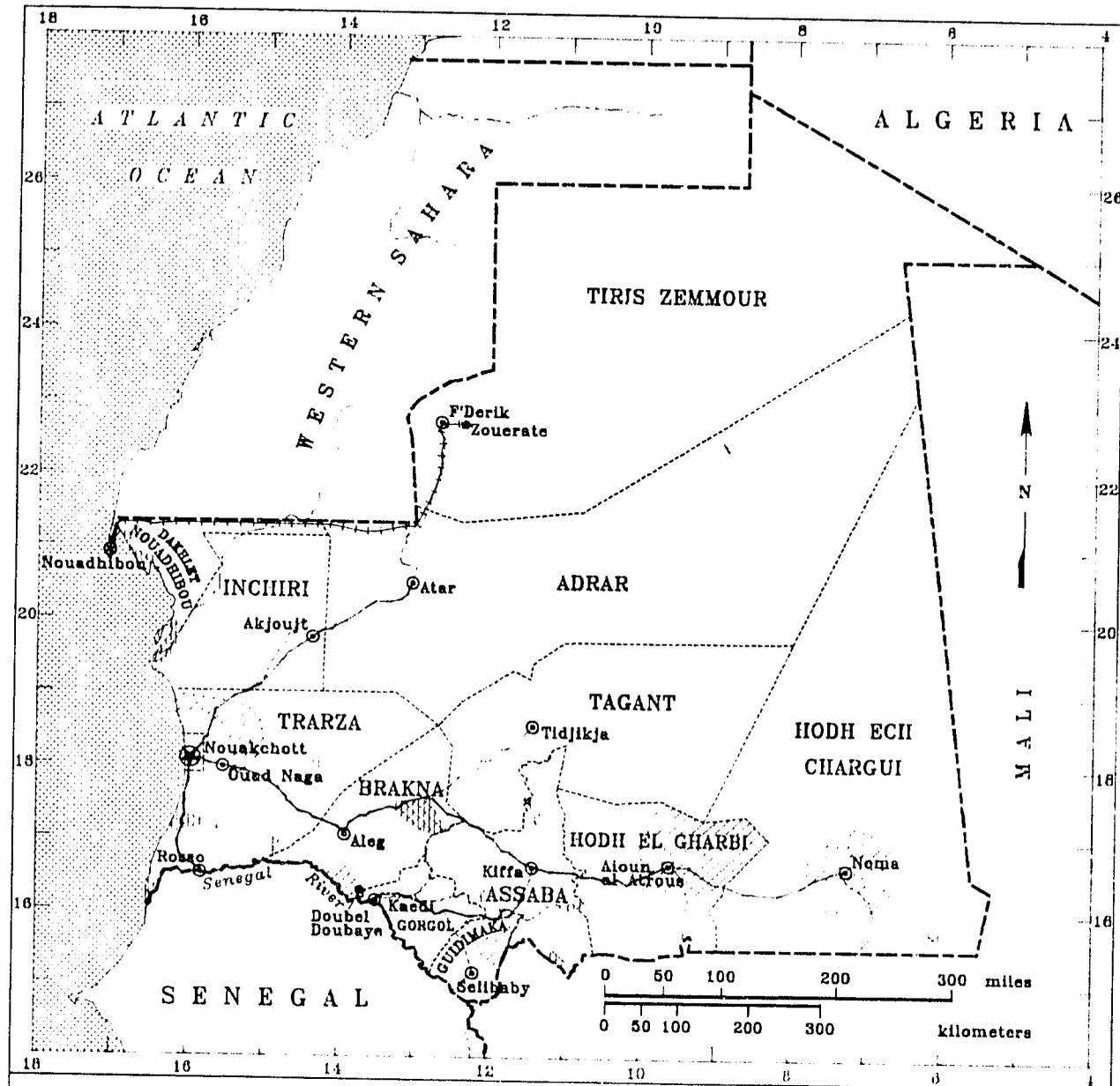
There appear to be few areas in Mauritania that will experience significant food access problems during 1989. The few areas of vulnerability that exist are quite small. In 1988, Mauritania experienced one of the best agricultural years on record, and should be able to meet at least 40 percent of cereal needs with domestic production. (In recent years, Mauritania has more often obtained one-third of its cereals through domestic production, one third through commercial imports, and one third from external aid.) Similarly, rainfall and satellite-derived vegetation data suggest that, in the southeast, pasturelands have had denser cover and have reached further north than in the previous six years (the picture in the southwest is more spotty). Current and pledged food aid should be adequate through the next harvest, assuming that it is targeted to those in need.

DRY FORECAST FOR 1989 RAINFALL IN THE SAHEL

The Synoptic Climatology Branch (SCB) of the U.K. Meteorological Office forecasts a 60% chance that the Sahel will receive less than 75% of normal rainfall. The SCB therefore expects rainfall to be less than 1988 (an average year compared to the long-term mean) but more than the "very dry years of 1986 and 1987".

