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1986 GRASSHOPPER & LOCUST INFESTATIONS

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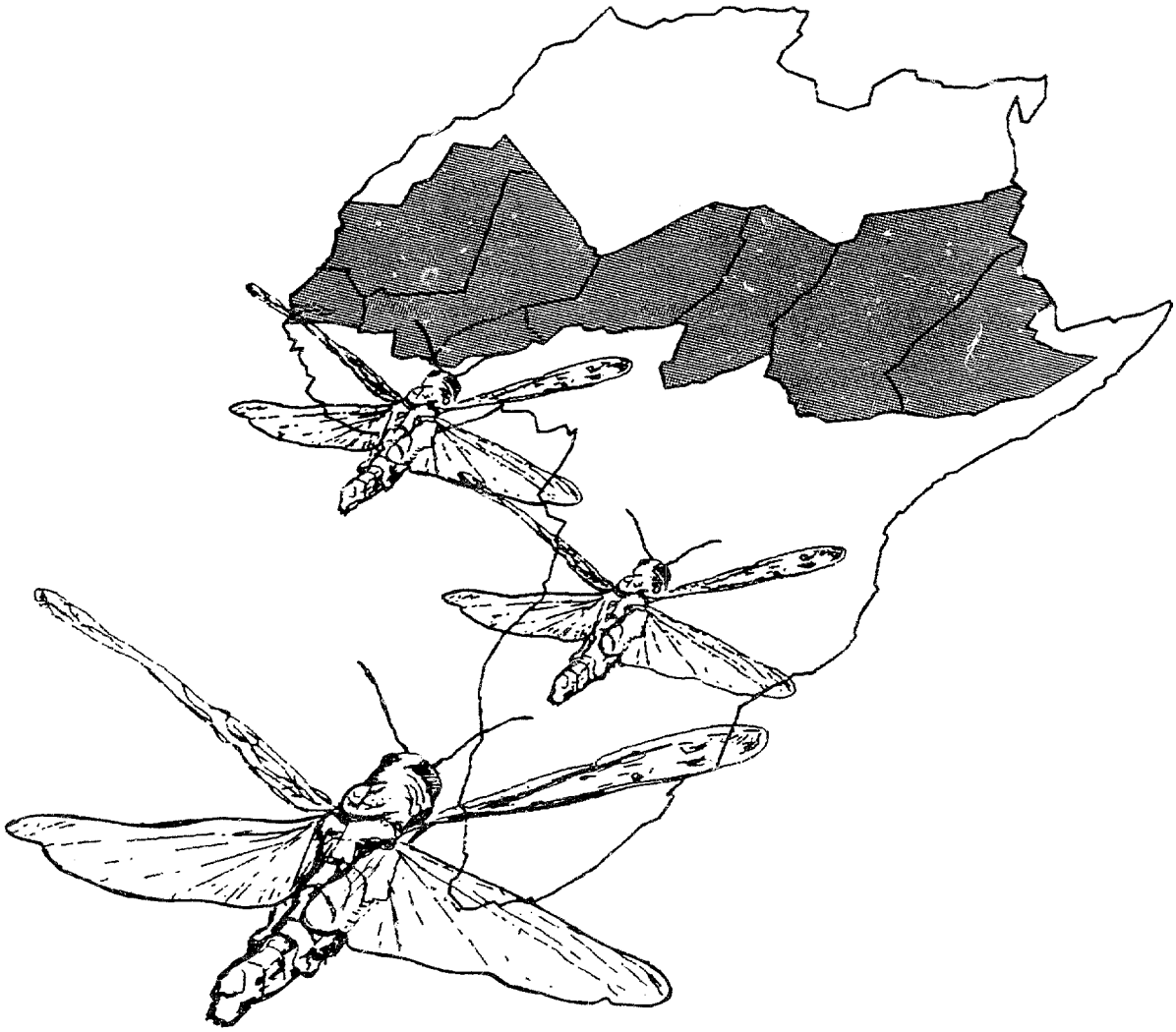

Africa Bureau, U.S. Agency for International Development

Famine Early Warning System Special Report

GRASSHOPPERS/LOCUSTS

Looking Back At 1986

Prepared for the
Africa Bureau of the
U.S. Agency for
International Development

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EXECUTIVE SUMMARY

This report takes a retrospective view of the 1986 locust and grasshopper infestations in Mauritania, Senegal, Gambia, Mali, Burkina, Niger, Chad, Sudan and Ethiopia. Using publicly available data that describe various facets of the infestations and their effects, the report attempts to answer three questions:

- What was the severity and impact of the 1986 grasshopper infestations?
- How efficient and effective were control measures?
- What costs and benefits are associated with the control effort?

A table of basic indicators describing the infestations in the nine countries forms the basis for the report. The data, or lack of it, show that it is difficult to objectively construct an historical or technical context around the data from the 1986 infestations in which to judge whether infestations in that year were more severe, or less so, than in other years. It is also difficult to compare indicators of severity and impact from the nine countries examined in the report because the indicators are not tied to an objective standard, and may describe differing conditions with the same terms. However, the data used for this analysis are the ones being used by decision-makers to plan for 1987 infestations, and relative rankings of the nine-country data do establish similarities, anomalies, and patterns in national-level data.

Despite some of the limitations of the data, the following conclusions about the severity and impact of the 1986 infestations seem to emerge from the measures examined in the report:

- The aggregate amount of damage caused by the grasshoppers was much less than feared. The losses are more on the scale of localized, perhaps "near-normal" stress than national calamities. While the losses are unfortunate, they are certainly not out of the normal realm of experience in the countries examined.
- The infestations seen in Sudan and Ethiopia are clearly of a different nature than those seen in the Sahel.
- The net contribution of grasshopper-related damage to 1986-87 food deficits was significant in some countries, but may not have been any greater than damage caused by other pre-harvest factors.

Looking at what are believed to be the limited losses due to the infestations, one can attribute a good portion of them to the control efforts. However,

- if the benefits of early treatment and less reliance on aerial control are real, the treatment that occurred looks late, expensive, and far beyond the capacities of the countries to provide for themselves;
- most expert observers indicate that the dry weather conditions in July and August in Senegal, Mauritania and Mali had as much to do with limiting losses as did control efforts;

- the incentives to strengthen ground control operations are likely to be negatively skewed by the predisposition of international assistance to provide aerial treatment;

- without better data and standard measures of the level of potential damage inherent in a particular infestation, no firm conclusions can be reached on how effective such control efforts actually were at limiting damage.

The following conclusions about the costs and benefits of the control effort appear to be supported by the data available:

- The value of the production saved was not generally greater than the cost of saving it. In five of the nine countries, the value of saved production did not equal or exceed the value of the inputs received for treatment. The estimated savings in Burkina and Niger were notably greater than elsewhere, and pulled the cost-benefit ratio for the whole group up to a positive level.

- Levels of donor contributions relate only marginally to the estimated level of threat, and to levels of actual damage incurred.

- Air treatment costs were a very significant component of the total control budget.

- The limitations of the data do not permit extensive conclusions to be drawn.

- The existing data do seem to support a view that the overall impact of the infestations was modest, as was the impact of the control efforts.

Introduction

This is the first of two FEWS Special Reports on Grasshoppers. It presents a retrospective look at the grasshopper infestation of 1986 in seven countries in the Sahel (Mauritania, Senegal, Gambia, Mali, Burkina Faso, Niger, and Chad), and Sudan and Ethiopia. It addresses three questions:

- What was the severity and impact of the 1986 infestation?
- How efficient and effective were control measures?
- What costs and benefits are associated with the control effort?

The foundation of the report is the data found in Table 1, which is entitled "Analysis of the Impact of Grasshopper and Locust Control Measures in Sub-Saharan Africa". Table 1 was compiled from USAID, Food and Agriculture Organization (FAO), Office of Foreign Disaster Assistance (OFDA), host country government and other documents, most of which are available to the public. The source for each individual data item is noted in an adjoining column to the data. Notes about some of the data are found in Appendix 1.

A second FEWS Special Report on Grasshoppers is in preparation. It will focus on a prospective look at the 1987 infestation.

Please note that throughout this report the term grasshopper will refer in general to three specific species: the Senegalese Grasshopper (Oedaleus senegalensis), the Desert Locust (Shistocerca gregaria), and the Migratory Locust (Locusta migratoria). Where reference is intended to one of these species in particular, its complete name will be used.

1. An Analysis of the Data Available on the 1986 Infestations

When the proverbial blind men tried to describe an elephant by what they were able to feel with their hands, there was of course a wide range of error in their descriptions. Had they been asked to describe one in terms relative to other elephants, the range of error might have been wider still. In attempting to determine the severity and impact of the 1986 infestations, one is implicitly faced with an analogous situation. It is difficult to describe this year's infestations, as the data available are few in number, sometimes of suspect accuracy, and without uniform meaning from country to country. It is equally challenging to relate an infestation occurring in one area this year to another in a neighboring country, or to others in past years. The data are simply incomplete, the normal baseline level of infestation in most areas unknown, and the historical record too shallow to permit a solid description or context to be constructed.

The problem is not a sterile one. Upon determinations like these ride basic decisions about the economically-justifiable level of control efforts, the geographic targeting of control resources, the nature and quantity of emergency aid for affected populations, and the amount of preparation required to meet the threat of infestations in succeeding years.

Look for a moment at the historical context in which the infestations of 1986 should be placed. Were they any worse than the problems of 1985, or those of 1975, or those of the 30's and 40's? The answer is that one cannot tell. Anecdotal evidence from infestations in Morrocco, or Ethiopia, or elsewhere sometimes gives a feel for the extent of local economic loss, or a vivid view of the ankle-high depth of a swarm on the ground, or the busy picture of millions of grams of vegetation being consumed every day by hungry hordes. Yet these measures are typically not very useful for comparison or judgement.

Another grid of contextual measurement which might have helped to determine the intensity or severity of a particular infestation is an empirically determined baseline or threshold measure of injury. When the infestation mounts above such a level, control efforts might be activated to protect against economically or socially undesirable amounts of damage. Such a measure does not yet exist.

Experts in plant protection frequently assume that the pre-harvest loss in Sahelian Africa from all factors (grasshoppers, birds, rodents, other insects, etc.), every year, runs up to 30% or higher of the gross harvest. Of this 30% or greater loss, grasshoppers may be responsible for roughly 5 to 18% (or between a sixth and a half of all pre-harvest losses), every year. If this assumption is correct, years in which there are particularly heavy infestations should see losses from grasshoppers at rates higher than the 5-20%. Table 1 shows that the 1986 loss rates due to grasshoppers are largely within a 0 to 6 per cent rate.

The exercise, then, of developing an accurate assessment of, or context for, a particular infestation is problematic. However, the experience of using insufficient data that are of uncertain quality to make critical determinations about the use of scarce resources, is nothing new in the Third World. Decision-makers have learned to make the best use of the data that are available, explicitly playing them off the impressions and educated guesses of people familiar with the area and the discipline involved. The data in Table 1 are products of this type of process. Data collected or sent in from the field have been refined by local and international expertise. They have then been published in the documents from which almost all of Table 1 is drawn. Most of these documents are in the public domain and are currently being used as a basis for planning grasshopper and locust control efforts in 1987.