As part of the SCB's research into the effects of sea surface temperatures on Sahelian rainfall, it has made experimental rainfall forecasts each year since 1986. The SCB employs four forecast methods, all based upon sea surface temperature anomaly patterns in April. Three statistical methods predict that 1989 will be dry to very dry. A dynamic general circulation model method predicts more rain in the Sahel than either of the statistical methods. At this early stage of research, the SCB has more confidence in the dry forecast. The SCB warns that the forecasts are experimental and must be used with caution. The forecasts are based on the assumption that sea surface temperature anomalies will not change in an unusual way between spring and summer. This assumption broke down for the 1988 forecast, leading the SCB to continue monitoring sea surface temperatures after April this year.

Map 1



MAURITANIA

- ⊕ National Capital
- ⊙ Regional Capital
- Cities and Towns
- International Boundary
- - - Regional Boundary
- Intermittent Drainage
- Primary Road
- - - Secondary Road
- Track
- ++++ Railroad

SUMMARY OF VULNERABILITY:
 Overlay Of Causes, Food
 Accounts, And Manifestations

-  Vulnerable to Famine
-  Significant Increases in Food Security

FEWS/PWA, June 1989

I. Vulnerable/At-Risk Populations

Methodology: Vulnerability Assessment

The FEWS vulnerability assessment uses agro-meteorological and socio-economic indicators to define a population's probable level of vulnerability to famine. Four stages of vulnerability are identified: vulnerable, at-risk, nutritional emergency, and famine. Because available indicator data are frequently of relatively poor quality, or without extensive baselines for reference, FEWS relies upon a "convergence of evidence", a comparison of several indicators, to interpret the meaning of any single indicator. Each section that follows (Causes, Food Accounting, Manifestations) uses indicator data in different ways to locate actual and potential food stress (see Appendix 1 for details). Each surface of food stress thus created is mathematically weighted for significance to vulnerability, subjective judgements are applied, and then the surfaces of food stress are combined into a summary of vulnerability. Maps for each surface and the summary are provided within this assessment.

Vulnerable zones in Mauritania are quite small and scattered (see Map 1). For the most part, the problems found in these zones are of several years' duration. The total rural population of the affected areas is 30,800. When urban populations are included, the total potentially vulnerable population becomes 113,500.

The main reason for ascribing vulnerability to the coast of Dakhlet Nouadhibou Region and the southwestern tip of Trarza Region is the fishing industry's poor performance during 1988. With lower revenues, fishermen in these areas should have more difficulty buying food in the market than in the immediately preceding years. There are some 1,500 people living along the Nouadhibou coast, and about 11,000 people living at the southern tip of Trarza.

The vulnerable spot in the far southeast is an area where Touaregs settled in early 1988. These pastoralists immigrated from Mali because conditions in their traditional grazing lands were too poor to support their herds. The Touaregs who arrived in Mauritania were quite destitute and included a large number of woman-headed households. Aid was provided to them soon after their arrival. By early 1989, there were still some 1,500 destitute Touaregs in the area. It is not clear how long this group will remain in Mauritania. If any have relatives in Mali who still have herds, further improvement in pastures there may allow those currently in southeastern Mauritania to return to Mali.

Areas in Assaba, Trarza, and Brakna were assigned high vulnerability values because of high rates of malnutrition found within them during late 1987 and early 1988. It is not certain that there is still a problem in these areas. The malnutrition levels seen were sufficiently high, however, that the areas warrant a second look (in these areas, village rates ranged from 25 to 69 percent of children weighing less than 80 percent of the standard for their heights). The rural population of these areas totals about 27,800 people.

Altogether, the areas of vulnerability are quite small. Donors and private voluntary organizations (PVOs) have pledged 13,700 metric tons (MT) of food for free distributions in 1989, which has already been programmed. They have also pledged 49,000 MT of stocks for the price support program, and expect to operate a Food-for-Work program that will supply some 7,600 MT of food over the year.

The areas that are doing much better than usual appear to be of a broader extent than the vulnerable zones, but are also quite scattered. These zones include a crescent in Trarza Region; Bababe, Ould Yenge, and Aioun el Atrous departments (in Brakna, Guidimaka, and Hodh el Gharbi regions, respectively); and territory surrounding Nema and Amourj towns in Hodh ech Chargui Region. Not only was rainfall well above normal in all of these areas, but also, there were no negative reports from the zone in Trarza,

local cereal production plus accountable aid and carry-over stocks were enough to meet the food needs of Bababe, Ould Yenge, and Aioun departments, and winter 1989 cereal prices were lower than those of 1988 in the Amourj and Nema neighborhoods, implying a greater availability of cereals in the market.

Prime among indicators that should be monitored for significant changes in vulnerability during the upcoming rainy season are the timing, intensity, duration, and geographic distribution of the rains. The rains relate not only to rainfed agriculture (essential in the southeast), but also to lowland and wadi recessional agriculture (practiced across Mauritania's agricultural zone) and to herding. A second group of flags are the timing, duration, and geographic spread of the annual flood of the Senegal River. A small or non-existent flood would cause duress from Rosso east to Kaedi, as happened in 1987. The results of nutritional surveys should be monitored, especially those carried out in previous high-malnutrition areas (as UNICEF/Mauritania plans to do in Boghé Department of Brakna Region in the near future). Reports of unusual population movements such as the departure of entire villages should be watched for, especially for villages that experienced severe pest damage this last year. Finally, reports of land access problems among the population along the Senegal River should be watched for. Traditional practice has allowed farmers in both Senegal and Mauritania to farm nearby land in the other country. Following the April disturbances in both countries, however, it is not clear what will happen during this rainy season. At the very least, there is sure to be some confusion as to who has rights to what land.

There are two areas of previously high vulnerability that are not on this year's list:

- Akjoujt Town, in Inchiri Region, was considered at risk of food crisis in 1988 owing to a two-year history of increasing malnutrition rates. From 1986 through June 1988 at least, the population of the town was projected to be on the order of 11,290 people. Following a severe flood in September, however, a new

survey found the population to be only 4,000 people. We assume that those people remaining in Akjoujt have sufficient means to obtain needed food. It is most likely that the people who left Akjoujt migrated to Nouakchott.

- People living along the Senegal River from Kaedi west were also considered at-risk in 1988. Flood recessional farmers in these areas came into 1987 with no food reserves and then experienced total crop failure when the river failed to flood. In contrast, the 1988 flood reached an extent not seen since 1974, although the duration of the flood was not optimal. While the harvest will not carry farmers through the 1989 harvest in most areas, there was at least a decent harvest by Mauritanian standards.

In addition, there are two areas that have been cited in-country as being vulnerable, but for which available data send conflicting signals:

- An area of pest damage in the southeast (see the unhatched area in southeastern Mauritania shown on Map 2) experienced a reduced rainfed harvest. Price data from the same area implies that the food supply situation is not that bad. The price data is from a fairly gross level, however, and food shortages may still show up this summer in individual towns in the southeast.
- According to reports from a development project in the area, the village of Doubel Doubaye, in the far southeast corner of Brakna Region, actually is vulnerable. The fact that the area does not show up on Map 1 is due mostly to scale. The data used in this assessment are predominantly at fairly gross level -- price, rainfall, and production zones overshadow the small blip that is Doubel Doubaye. There are probably other villages that have food security problems similar to those of Doubel Doubaye within Mauritania's agricultural zone. Villages immediately surrounding Doubel Doubaye, however, are reported to be in fairly good shape.

II. Causes of Reduced/Increased Access to Food

Methodology: Causes of Reduced or Increased Access to Food

Food is acquired through production, exchange, or transfer (gifts). Many factors, including rainfall, pests, floods, and warfare, can affect these acquisition mechanisms. This section provides a qualitative assessment of these factors and their likely impact on food access.

In Mauritania, direct food production takes the form of animal husbandry, fishing, and cereal, legume, and melon production. Resources used for exchange include mining wages, fish production, oasis production, livestock sales, and income from petty commerce. While estimates are available for some of these sectors at a fairly gross level (region, industry, or nation-wide), a more geographically refined understanding of the function of these sectors must be obtained on the basis of indirect indicators. The available indirect indicators show that, for the most part, Mauritania's food acquisition systems functioned fairly well (see Map 2 for analysis results and Appendix 2 for a list of indicators considered). From the food or resource production side, only two small areas had an overall poor year, and then only marginally so.

The areas of probably decreased food access along the Dakhlet Nouadhibou coast contain fishing villages. Using statistics for the tonnage of fish that pass through the Mauritanian state-owned company, SSPAM, 1988 production was much lower than the previous three years. Fish production was 21 percent less than that of 1987 and some eight percent less than that of 1986. Because the statistics are for the fishing industry as a whole, it is not possible to say whether the catch was better in the north or the south. It is also not clear to what degree the town of Nouadhibou (population 59,000) is affected by the slowdown in fish production. Besides the fish processing plant, activities