Where the analysis in this report, using this published data, runs in a similar vein to the general perceptions about the infestations, one might be tempted to assume that the data are good enough. Where the analysis runs counter to these perceptions, a more interesting set of alternatives are posed: either the interpretation of the data is incorrect, the data are not sufficient to permit a valid conclusion, or the general perception may not reflect reality. Whatever the case may be, decision-makers are currently using these same data in a much more immediate fashion to make concrete decisions. What do the data show?

Table 1 (below) displays a series of basic indicators of the severity and impact of the infestations and of the effectiveness and efficiency of the control effort, as well as some preliminary and cautious evaluations of the costs and benefits of the control efforts. Appendix 1 annotates some of the data found in Table 1, and describes some of the problems associated with the quality of the data. Sections 2, 3, and 4 of this report follow the table, and use particular

indicators derived from Table 1 to give a complementary and more graphic illustration of what is shown there in tabular form. Rather than repeatedly cite in following sections the qualifications and cautions about the strength of the data, it should be understood here that:

- observations about the data are contained in Appendix 1;
- these data are the best currently available;
- most would agree that the data are not of excellent quality;
- these data are currently being used to make decisions about future courses of action.

TABLE 1:

Analysis of the Impact of 1986 Grasshopper and Locust Control Measures in Sub-Saharan Africa

	Mauritania S	Senegal S	Gambia S	Mali S	Burkina S	Niger S	Chad S	Sudan S	Ethiopia S	ALL
PRODUCTION (Thousands of Metric Tons)										
Gross Production	125.0 U	964.0 U	144.0 C	1,780.0 U	1,917.0 U	1,807.0 U	685.0 U	4,300.0 F	6,504.0 U	18,226.0
Product Lost to Grasshoppers	10.0 F	50.0 F	1.0 E	30.0 F	8.3 F	108.0 F	24.0 F	9.2 E	0.5 E	241.0
Product Saved	10.0 F	70.0 F	1.0 E	30.0 F	91.5 F	108.0 F	30.0 F	9.2 E	0.5 E	350.2
Production Directly Affected	20.0 F	120.0 F	2.0 E	60.0 F	99.8 F	216.0 F	54.0 F	18.5 E	1.0 E	591.3
AREA (Thousands of Hectares)										
Total Cultivated Area	260.0 E	2,300.0 H	165.0 F	2,102.0 H	3,250.0 H	4,500.0 F	1,255.0 F	8,400.0 H	5,610.0 H	27,642.0
Total Area Treated	293.1 F	1,459.8 F	259.2 F	594.0 F	248.2 U	388.8 F	174.2 F	370.0 U	10.4 O	3,797.7
Area Treated before 10/86	189.0 f	774.9 f	2.3 f	364.0 E	39.2 E	162.9 E	27.0 f	37.0 E	10.4 O	1,606.7
Area Treated by Air	193.1 F	1,159.8 F	247.7 F	503.0 H	212.0 F	253.0 F	147.8 F	333.0 U	0.0 O	3,049.4
Area Treated from Ground	100.0 F	300.0 F	11.5 F	91.0 H	36.2 U	135.8 F	26.4 F	37.0 U	10.4 O	748.3
ESTIMATED VALUE OF METRIC TON	$120 f	$171 f	$171 E	$166 f	$120 f	$111 f	$133 f	$88 E	$100 E	$131
VALUE (Thousands of Dollars)										
Gross Production	$15,000 D	$164,844 D	$24,624 D	$295,480 D	$230,040 D	$200,577 D	$91,105 D	$378,400 D	$650,400 D	$2,050,470
Production Directly Affected	$2,400 D	$20,520 D	$342 D	$9,960 D	$11,974 D	$23,976 D	$7,182 D	$1,628 D	$100 D	$78,082
Production Lost to Locusts	$1,200 D	$8,550 D	$171 D	$4,980 D	$997 D	$11,988 D	$3,192 D	$810 D	$50 U	$31,938
Product Saved	$1,200 D	$11,970 D	$171 D	$4,980 D	$10,976 D	$11,988 D	$3,990 D	$810 D	$50 D	$46,135
DONOR INPUTS (Thousands of $)	$3,590 E	$8,277 E	$1,846 E	$8,274 E	$2,286 E	$3,200 E	$3,393 E	$6,752 E	$4,152 E	$41,770
DISTRIBUTION OF DONOR INPUTS: AIR/GROUND										
All Inputs for Air Treatment ($ 000)	$3,059 E	$6,186 E	$1,441 E	$5,501 E	$1,175 E	$408 E	$1,773 E	$3,836 E	$150 E	$23,529
Inputs for Airplane & Support ($000)	$1,329 E	$3,757 E	$465 E	$3,204 E	$414 E	$135 E	$446 E	$630 E	$150 E	$10,530
Balance for Ground Treatmnt & Stocks	$531 D	$2,091 D	$405 D	$2,773 D	$1,111 D	$2,792 D	$1,620 D	$2,916 D	$4,002 D	$18,241
Area Treated Air/Total Area Treated	65.88%D	79.45%D	95.56%D	84.68%D	85.41%D	65.07%D	84.85%D	90.00%D	-	80.30%
Air Treatment as % All Donor Inputs	56.33%D	74.74%D	78.06%D	66.49%D	51.40%D	12.75%D	52.25%D	56.81%D	3.61%D	56.33%
Airplane as % of All Donor Inputs	37.02%D	45.39%D	25.19%D	38.72%D	18.11%D	4.22%D	13.14%D	9.33%D	3.61%U	25.21%
Inputs for Air Treatment per Hectare	$15.84 D	$5.33 D	$5.82 D	$10.94 D	$5.54 D	$1.61 D	$12.00 D	$11.52 D	$14.42 U	$7.72
Inputs for Airplane & Support per HA	$6.88 D	$3.24 D	$1.88 D	$6.37 D	$1.95 D	$0.53 D	$3.02 D	$1.89 D	$14.42 U	$3.45
EFFECT ON PRODUCTION YIELDS :										
Kilograms Lost per Hectare Treated	34.1 8	34.3 D	3.9 D	50.5 D	33.5 D	277.8 D	137.8 D	24.9 D	48.1 D	63.5
Kilograms Saved per Hectare Treated	34.1 8	48.0 D	3.9 D	50.5 D	368.5 D	277.8 D	172.2 D	24.9 D	48.1 D	92.2
PERFORMANCE MEASURES : (in US $)										
Donor Inputs per Hectare Treated	$12.25 8	$5.67 D	$7.12 D	$13.93 D	$9.21 D	$8.23 D	$19.48 D	$18.25 D	$399.23 D	$11.00
Donor Inputs perMT Directly Affected	$179.50 8	$68.98 D	$923.00 D	$137.90 D	$22.91 D	$14.81 D	$62.83 D	$364.97 D	$4,152.00 D	$70.64
Donor Inputs per MT Saved	$359.00 8	$118.24 D	$1,846.00 D	$275.80 D	$24.99 D	$29.63 D	$113.10 D	$733.91 D	$8,304.00 D	$119.28
Value Saved per $1.00 of Donor Input	0.33 8	1.45 D	0.09 D	0.60 D	4.80 D	3.75 D	1.18 D	0.12 D	0.01 D	1.10

****

S=Source: U=USAID; O=OFDA; F=FAO; f=Derived from FAO Data; H=Host Country Govt.; E=FEWS Estimate from these same sources; C=CILSS/FAO; D=Derived from these same data.

** See Annex 1 for notes about the data shown here.

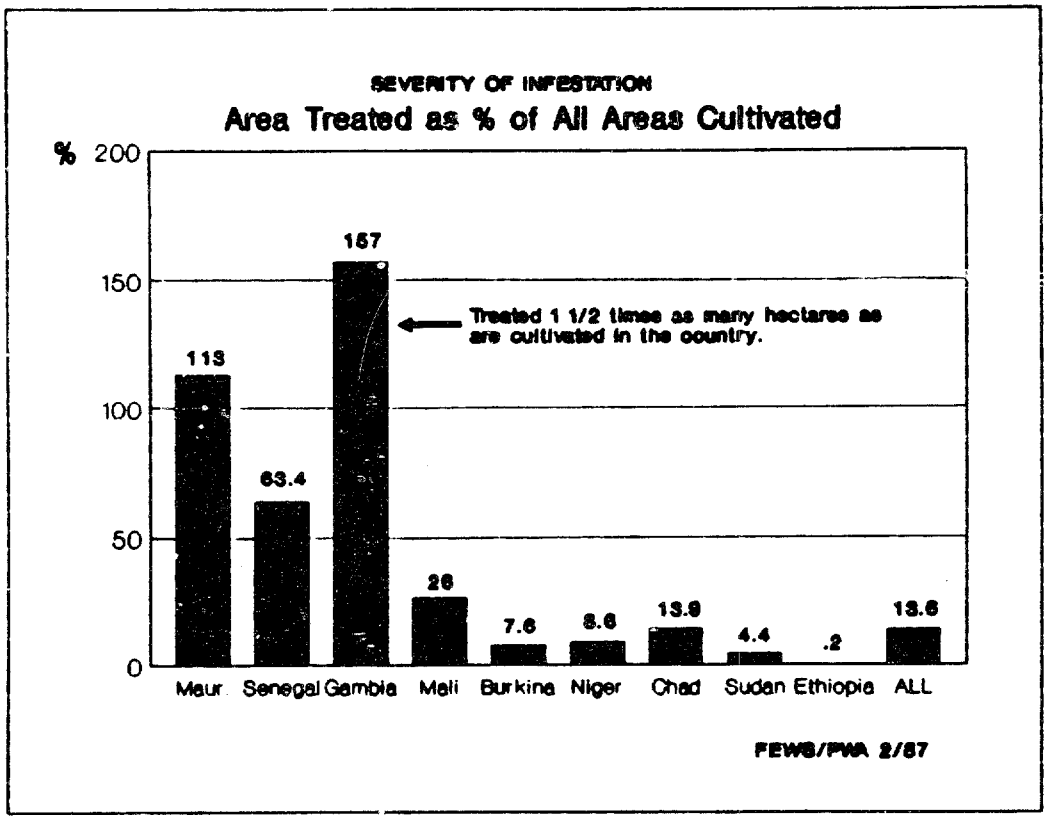
TABLE 1

2. Severity and Impact of the 1986 Infestation

2.1. Areal Extent of the Infestation

Chart 1 relates the total number of hectares treated in the control effort to the total number of hectares cultivated in the country. Generally, the higher the percentage, the greater the chance that agricultural production might have been placed at risk of loss from the infestation.

Chart 1. Area Treated as Percentage of Total Cultivated Area



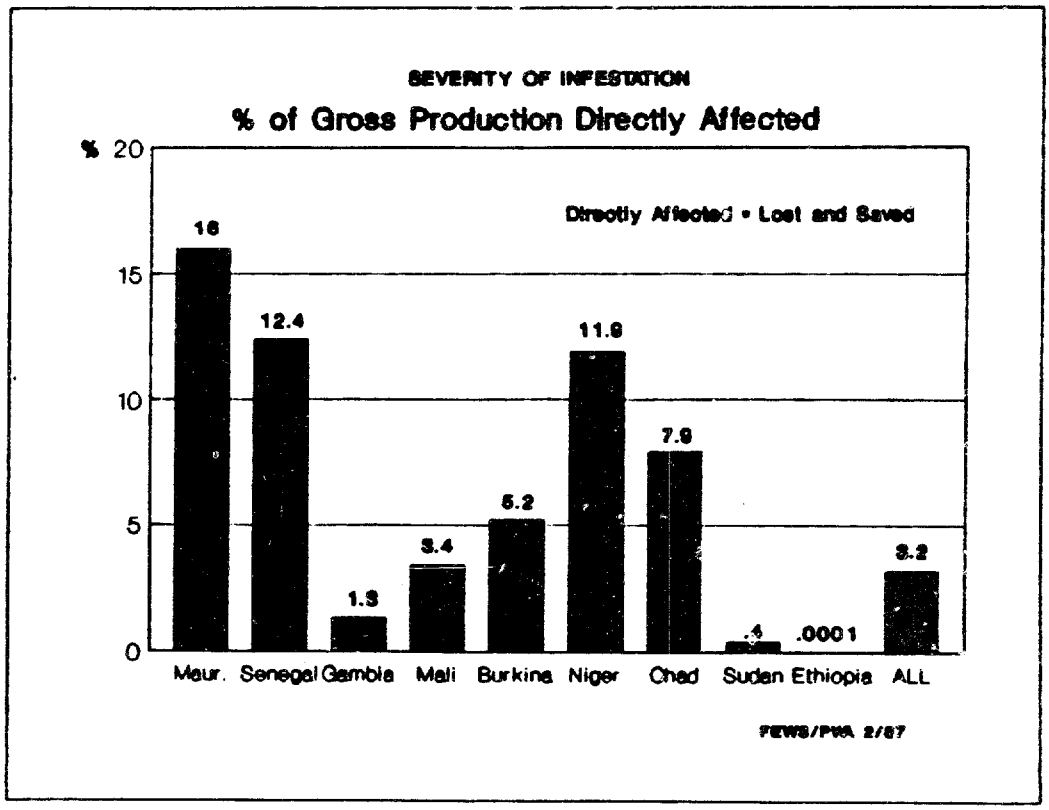
As is seen, the extremely high percentage shown for The Gambia dwarfs all the other figures. Almost four times as many hectares were sprayed as exist under cultivation in The Gambia. The conclusion must be that either many non-agricultural areas were sprayed, or that many cultivated areas were sprayed more than once. As is shown in Table 1, the number of hectares which were sprayed in The Gambia before the end of September (when harvests are underway, and the last grasshopper generation of the year is laying its eggs) was extremely small. This suggests that wherever the treatment occured, its impact in 1986 (and in 1987, by reducing the number of eggs laid) was limited. The FAO Joint Review team noted as much, and determined that the number of hectares sprayed would be difficult to economically justify.

Senegal, Mauritania, and, to a lesser extent, Mali also show relatively higher amounts of treated areas than the other countries. While the general perception is that the infestation was particularly severe in these countries, and so might indicate the need for more extensive spraying, another feature of the control effort may partially explain the high numbers. The "big plane" option for spraying was implemented in all these four countries. The big plane (in this case four DC-7's) is most effective in hitting large contiguous areas. It is an option which allows the use of a grasshopper control strategy which emphasizes hitting infestations wherever they might be found, anticipating that they may eventually move to cultivated areas. Where this strategy was determined useful by host governments, large infested tracts of grassland were sprayed.

2.2. Impact of the Infestation on Gross Production

2.2.1. Chart 2 shows the percentage of each nation's gross agricultural production that was directly affected (lost or saved) by control efforts. It gives a relative view of the percentage of the potential harvests that were immediately affected by the infestations. A broader indication of the percentage of the nation's potential gross harvest that was put at some level of risk of loss by grasshoppers is not possible to construct. The definitions of "at-risk" vary too greatly between countries in the available documentation to give a fair relative ranking to the size of the potential threat (see Appendix 1 for a discussion of estimates of production at risk).

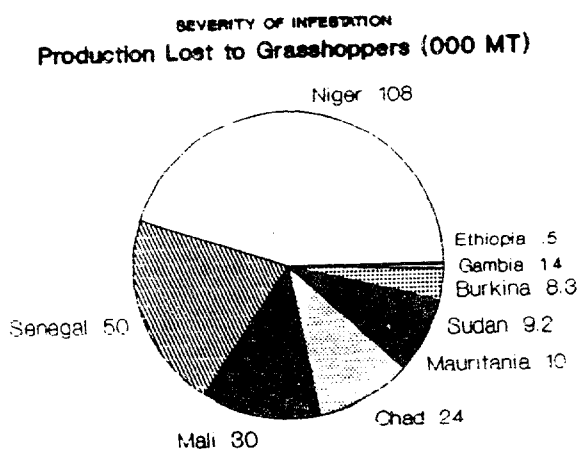
Chart 2. Directly Affected Production as a Percentage of Gross Production



Relatively high percentages of the gross production that was either lost or saved are shown by Senegal, Niger, and Mauritania. Very low figures are found for Sudan and Ethiopia. One would expect that in those areas with the most to potentially lose, there might be correspondingly high levels of control activities if the threat were clear and the control effort responsive. Table 1 shows that the three countries with high percentages rank first, third, and fifth in terms of number of hectares treated. Sudan, on the other hand, shows a relatively high number of hectares treated (370,000) to protect a relatively small percentage (.4%) and actual tonnage (18,500 MT) of its national crop. Some of this seemingly excessive caution may, however, be due to a concern for the relatively greater potential for explosive growth of (and to years of experience with) the Desert Locust, than for the Senegalese grasshopper, more common in the Sahelian countries examined here.

2.2.2. Charts 3a and 3b show the actual production lost to grasshoppers, and the production saved by control efforts, while Chart 4 shows the percentage of the the gross harvest that the lost production represents.

Chart 3a. Product Lost to Grasshoppers



3b. Product Saved from Grasshoppers

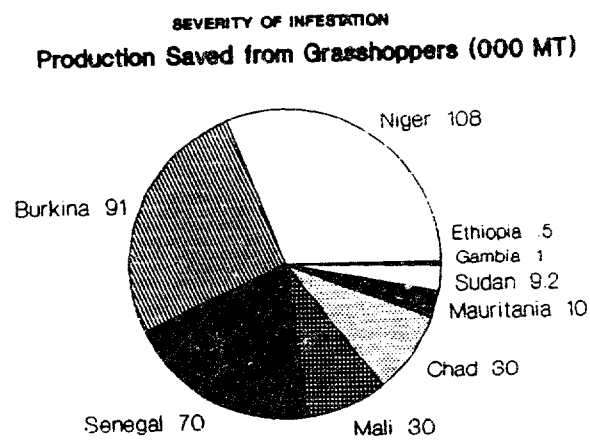


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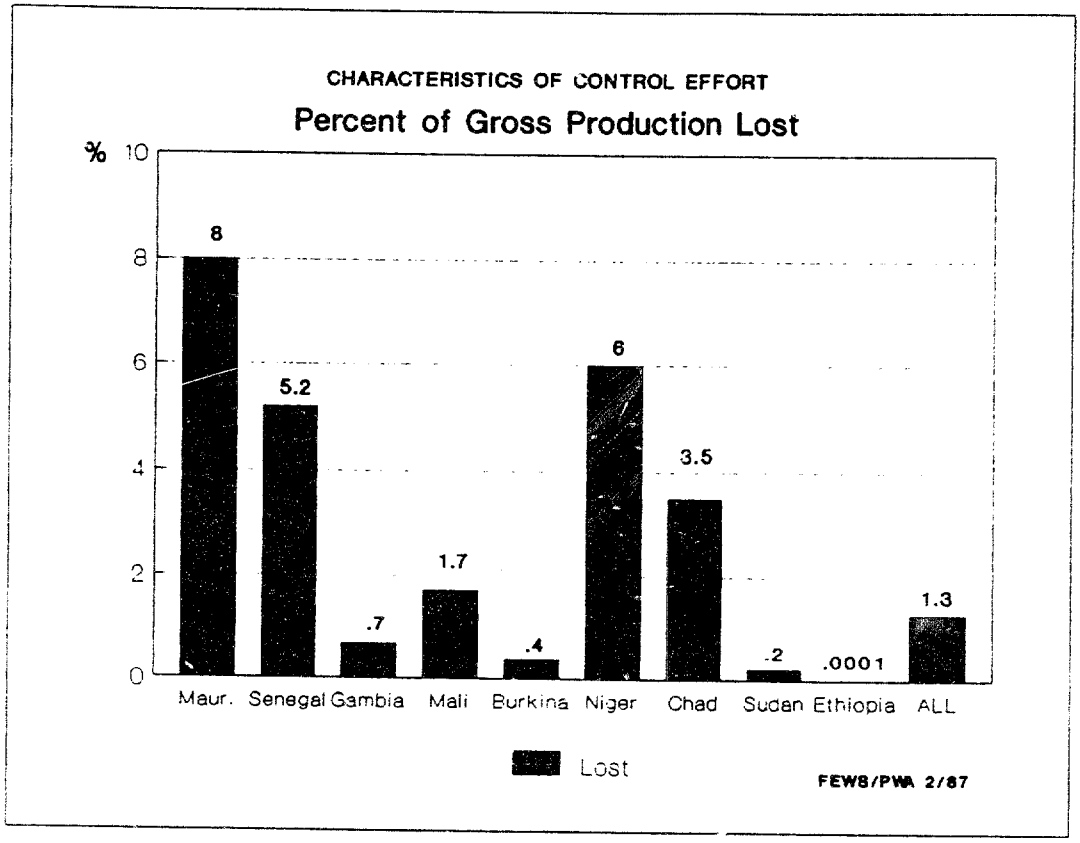
Chart 4. Percentage of Gross Production Lost to Grasshoppers



Contrary, perhaps, to the general perception that infestations caused the greatest agggregate loss of production in Senegal, Mauritania, or Mali, Chart 3a shows that the estimated losses in Niger were at least double those in any other country. As possible as this may be, the way that the Niger figures overwhelm all other estimates raises questions about the method of measurement that was being used in Niger, and those used in the other countries.