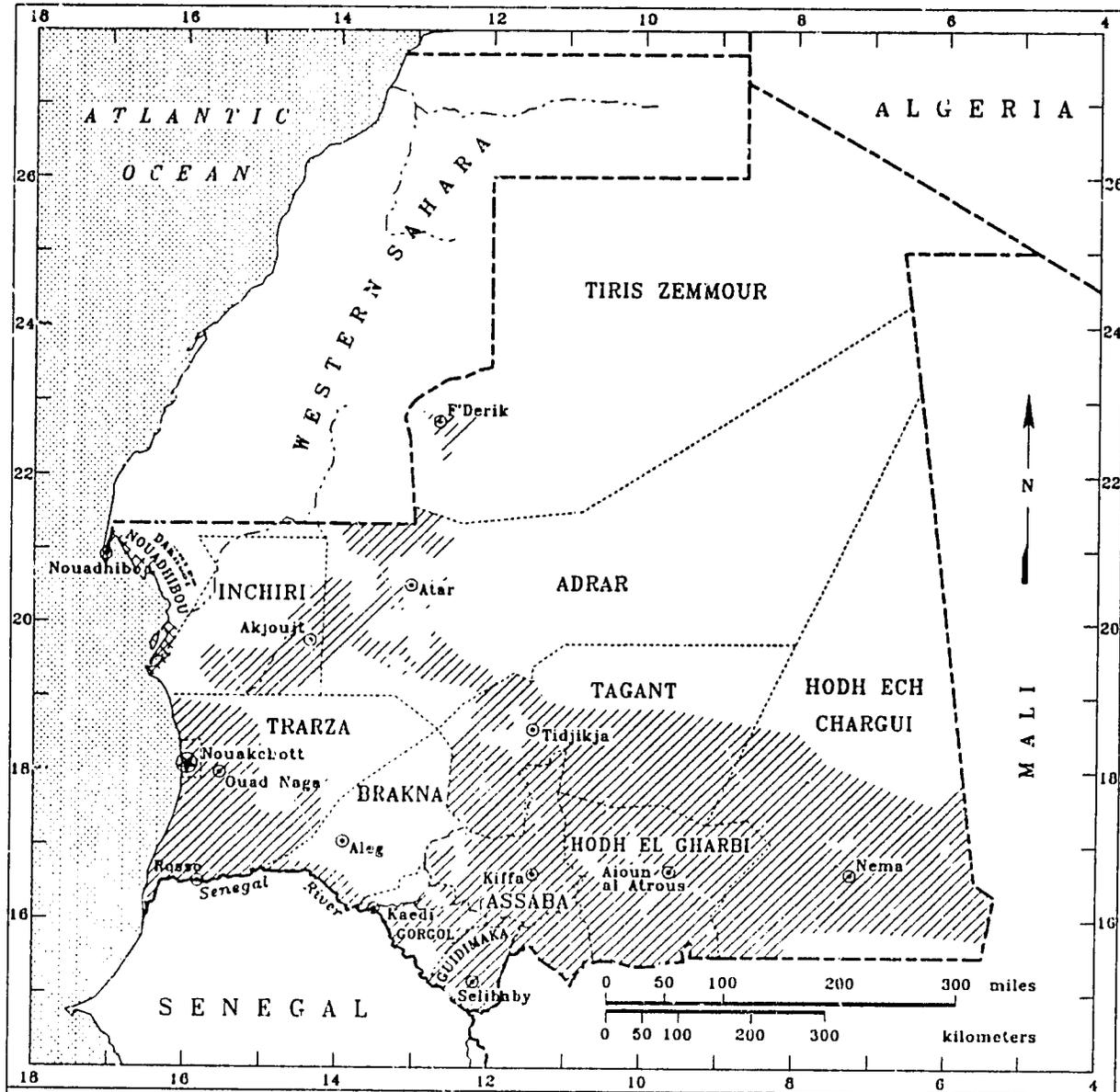
at Nouadhibou also include the shipment of iron ore from the F'Derik/Zouerate area and other port activities.

On the positive side, mine production (at F'Derik in Tiris Zemmour) has been holding steady after a period of increase, while employment rates at the mine have been stable over the past two years (following a decrease). Wages available to the mine workers therefore should also be stable. Oases are said to have done quite well in cereal production in 1988. The date harvest in southern oases is expected to be quite good. It is not as clear how the date harvest at the more northern oases (near Atar and Tidjikja) will fare, as many experienced heavy locust infestations. The situation will become clearer when the date harvest is in.

Rainfall and Normalized Difference Vegetation Index (NDVI - see inside back cover for explanation) statistics show 1988 vegetation potential to have been outstanding for agricultural and pastoral Mauritania, as in the rest of the Sahel. For rainfall, exceptions to this were found in Brakna and Hodh el Gharbi regions. For NDVI, exceptions were seen in eastern Brakna, western Assaba, eastern Gorgol, and eastern and southern Guidimaka regions. There were areas that had problems with floods that damaged dikes and obstructed wadi agriculture (small areas without hatching in Assaba and Hodh el Gharbi regions). Also, southeastern Mauritania and areas along the upper reaches of the Senegal River experienced strong pest damage to crops.

This information offers an incomplete picture of the resources available to Mauritians within the national food acquisition system. In a normal year, domestic production supplies only one-third of the country's cereal needs. The remainder must be made up through trade, or, failing that, aid. A prime source of income with which to trade is animal husbandry. Although statistics for that sector are not readily available, the relatively excellent 1988 vegetation cover deduced from satellite imagery implies that Mauritania's pastoral sector did well this last year.

Map 2



MAURITANIA

- ⊗ National Capital
- ⊙ Regional Capital
- Cities and Towns

- International Boundary
- Regional Boundary
- - - Intermittent Drainage

- CAUSES OF FOOD STRESS:
Consequences Of Factors
Affecting Food Access**
-  Significantly Decreased Food Access
 -  Probably Decreased Food Access
 -  Significantly Increased Food Access

FEWS/PWA, June 1989

III. Food Accounting

Methodology: Food Accounting

A quantitative account of all estimable food resources (production and aid) available for consumption until harvest is calculated using department-level data. Seed, feed, post-harvest losses, exports, and consumption-to-date are subtracted from this account. The months of food remaining are then calculated by dividing the food resources by the consumption rate (population times monthly consumption rate). Inadequate food access is assumed if stocks fall short of needs until harvest.