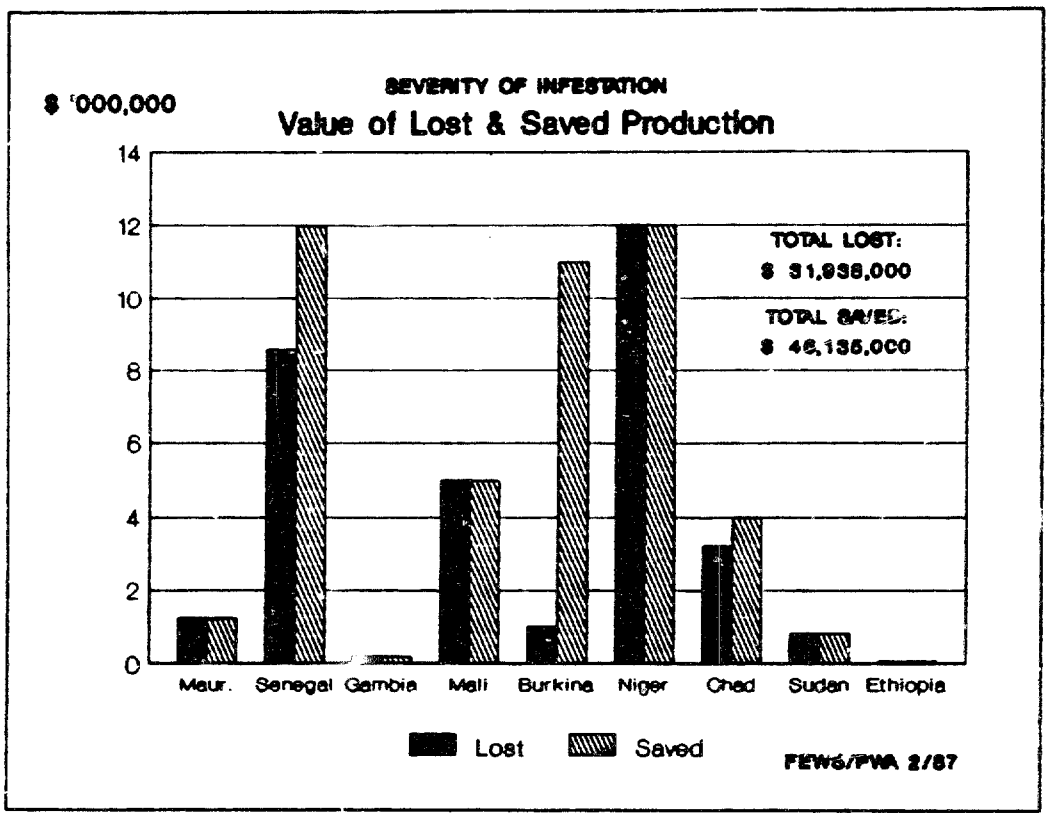
This question is particularly interesting given the evolution of the infestation in Niger, as distinct from those seen in the western Sahel. In Niger, notable infestations only began occuring in late August, whereas the infestations were heavy much earlier in the West. It is also pertinent to note that the Nigerien plant protection service is generally recognized as one of the best, and the higher figures here might be open to the same discussion as crime statistics: are there more crimes, or are they simply better at recording them?

The data in Chart 4 helps show that the high estimate of actual loss for Niger is primarily due to its high gross production and a "normal" loss rate. The percentage of its loss (6%) does not differ markedly from what one would expect in the Sahel. Indeed, the extremely low percentage loss figures noted for Burkina and Mali are perhaps more curious than the large actual losses in Niger. Why are the estimated percentage losses in Mali and Burkina so much lower than those of their neighbors? It may be that the reality of grasshopper-related

damage in those countries is exactly what is shown here, but it may also be that the loss estimates from Mali and Burkina were made upon differing assumptions than those in other countries (see Appendix I for a discussion of loss estimates). The other element of note in these three charts is the relatively low estimates of loss from Sudan and Ethiopia.

2.2.3. Further exploring the severity and impact of the 1986 infestations, the dollar value of the portions of the harvest lost and saved are shown in Chart 5.

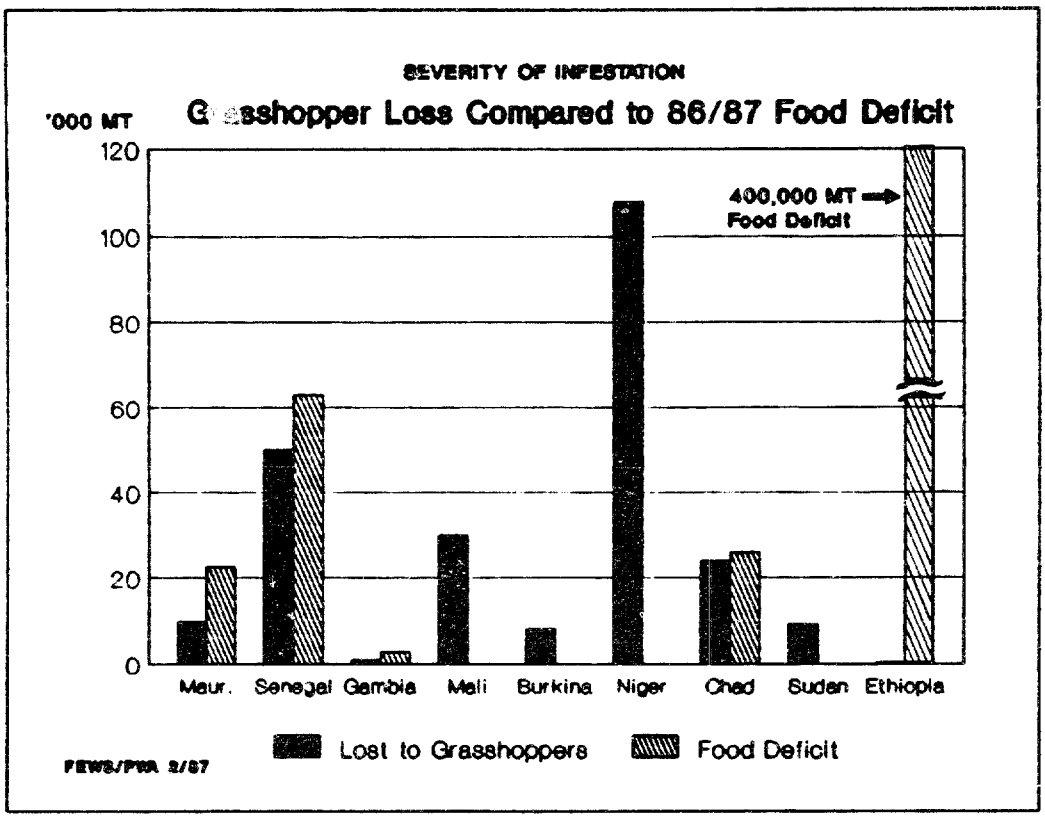
Chart 5. Value of Lost and Saved Production



The values of a metric ton used in this analysis to compute the value of production lost and saved in each country were taken from the FAO Asssessment. They represent an estimation of the cost of purchasing a metric ton of an unnamed grain in each country. In a number of cases, open market prices of the major grains are currently running much lower than most of the estimated costs shown here. However, had the price of importing a metric ton of cereal been used, both the value of lost and saved production would have been somewhat higher. Notable in this chart is simply that the value of what was saved was greater than what was lost. Also, in examining Table 1 for the amount of donor contributions, it appears that the total value of what was saved marginally outweighs the total value of donor contributions to the control effort.

2.2.4. One of th more interesting measures of the severity and impact of the infestation is a comparison of what was lost from grasshoppers to the estimated food deficit (production plus stocks and imports minus exports and consumption requirements) for the 1986/87 year. Chart 6 illustrates this relationship. Note that current USAID estimates indicate that Mali, Burkina Faso, Niger, and Sudan do not have a food deficit this year.

Chart 6. Relationship of Food Deficit to Grasshopper Damage



Assuming that the losses given in Table 1 and used here do accurately summarize the situation, the loss from grasshoppers formed a significant part of the food deficit in all the countries with a deficit, except Ethiopia. It is also likely that annual normal losses due to grasshoppers are greater than shown for at least Mali, Burkina, Chad, Sudan and Ethiopia. It should be noted, however, that the 1986 deficits in the four West African countries are not particularly severe when compared to previous years. More effective control on grasshopper damage would undoubtedly be useful, as would control on bird and rodent damage and a number of other pre-harvest loss factors that produce almost as much or more damage each year. The price, though, of this extra control might not be covered by the savings earned by it.

2.3 Conclusion About the Severity of the 1986 Infestation

As noted above in Section 1, it is difficult to objectively construct an historical or technical context around the data from the 1986 infestations in order to tell whether infestations in that year were more severe, or less so, than other years. It is also difficult to compare indicators of severity and impact from the nine countries examined in this report because the indicators are not tied to an objective standard, and may use the same terms to describe differing conditions. However, the data used here are being used by decision-makers to plan for 1987 infestations, and the relative rankings of the nine-country data do establish similarities, anomalies, and patterns in national-level data.

Despite some of the limitations of the data, the following conclusions about the severity and impact of the 1986 infestations seem to emerge from the measures examined here.

- The aggregate amount of damage caused by the grasshoppers was much less than feared. The losses are more on the scale of localized, perhaps "near-normal" stress than national calamities. While the losses are unfortunate, they are certainly not out of the normal realm of experience in the countries examined.

- The infestations seen in Sudan and Ethiopia are clearly of a different nature than those seen in the Sahel.

- The net contribution of grasshopper-related damage to 1986-87 food deficits was significant in some countries, but may not have been any greater than damage caused by other pre-harvest factors.

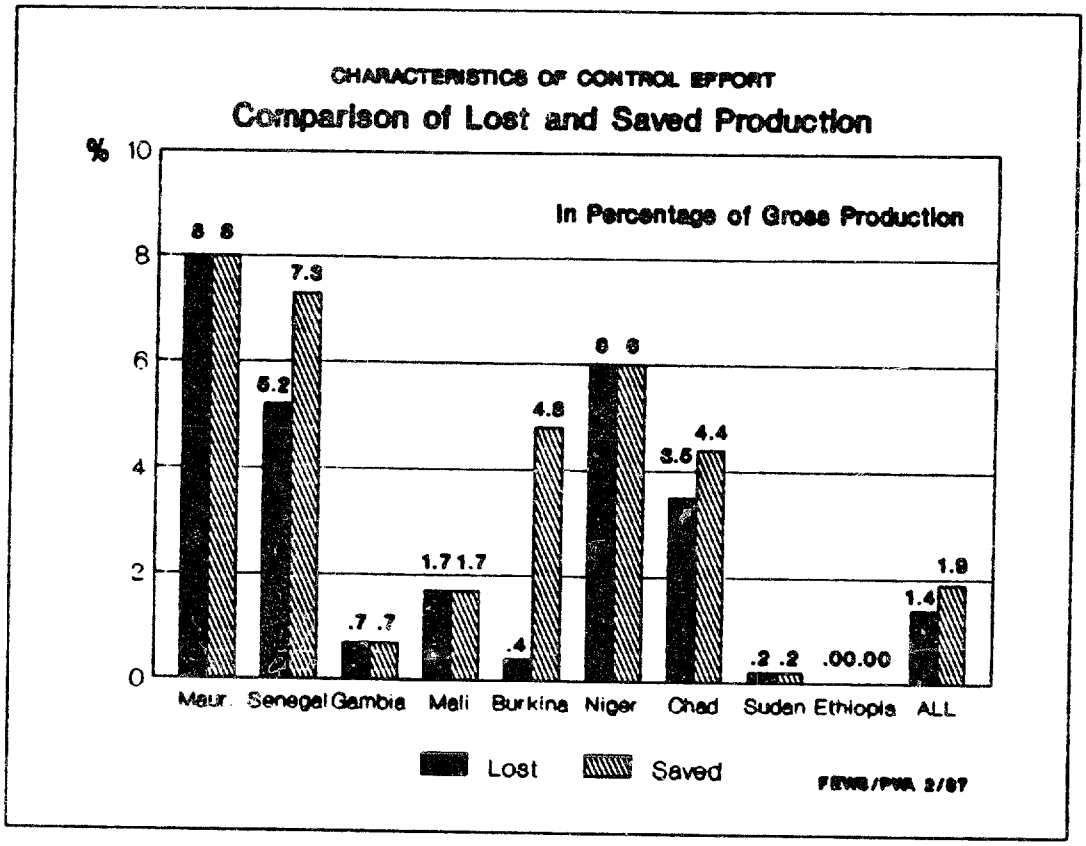
The question that then emerges, particularly from the conclusion that damage was much less than feared, is "due to what?". The next section examines several indicators of the efficiency and effectiveness of the control operations.

3. Efficiency and Effectiveness of Control Efforts

3.1. Characteristics of the Control Efforts

3.1.1. The most obvious measure of how effective control measures were in limiting the damage of the infestations is perhaps found in a comparison of estimates of crops lost and crops saved. Chart 7 compares the percentage of the national gross harvest lost with that saved.

Chart 7. Comparison of Crops Lost and Crops Saved



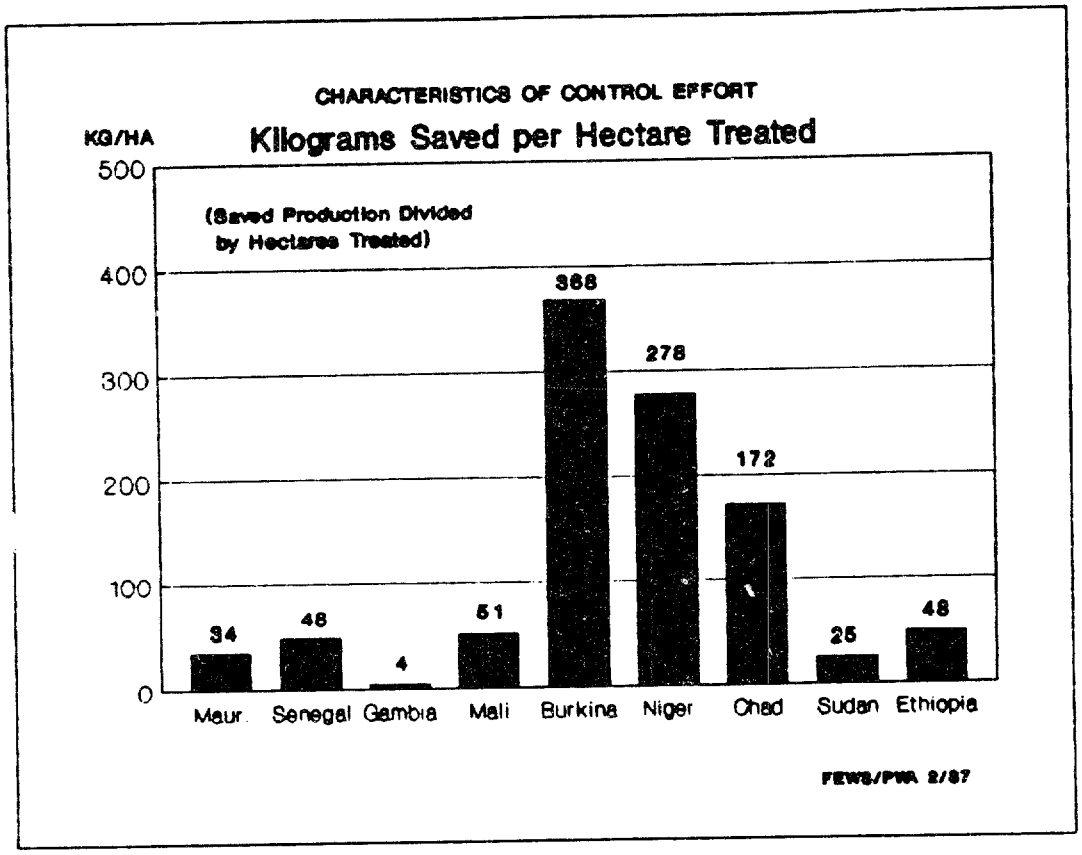
In all countries, the estimates show that control measures generally saved as much, or marginally more production than was lost to the grasshoppers. In several countries, the losses and savings are equal, which reflects as much about the way the estimates were made, as it shows in terms of effectiveness.

Unfortunately, neither this indicator, nor others in the data available, can help us define the gross potential for damage, and whether the control measures alone were responsible for limiting losses to the estimated levels. This point is an important one, because several expert observers attribute much of the light grasshopper damage, particularly in Senegal, Mauritania, and Mali, to a lengthy dry period during late July and most of August. This period of drought interrupted the exponential population growth of the grasshoppers at a critical period, and may be a very major reason why crop losses were so much less than anticipated.

3.1.2. Chart 8 relates the amount of production saved to the number of hectares treated. This measure helps to define the degree to which a particular spraying strategy was used. If a strategy which limits spraying to largely agricultural areas is chosen, the average savings in production per hectare of treated areas will be some percentage of the yields of those areas. When a different approach is taken, such that large concentrations of grasshoppers are sprayed wherever they are found, whether in fields, grasslands, or desert, the average savings in

the treated areas will reflect the lower yields of largely non-agricultural areas (this measure does not in itself comment favorably or poorly on either strategy; it simply shows that different tactics were used in different areas).

Chart 8. Average Kilograms Saved Per Hectare Treated

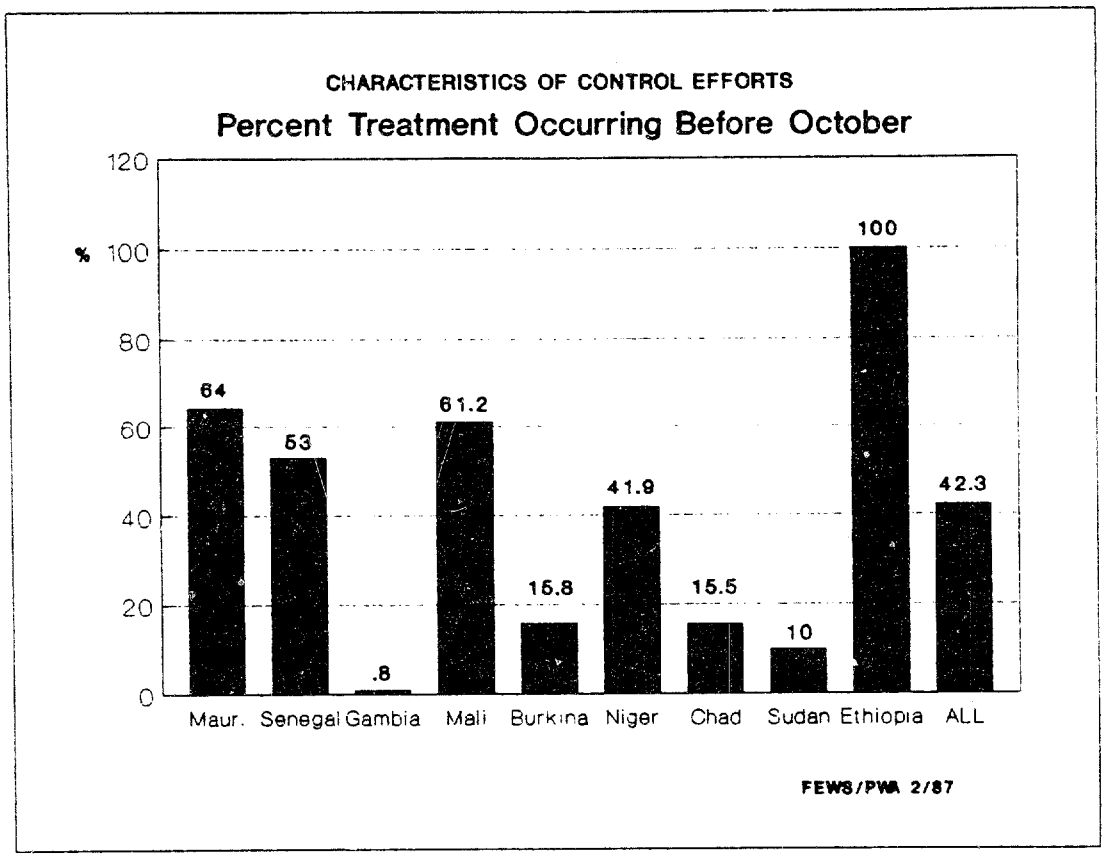


As might be expected, those areas, apart from Sudan, in which the "big plane" option was used, show a low average of saved production in treated areas. The higher average saved production figures in Burkina, Niger, and Chad indicate that primarily agricultural areas were treated. The low figure for treated areas in Sudan probably shows the influence of a concern over the Desert Locust, whose name suggests an important place where control efforts against it might occur. The high average savings in treated areas in Burkina and Niger are noteworthy, as they equal a substantial portion of the typical yield of a millet field in those countries. This tends to indicate either a vigorous implementation of an "agricultural area only" spraying strategy, or a liberal estimate of the amount of saved production found in the treated areas. The data that produced these figures do not, however, provide the depth to probe much further than this.

3.1.3. An efficient, early rainy-season treatment program is generally considered to be critical for efficient use of control resources. Early in the first generation, non-flying hoppers are very easy to treat, and control measures pursued at this point pay dividends in reducing the potential number of eggs which will hatch in the second and third generations of that season. Ground

treatment and access to remote areas are also relatively easier before the rainy season is fully underway. Spraying late in the season accomplishes little if harvests have already been largely brought in, and if the last egg-laying has already occured. Chart 9 relates the percentage of all hectares treated to those sprayed before the end of September, a point at which many harvests are completed, and much of the egg-laying already accomplished.