The current food accounting picture in Mauritania is similar to that of past years, in that carry-over stocks, local production, and food aid do not meet food needs in all but three departments (see Map 3). Even so, the 1988 harvest is the best ever seen¹ and could supply more than 40 percent of Mauritania's 1989 cereal needs. Because estimates of the contribution to the food supply of imports, the commercial sector, herding, and remittances are not available, the picture here is based chiefly on cereal production and is therefore skewed to the negative in non-cereal producing areas. It is quite possible, for instance, that herding and commerce contribute enough wealth in some regions to make up for the customarily small cereal harvests.

While it is not surprising that so little territory is food sufficient, the departments that did this well in 1988 are a surprise, especially when compared with the previous three harvests. In previous years, only the departments of Gorgol Region met food needs with their own production. In 1988 the food sufficient departments were Bababe in Brakna Region, Ould Yenge in Guidimaka Region, and Aioun el Atrous in Hodh el Gharbi Region. In 1987, Brakna production covered only

11 percent of local food needs, Guidimaka production provided 35 percent of needs, and Hodh el Gharbi production supplied 40 percent of food needs. The poor performance in Gorgol Region was attributed to heavy pest damage to lowland and river recessional crops. The success in Bababe and Aioun el Atrous appears to be due to dramatic increases in their respective lowland recessional harvests, while that in Ould Yenge can be attributed to a rainfed harvest that is twenty times the size of the 1987 rainfed harvest and sixty times that of the 1986 rainfed harvest. (Because Mauritanian agriculture takes place at the northern limit of the Sahelian agriculture zone, the year-to-year variation an area's crop production tends to be large.)

There is much more to Mauritania's food acquisition system besides agriculture and government sponsored food aid that should be accounted for, eventually. Purchases in the marketplace (mostly of imported foods), the contribution from non-cereal foods (both animal products and other farm produce), and transfers (gifts) from family or private charity are needed to complete the picture. It should then be possible to tell whether the amount of food available is truly sufficient.

IV. Manifestations of Reduced Access to Food

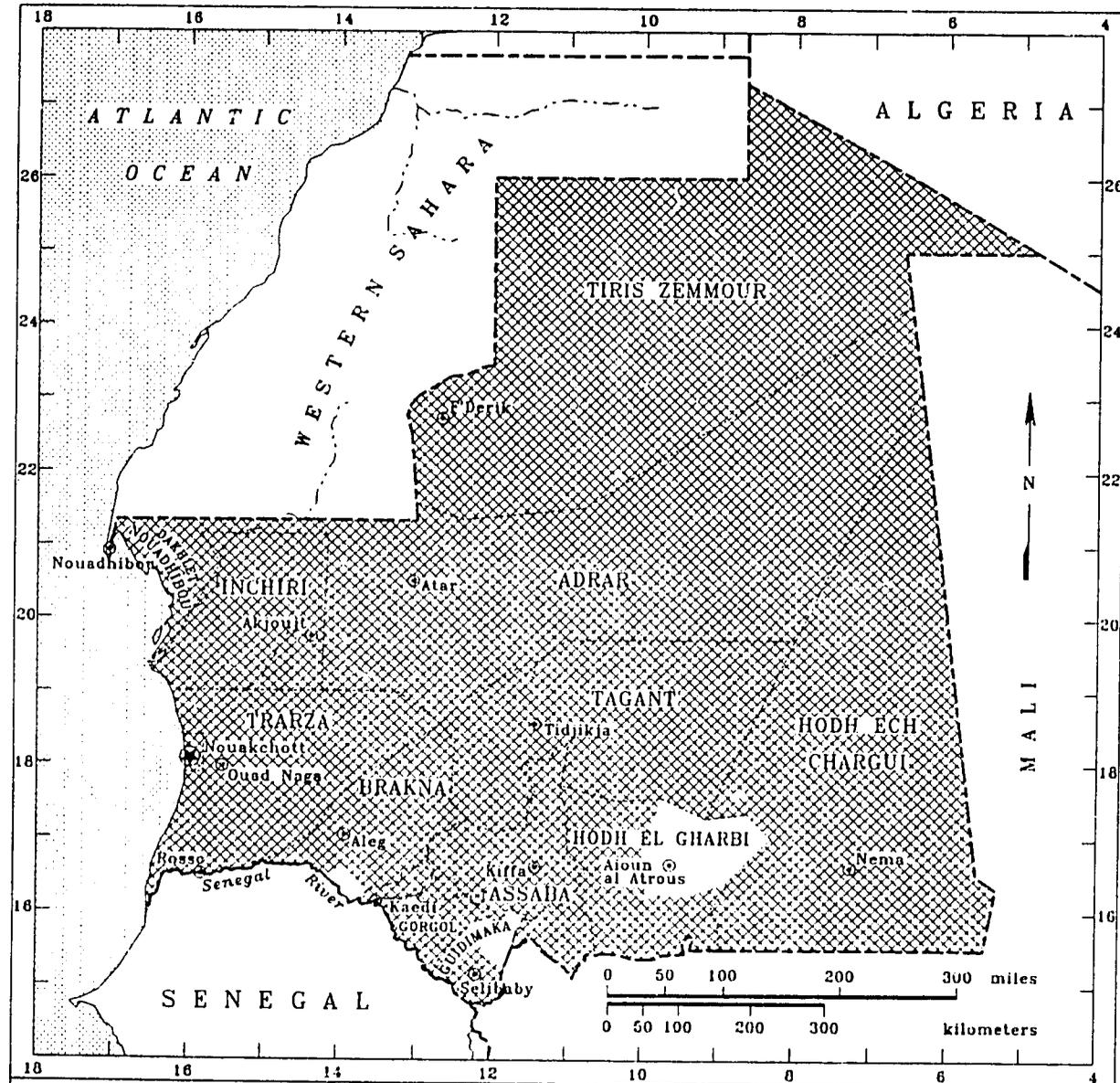
Methodology: Manifestations of Reduced or Increased Access to Food

Populations may manifest their current vulnerabilities to famine by their physical and socio-economic reactions to food access conditions. Based upon observed behaviors and conditions compared to a reference baseline, a subjective judgement is made of their degree of vulnerability.

Available information on the outcome of food acquisition is not as positive as that available for

¹ A new method of crop estimation was introduced into Mauritania during 1985/86, making comparisons with earlier production estimates difficult -- it may be that earlier harvests were larger than the record implies.

Map 3



MAURITANIA

- ⊙ National Capital
- ⊙ Regional Capital
- Cities and Towns
- International Boundary
- Regional Boundary
- - - - Intermittent Drainage

FOOD ACCOUNTING: Per Capita Access to Food

Inadequate Access at Department Level

FEWS/PWA, June 1989

the process of food acquisition (see Map 4 for results of analysis and Appendix 2 for list of indicators used). The problems found in the north (Dakhlet Nouadhibou, Inchiri, Adrar, and Tiris Zemmour regions) were identified through cereal price data. Prices in these areas are high and are increased over those of last year. Although this is the only indicator that is readily available for these areas, it is fairly weak, as there is little historical price data upon which to base interpretations.

Most of the problem areas found in the southwest (Trarza, Brakna, and Assaba regions) were identified through historical nutrition data showing very high malnutrition rates (25 to 69 percent of the children in the areas were found to weigh less than 80 percent of the standard weight for their height in surveys carried out in late 1987 and early 1988). People in these areas presumably have had few resources with which to obtain food in the past and, therefore, now have a longer way to go before obtaining adequate levels of food. The difference between the areas marked as significantly improved access and those marked as probable food access problems is that price data for the latter areas show cereal prices to have decreased over the last year. Again, historical nutrition rates are weak indicators, as much could have changed in children's nutritional status over the space of a year. The rates of malnutrition found, however, were sufficiently high that the areas warrant monitoring even two years later.

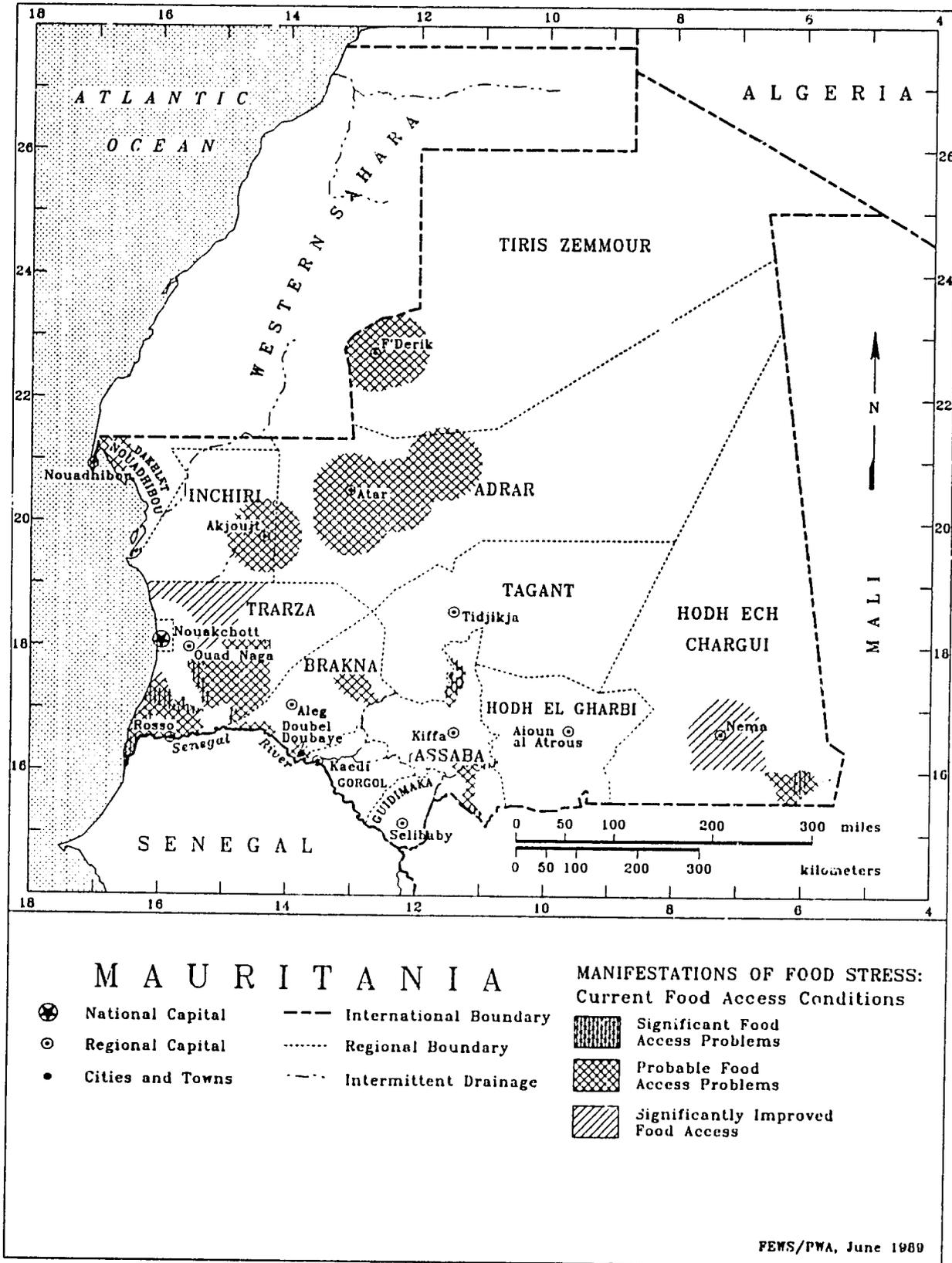
The one area where the assessment of food access problems is not based on nutrition data is that