Chart 9. Percentage of Hectares Treated before October



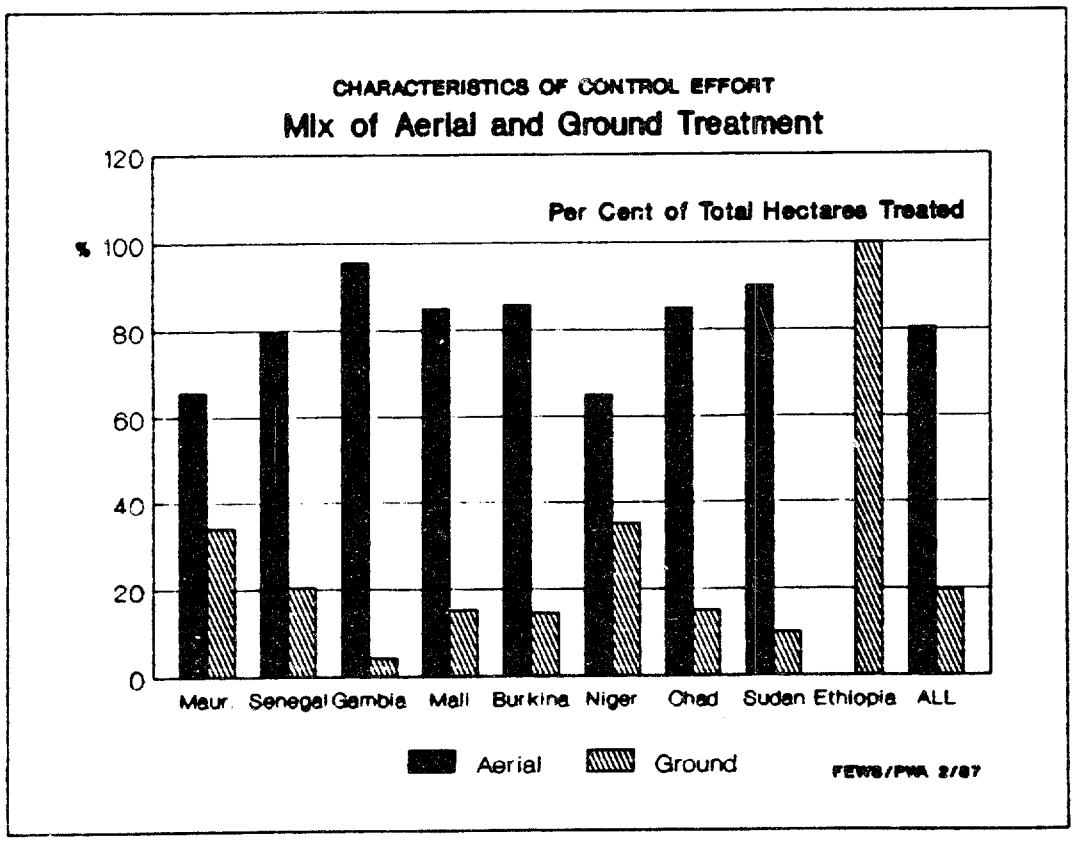
In view of the importance of early treatment, it is significant that such low percentages were sprayed before this date. Despite the warning from 1985 that a problem was likely in 1986, resources to control the infestations were not in place until very late in the season. Relatively well-organized ground treatment campaigns were mounted early in the season in Mauritania, and to a lesser extent in Burkina and Niger. Ethiopia also falls into this category, but the extent of the infestations was much smaller there than in the other countries. In Mali and Senegal, the beginning of aerial spraying in mid-September pushed up the percentages shown here, even though there was still very much a problem of late treatment in these countries.

Any impact at all from treatment applied after the end of September 30, can be attributed to the tardy withdrawal of the Inter-Tropical Convergence Zone, which kept rain falling, grasshoppers mating, and quiescent eggs hatching. However, according to the evaluations done by most grasshopper experts, all of the West

African countries examined here contain a similar or greater number of grasshopper eggs in 1987, than they did at the beginning of 1986, due in great part to ineffective and limited early treatment.

3.1.4. Chart 10 shows the mix of air and ground treatment in each country. The difference between air and ground treatment in terms of cost, strategy of use, and the national ability to wield a self-sufficient control campaign, is enormous. Even where a national aerial treatment option exists, as in Niger, aerial resources are costly, consume large amounts of foreign exchange, and need a support structure that either does not exist or that strains local capacities. Ground control, on the other hand, is usually much less costly, generally benefits from the low-cost participation of those who stand to earn the most from it -- the farmers, and is more efficient in terms of the ratio of inputs to results. Particularly for control of Oedaleus senegalensis, if infestations are in areas of relatively easy access, and if the ground control effort is organized early and fully supported, ground control efforts usually need only a back-up aerial spraying capability to guard against outbreaks later in the season in uninhabited areas.

Chart 10. Mix of Air and Ground Treatment



The general reliance upon the aerial option, except in Ethiopia, is striking. Niger and Mauritania show relatively greater use of ground control in 1986 than their neighbors, but the generally late start and small size of ground control efforts made massive aerial spraying a necessity, rather than an option, in most countries. In 1987, it will be clearer whether the aerial treatment option is also the method of choice, despite its expense (remember that most of the aerial treatment costs were not borne by the countries themselves). While ground control is relatively less expensive, it does require substantial inputs from the national budget to cover personnel, equipment, pesticides, and support costs, as well as a minimal ability to organize and supply control teams in rural areas. Given the availability of inexpensive international assistance and limited national resources, a cost-conscious national planner would be hard put not to recommend greater reliance on the former, rather than the latter.

3.2. Conclusion About the Effectiveness and Efficiency of Control Efforts

Looking at what are believed to be the limited losses due to the infestations, one can easily attribute some of the savings to the control efforts. However,

- if the benefits of early treatment and less reliance on aerial control are real, the treatment that occurred looks late, expensive, and far beyond the capacities of the countries to provide for themselves;

- most expert observers indicate that the dry weather conditions during July and August in Senegal, Mauritania and Mali had as much to do with limiting losses as did control efforts;

- the incentives to strengthen ground control operations are likely to be negatively skewed by the predisposition of international assistance to provide aerial treatment;

- without better data and standard measures of the level of potential damage inherent in a particular infestation, no firm conclusions can be reached on how effective such control efforts actually were at limiting damage.

The major facet of the control effort that now needs to be examined is how its costs relate to the benefits it helped to produce. This is the subject of Section 4.

4. Costs and Benefits

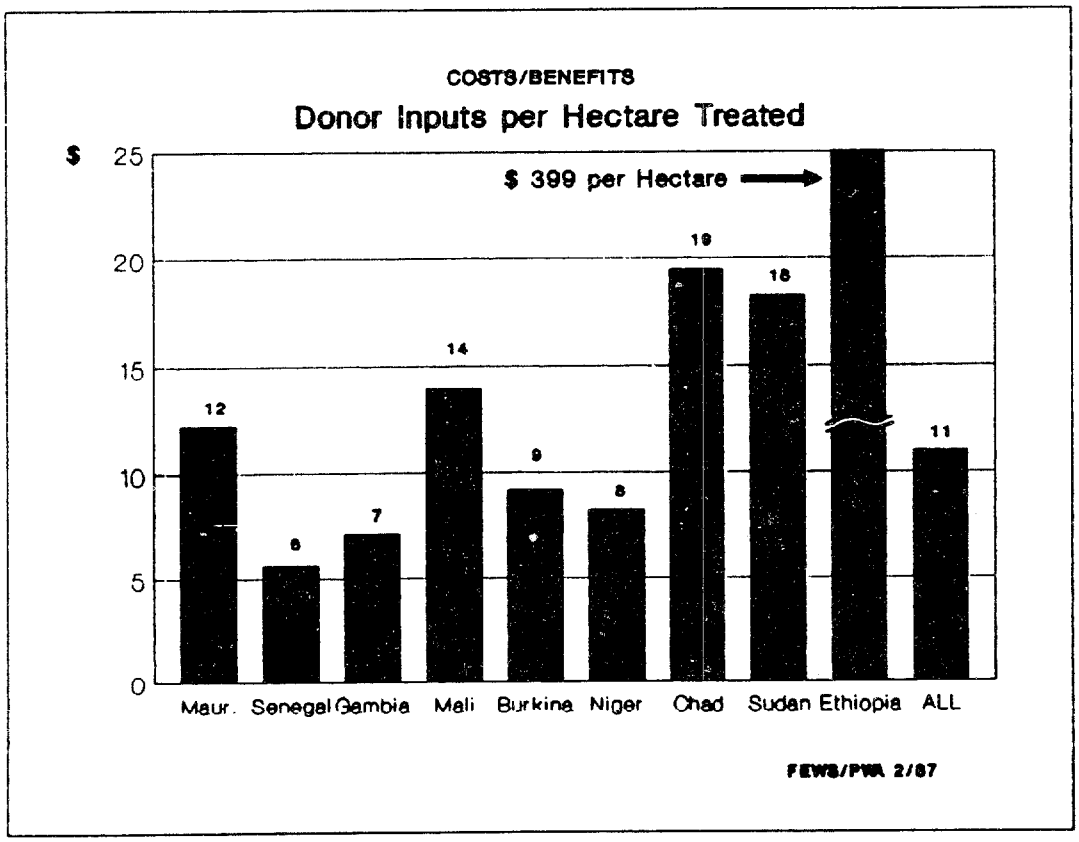
4.1. Cost/Benefit Indicators

The weakness of the best available data on the severity and impact of the infestations, limits the depth of the conclusions that can be drawn about the benefits of the control efforts. On the cost side, as well, it is still early to estimate with much precision what the costs, as opposed to the inputs, of treatment were. Much of the data currently available from donors on costs incurred in the effort, does not distinguish between those contributions which

were actually consumed in 1986, and those that are still available for the 1987 effort. Despite these obvious problems, a series of cost/benefit measures are presented below. They permit a relative ranking of the countries examined here, a ranking which does reveal trends, patterns, and anomalies. One element which is absent from this analysis, and which is only now beginning to be available in some of these countries, is the amount of national resources spent on grasshopper control in 1986. These contributions to the control effort are therefore, unfortunately, not considered in the following measures.

4.1.1. Chart 11 shows the relationship between the value of donor contributions and the total number of hectares treated. Generally, a more cost-effective control effort would be reflected by a lower bar in the chart. Because the costs used here are in reality contributions, the relative meaning of the height of the bars will have to be qualified by other information, some of which follows.