surrounding the deficit village of Doubel Doubaye, in the southeastern corner of Brakna Region. This area has experienced crop failure two years in a row, and a development project in that area has found that the villagers are reduced to eating one meal a day in order to make resources last. The crop failure in 1987 came from a lack of flood, which affected Doubel Doubaye and surrounding territory. The 1988 failure has been attributed to pest damage (grasshoppers and birds), which did not affect every village in the area. Price data from nearby large towns suggest that the food security situation for the general area is not desperate. There could be other villages such as Doubel Doubaye, however, which may be in need of some assistance.

The area of food access problems in southeastern Hodh ech Chargui Region contains a group of about 1,500 Touaregs who arrived in Mauritania in early 1988 with almost no resources. This group has been monitored since then, so there can be confidence in the assessment. Again, part of the area is found to have lesser food problems owing to improvement in cereal prices over those of early 1988.

There are two areas of improved food access. That in the northeast of Trarza Region is an area where recent nutrition surveillance has shown very low levels of malnutrition, according to an unofficial report. The improved access surrounding Nema, in Hodh ech Chargui Region, was identified by the significantly lower prices found there, as compared to those of early 1988.

Map 4



APPENDIX 1

Mechanics of the Vulnerability Assessment

All available indicator data of major significance to the food security of Mauritania was gathered and analyzed for significance. The geographic boundaries for each were mapped as accurately as possible. Using a computer-based Geographic Information System (ArcInfo), the indicator maps were scored according to a three position scale of food stress to indicate whether they showed 1) an obvious cause of food stress, 2) no obvious food stress or significant increase in food access, or 3) a significant increase in food access (only applicable in areas without stress).

All indicators relating to "Causes" of food stress were overlaid to produce a summary surface of food stress as seen by these indicators (Map 2). A similar process was used for all indicators relating to "Manifestations" of food stress (Map 4). For the food accounting analysis, areas were mapped and scored as having adequate or inadequate access depending upon whether all food resources identified met assumed food needs (Map 3).

In a final step, the "Causes", "Manifestations", and "Food Accounting" summary maps were themselves overlaid for a grand summary of "Food Access" (Map 1). Analysts were free to use subjective criteria in applying food stress scores at each stage based upon their best judgments.

APPENDIX 2

Indicators Used In Mauritania Vulnerability Assessment

NDVI - Growing Conditions: The 1988 NDVI maximum was compared to the normal (1982-1987) yearly maximum. All areas significantly higher or lower (± 0.05 NDVI) than normal were identified. Areas of sparse vegetation (less than 0.1 NDVI) were excluded from this analysis. Sources: NOAA/NASA GAC NDVI

Rainfall: 1988 cumulative rainfall was compared to the 1968 to 1987 normal historic cumulative rainfall. All areas receiving more than 120 percent or less than 80 percent of normal were identified. Areas where 1988 cumulative rainfall was less than 200 mm were excluded from this analysis. Sources: Joint Agriculture Weather Facility and the Government of the Islamic Republic of Mauritania (GIRM) Meteorological Service (AGRHYMET).

Pest Damage: Areas in which pest damage was judged to have had a significant negative impact on food access were identified. Sources: GIRM/Crop Protection Service (CPS), GIRM/Agricultural Statistics Service (SSA), and USAID/Nouakchott.

Flooding: Areas in which floods were judged to have had a significant negative impact on food access were identified. Source: GIRM/SSA.

Contribution from Mining, Fishing, and Oases: For mining, 1988 production and employment rates were compared to those of 1986 and 1987. For fishing, 1988 production was compared to total production for 1985 through 1987. For oasis production, anecdotal reports were used to judge the success of production at groups of oases. Sources: SNIM, SSPAM, USAID/Nouakchott, GIRM/CPS, and FEWS/Mauritania.

Cereal Price Behavior: Comparison of February 1989 millet prices to February 1988 prices. Where the current average was greater, food access was judged to have declined; where less, food access was judged to have improved. Sources: CSA, GIRM/Ministry of Economy and Finance, World Bank Life Measurements Survey.

Food Production Trend: By region, subjective assessment of the possibility that carry-over stocks 1) exist and 2) are substantial. Based on historical agricultural statistics and population growth from 1986 through 1988. Sources: Population data from GIRM/CEDES; production data from GIRM/SSA and SONADER.

Nutrition Data: Areas in which 1987/88 nutrition rates were of serious concern (more than 25% of children weighing less than 80% of standard weight for their height), plus one area in which 1989 nutrition rate was exceptionally good. Source: UNICEF, *Medecins Sans Frontieres*, *Terres des Hommes*, and World Vision.

Reported Areas of Risk: Areas reported to have experienced significant decreases in food security. Sources: FEWS/Mauritania, GIRM Food Security Commission (CSA), UNICEF, and *Medecins Sans Frontieres*.

Conflict/Civil Disruption: No reports were received from which conflict could be judged to have had a significant negative impact on food access within Mauritania.

Food Accounting notes and sources: Net harvest includes millet, sorghum, maize, and rice and is estimated at the department level. The food accounting includes planned distributions of emergency food aid for calendar year 1989 and a 10,000 MT household carry-over stock, which was attributed to departments according to 1987 production estimates for rainfed, river recessional and lowland recessional crops. The food accounting does not count imports or off-season production. Rate of consumption used averages to 165 kg per person per year over the whole country, but varies by region according to a 1980 AID/RAMS survey. Nouakchott population is accounted for as a separate department. Date of harvest is chosen as December 31 as a compromise between the rainfed and recessional/irrigated agricultural calendars. Amount of cereals consumed is based on a June 1989 population times five months of consumption to give amount consumed from harvest until June 1. Sources: GIRM/SSA, SONADER, GIRM/CEDES, USAID/Nouakchott, GIRM/CSA, and FEWS/Mauritania.

Key Terms

At Risk - FEWS Reports employ the term "at risk" to describe those populations or areas either currently or in the near future expected to be lacking sufficient food, or resources to acquire sufficient food, to avert a nutritional crisis (i.e., a progressive deterioration in their health or nutritional condition below the status quo), and who, as a result, require specific intervention to avoid a life-threatening situation.

Where possible, food needs estimates are included in the FEWS reports. It is important to understand, however, that no direct relation exists between numbers of persons at risk and the quantity of food assistance needed. This is because famines are the culmination of slow-onset disaster processes which can be complex in the extreme. The food needs of individual populations at risk depend upon when in the disaster process identification is made and the extent of its cumulative impact on the individuals concerned. Further, the amount of food assistance required, whether from internal or external sources, depends upon a host of considerations. Thus the food needs estimates presented periodically in FEWS reports *should not* be interpreted to mean food aid needs, e.g., as under PL480 or other donor programs.

ITCZ - The Intertropical Convergence Zone (ITCZ) is where the high pressure system originating in equatorial regions of the Atlantic (the St. Helena's High) collides with the Azores High descending from the north. The ITCZ tends to move northward during the spring and summer in response to normal global weather patterns. The position of the ITCZ normally defines the northern limits of possible precipitation in the Sahel; rainfall generally occurs 100 to 300 kilometers south of the ITCZ.

NDVI - Normalized Difference Vegetation Index (NDVI) images are created at the laboratory of the National Aeronautic and Space Administration (NASA) Global Inventory Modeling and Monitoring System (GIMMS). These images are derived from Global Area Coverage (GAC) imagery (of approximately 4 km resolution) received from the Advanced Very High Resolution Radiometer (AVHRR) sensors on board the National Oceanic and Atmospheric Administration (NOAA) Polar Orbiting series of satellites. The polar orbiter satellites remotely sense the entire Earth and its atmosphere once each day and once each night, collecting data in 5 spectral bands. Bands 1 and 2 sense reflected red and infra-red wavelengths respectively, and the remaining 3 bands sense emitted radiation in 3 different spectral bands. The NDVI images are created by calculating

$$(\text{infrared} - \text{red}) / (\text{infrared} + \text{red})$$

for each pixel from the daytime satellite passes. Since chlorophyll reflects more in the infrared band than in the red band, higher NDVI values indicate the presence of more chlorophyll and, by inference, more live vegetation. A composite of daily NDVI images is created for each 10-day period, using the highest NDVI value for each pixel during that period. This technique minimizes the effects of clouds and other forms of atmospheric interference that tend to reduce NDVI values. NDVI is often referred to as a measure of "greenness" or "vegetative vigor." The NDVI images are used to monitor the response of vegetation to weather conditions.

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