Chart 11. Donor Contributions Per Hectare Treated

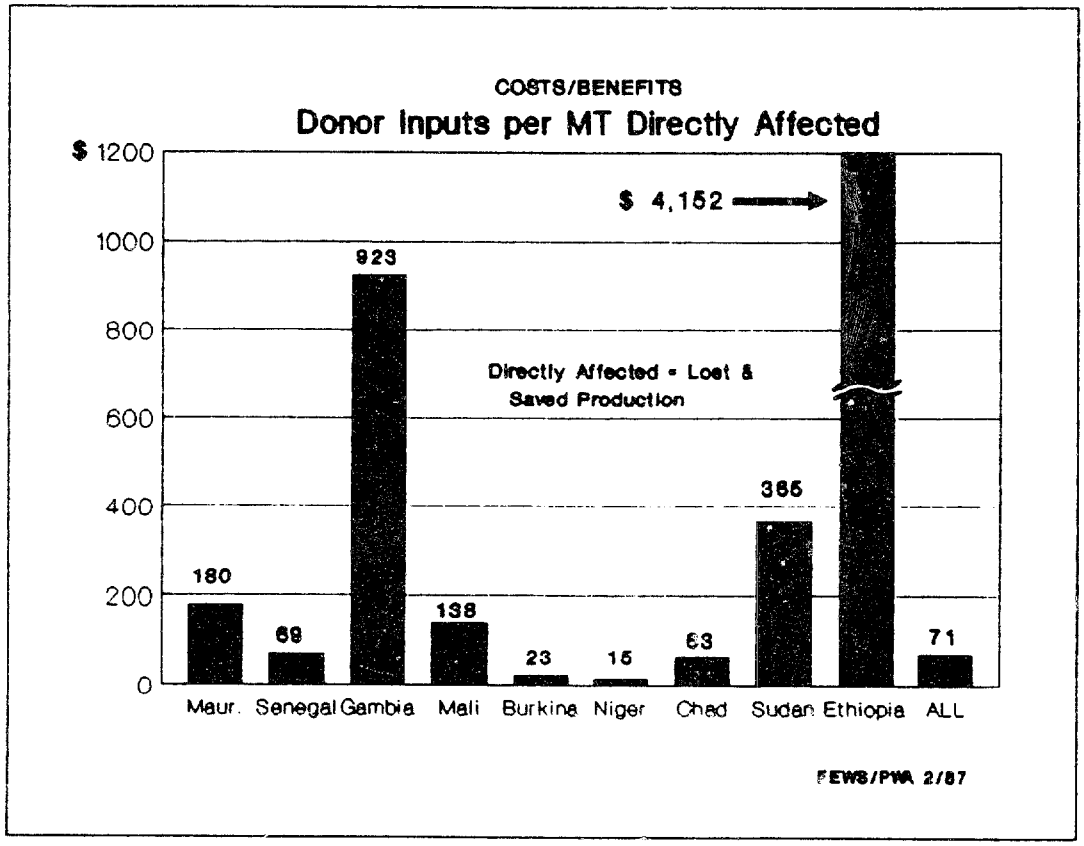


Out of all proportion to the other countries examined here, contributions to Ethiopia are much greater, per hectare actually treated, than elsewhere. How much this has to do with an excess of donor caution due to conflicting claims of infestation coming from the Ethiopian government (which did not generally claim grasshopper or locust problems), and from Eritrean rebel fronts and Sudan (which reported large locust swarms in Ethiopia), cannot be known. The explosive nature

of the Desert Locust threats that are frequently present in Ethiopia and Sudan, is a factor that may explain the magnitude of the donor contributions to control efforts received by these two countries in 1986. Other relatively high quantities of donor support per hectare treated are found in Chad and Mali.

4.1.2. Chart 12 displays a related measure, the relationship of donor contributions per metric ton of production directly affected (lost and saved).

Chart 12. Donor Contributions Per Metric Ton Directly Affected

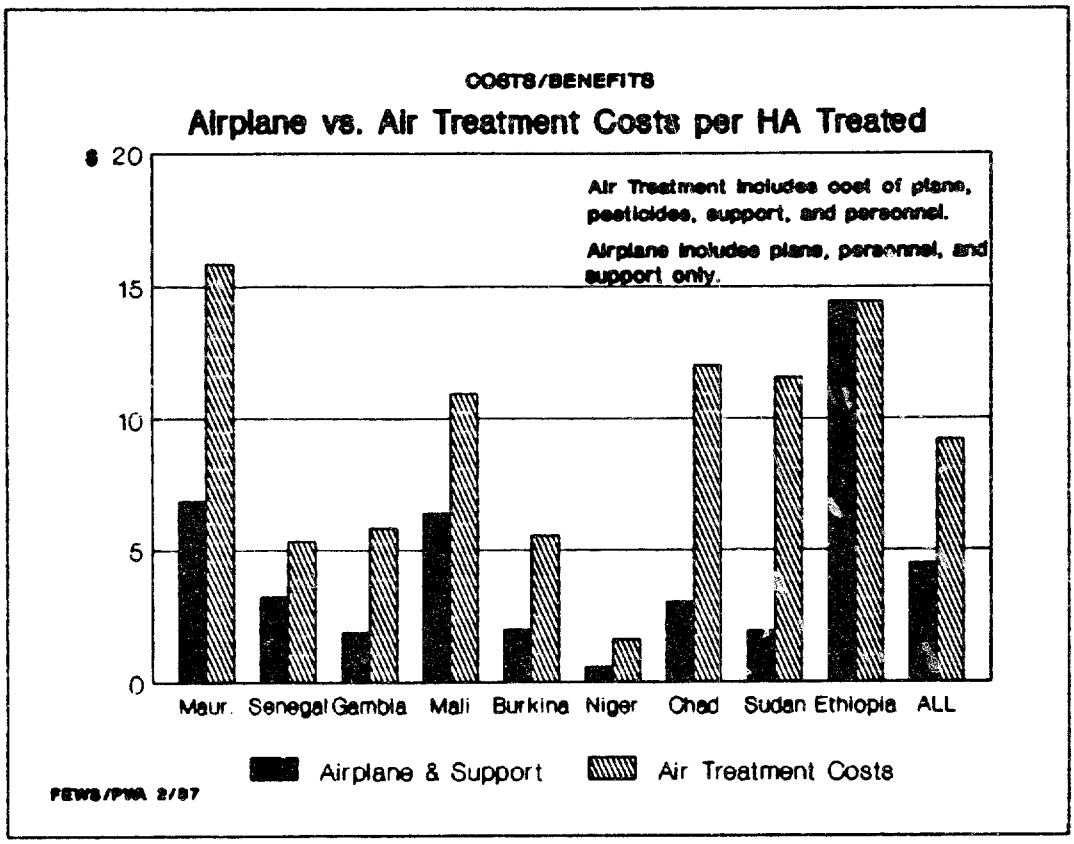


Donor contributions per metric ton of directly affected production are relatively higher in those countries where losses were small, and where spraying accomplished little in terms of the inputs which were made available for it. Both Sudan and Ethiopia again show that the grasshopper infestations, and most things associated with them, were different from infestations in the Sahel. The Gambia, with its massive spraying, small losses and small savings, also differentiates itself in this chart.

4.1.3. Since the use of aerial treatment was so important to all the countries in their 1986 control effort, an attempt to determine the minimal cost per hectare of aerial treatment has been presented in Chart 13. It shows the total cost of the air treatment option (airplane, pesticides, personnel, and support),

as compared to the cost of the airplane, personnel, and support only (pesticide cost not included). This gives a rough picture of what the aerial option itself costs, over and above the cost of the pesticides.

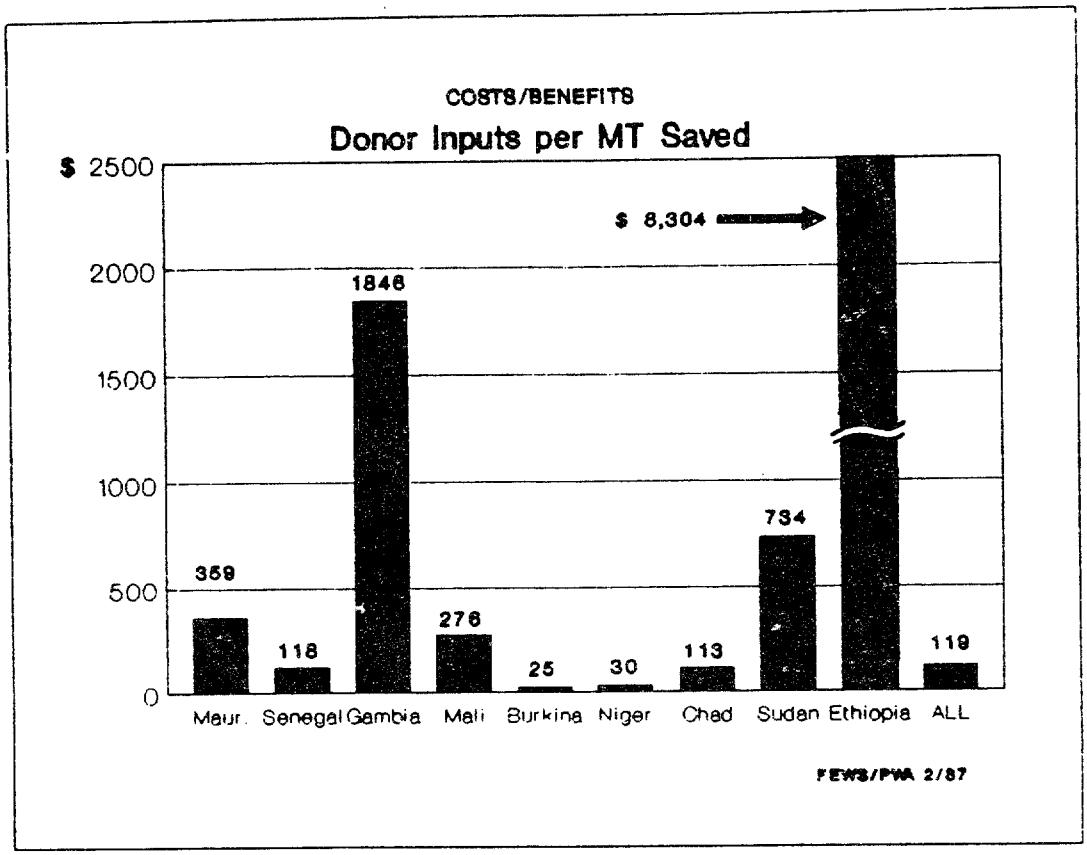
Chart 13. Airplane vs. Air Treatment Costs Per Hectare Treated



As seen in the chart, the relative cost of the airplane and its operation in these countries ranges from approximately a fifth to two thirds of the total cost of the aerial control operation. The percentage does appear to be higher in those countries where the "big plane" option was used (Senegal, The Gambia and, to a lesser extent, Mali and Mauritania). The overall costs of air treatment vary greatly and do not show such a clear division between "big plane" and small plane treatment. It would have been very interesting if one had been able to compare the cost of air treatment to the cost of the ground control operation. However, the data do not currently allow that comparison to be made.

4.1.4. All of the above measures point finally to attempting a cost and benefit-type measure that relates the value of what was saved to the value of what was spent (or in this case, contributed). The two charts that follow show rankings, by country, of these relationships. Chart 14 shows donor contributions per metric ton of production saved by the control effort. The larger the column in this chart, the more contributions have been received and/or used to save a metric ton of cereal. The estimated value of a metric ton varies from approximately 88 to 170 U.S. dollars in these countries.

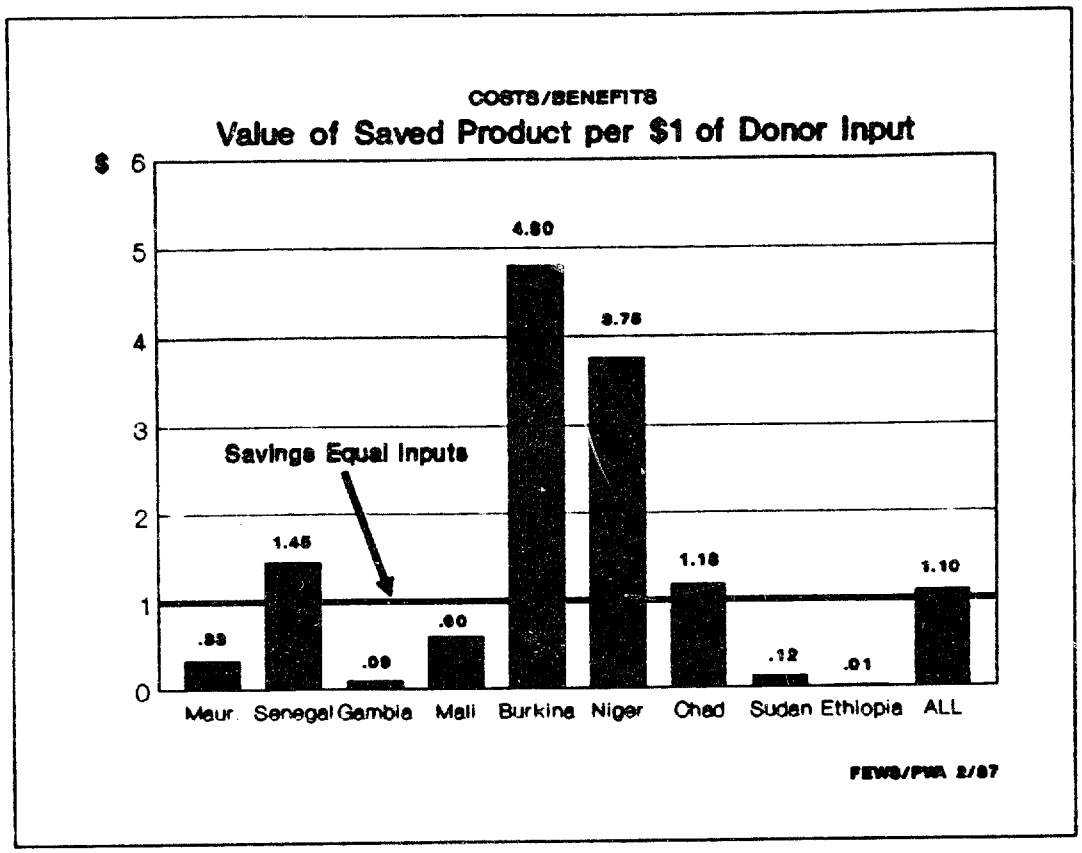
Chart 14. Donor Inputs Per Metric Ton Saved



As the overall savings were small when compared to the amount of costs (contributions), the control effort looks very expensive in The Gambia, Sudan, and Ethiopia. It was relatively low in Niger and Burkina.

Chart 15 relates the return, in value of product saved, per dollar of donor contribution. Here also, the higher the bar, the greater the return on a dollar of donor control contributions. Those bars which indicate less than a dollar of value imply that the control effort was, on these terms only, uneconomic to perform.

Chart 15. Value of Saved Product Per $1 of Donor Input



Very healthy returns on a dollar of donor contribution are noted in Niger and Burkina Faso. In addition to these two countries, only in Senegal and Chad did the control efforts save more than what was spent. Very low returns are shown for the control efforts in The Gambia, Sudan, and Ethiopia. Caution should be used in interpreting both of these measures. The low ratio of savings to costs may simply reflect the consequences of over-generous donors, a healthy stock of control resources, or the poor quality of the estimates, as much as an unwise or inefficient use of contributions.

4.2. Conclusion about the Costs and Benefits of the Control Effort

The following conclusions about the costs and benefits of the control effort appear to be supported by the available data:

- The value of the production saved was not generally greater than the cost of saving it. The value of the production saved in five of the nine countries was not equalled or exceeded by the value of the inputs they received for treatment. The estimated savings in Burkina and Niger were notably greater than elsewhere, and pulled the cost-benefit ratio for the whole group up to a positive level.

- Levels of donor contributions relate only marginally to the estimated level of threat, and to levels of actual damage incurred.
- Air treatment costs were a very significant component of the total control budget.
- The limitations of the data do not permit extensive conclusions to be drawn.
- The existing data do seem to support a view that the overall impact of the infestations was modest, as was the impact of the control efforts.

Appendix 1:

SOURCES USED:

U = USAID cables, reports etc.
O = OFDA draft report entitled "West Africa - Grasshopper Infestation"
F = FAO documents, primarily Joint Review team reports, and the Rome Technical Meeting Report (Item 1: Analysis of the 1986 Campaign).
f = Data derived from other figures given in FAO reports.
H = Host Government figures
E = FEWS/PWA estimate based on data from all sources listed here
C = CILSS/FAO Production estimates
D = Information derived from other data in Table 1

NOTES ABOUT PRODUCTION FIGURES IN TABLE 1:

Actual production saved was the primary figure upon which the rest of the production and value measures were built. Most of these estimates of savings were extracted from the FAO Joint Review reports. The actual loss figure was usually derived by subtracting a savings figure from a potential loss figure. Percentage loss figures given in the FAO Joint Review team reports were not used as they refer in some cases to the gross production of sub-national areas, and not the national gross harvest. Most of the gross production figures used here are those accepted by USAID.

Instead of the "Production Directly Affected" figure given in Table 1, which is composed of the sum of the production estimated to be saved and that estimated to be lost, a useful indicator of severity of an infestation would normally be the percentage of the crop or pastures that was at some level of risk of loss. This was not possible to do, given the nature of the data available. How much production is at risk of loss? In the above named documents and others, estimates given about the production potentially at risk of loss sometimes include all (100%) of the metric tons of production found in an infested area. However, sometimes they only include that percentage (less than 100%) of the production in a specific area which would likely be lost without treatment occurring. An additional complication, in the second case, arises because the baseline of normal losses from infestations is not known. Does the estimate of loss only include the additional amount expected to be lost to the greater infestation this year, or does it include "normal", as well as "abnormal" damage?

If the "normal" annual loss due to grasshoppers is in the range of the 5 to 20% discussed in Section 1, many of the 1986 estimates of loss seem to be low.

Sources of Production Data:

- Mauritania: FAO Technical Meeting report uses percentages from Mali for loss and potential loss figures. According to FAO Joint Review team, grasshopper loss not determined, but damage from all pests is likely to be greater than 20%. Little crop damage due to grasshoppers reported this year except in two areas.

- Senegal: FAO Joint Review team reports an estimate of 5% loss of millet due to grasshoppers. FAO Technical Meeting report uses Burkina figure for potential loss.

- The Gambia: FAO Joint Review team reports that data is unavailable, but also mentions that losses due to grasshopopers were hard to find. Also reports that, due to lateness of control, little savings can be seen.

- Mali: FAO Technical Meeting report notes a 10% loss and 20% potential loss.

- Burkina: FAO Joint Review team quotes government for a 9,810 MT loss in 3 infested areas. Reports that 12% was potential loss.

- Niger: FAO Joint Review team quotes USAID for a 108,000 MT loss. FAO Technical Meeting Report uses Burkina figures for estimated potential loss percentage.

- Chad: FAO Joint Review team quotes loss rates of 6-18%. FAO Technical Meeting Report gives saved figure as estimated "10% reduction in losses from millet crop".

- Sudan: No loss data available. Estimate composed as follows: Sudan treated 370,000 hectares as of the end of November. Assuming that half of these were agricultural areas with an average yield of 500 kg/ha, the production in the infested area is 92,500 MT. A conservative, (higher than probable), estimate of potential loss (higher than probable) is made at 20% (18,500 MT) of this production. A relatively effective (even if late) control effort saved half (9,250 MT) of this and lost half (9,250 MT).

- Ethiopia: USAID cable of 10/22/86 estimates losses at $ 50,000 of production of crops and ranges. A similar quantity of savings was estimated by FEWS, given the picture found in the other countries examined here.

NOTES ABOUT AREA IN TABLE 1:

- Area treated before October was extracted from other data in FAO Joint Review team reports, the OFDA Draft report, and from USAID cables. In the case of Niger, bi-monthly agricultural reports from the Ministry of Agriculture were the source of some information.

- There are frequent small disparities between the documents used in the estimates of area treated by either air or ground control. In most cases these differences are not major, and are due primarily to the differing dates on which these reports were published, and the best estimate available at that time.

NOTES ABOUT VALUES OF PRODUCTION IN TABLE 1:

- The value of a metric ton was computed from figures given in the FAO Technical Meeting report. Though it is not specified in a number of these Joint Review reports, this value appears to be the purchase price of a metric ton of an

unnamed grain in each country. Current in-country prices are, however, much lower than some of the prices given in the reports. An alternative way to measure the value of a ton of production might be to give the cost as if it had to be replaced with imported food assistance. The cost in that case would be higher than buying it in country, but might not be much higher the the figures (relatively high) given here.

- The estimate of $ 100 per metric ton for Ethiopia is based on that of Sudan. Various factors make this value a difficult one to estimate (no open market structure for grain, widely varying costs, etc.).

NOTES ABOUT DONOR CONTRIBUTIONS IN TABLE 1:

- Sources for the FEWS/PWA estimates given in Table 1 are the FAO Joint Review team reports, and the OFDA Summary report. In a number of cases, no values were given by donors for their inputs. No attempt was made to count these in the estimate unless other comparable goods and values were given by other donors. Because of this, the estimates given in Table 1 are probably in the low range of value of what was actually given.

- When this report was written, it was still too early to know how much of those resources given by donors were used and totally consumed, and what was still in stock. Therefore, for all measures used in this report that normally need cost data to relate to benefit levels, donor inputs are used in the place of costs. This introduces some bias toward more expensive costs (inputs) per unit of value.

- Counterpart funds in the amount of $600,000 were given by USAID/Sudan for control efforts. Apart from this sum, other funds given by USAID (not counting personnel costs and other services rendered incidentally from the Missions in-country) for grasshopper control were dollar contributions or in-kind inputs.

- No host country inputs for the control effort are included in Table 1. The FAO Joint Review teams were generally unable to develop estimates of amounts spent by national services for crop protection services.

NOTES ON DISTRIBUTION OF DONOR INPUTS IN TABLE 1:

- Sources for these estimates were the OFDA draft report, the FAO Joint Review teams, and the FAO Rome Technical Meeting reports.

- A helicopter was used for surveying locusts in Ethiopia. Its cost is shown as an air treatment, and an airplane cost. As it did not spray areas, no percentage is given for the ratio between "Area Treated Air/Total Area Treated".

NOTES ON PERFORMANCE MEASURES IN TABLE 1:

All these indicators are derived from other data found in Table 1. As noted above, the use of donor input amounts, rather than cost figures, introduces a bias towards higher costs to each unit of value.