Chapter 2

What is the Problem

CONTENTS

Figure

Tables

Chapter 2

What Is The Problem?

VARYING PERCEPTIONS OF THE PROBLEM

*Finding: **Many** views exist on various **aspects of** locust and **grasshopper problems** but these have **not** been widely **debated** nor **resolved. Instead, many host-country** and **donor policymakers** base **control policies and programs** on **certain assumptions: that** locusts **and grasshoppers are a** serious problem, **that** pesticides **are** the way **to** control them, and that **con-trol programs** have substantial benefits for most **farmers and herders. OTA finds** these **assumptions** questionable.*

Locust and Grasshopper Outbreaks as Disasters

To many, especially the general public, the recent upsurges of locusts and grasshoppers in Africa seem to pose a major threat to that continent's already precarious food security. The New *York Times* proclaimed: "Locusts Threaten Sub-Sahara Africa With Famine" (April 24, 1988, p. 14) and "The Cloud Over Africa Is Locusts" (November 11, 1988, p. A3). This perception is one of large swarms of insects, stripping vast areas of vegetation. Also, people assume that these insects are the most damaging pests facing African farmers and herders and the problem seems unsolvable because, after all, locusts have caused plagues since biblical times. In many minds, these insect outbreaks are inevitably linked to famine and the popular press has reinforced this view.

Many aspects of the public policy response to locust and grasshopper problems match this perception. For example, the U.S. Agency for International Development (USAID) organized a special Desert Locust Task Force within the Office of Foreign Disaster Assistance (OFDA) to manage U.S. contributions to control efforts. Earlier locust and grasshopper outbreaks had been treated in much the same way, with special control efforts, by donors and regional and national organizations. The contributions of donors, *$275* million from early 1986 through mid-1989, reflect this view of averting plague-induced disaster.

The resources committed by USAID, $59 million from fiscal year 1986 through fiscal year 1989, indicate the high priority given to this officially declared emergency.

Many within the expert community, especially those who work with grasshopper and locust control, agree with this assessment of the disastrous impact of locusts and grasshopper on African agriculture. The problem is perceived as serious enough to warrant specialized attention and to mobilize substantial donor and host country resources. Most people who responded to OTA'S survey (app. B) noted that locust and grasshopper problems are "very serious" in the areas with which they are familiar, with the 1986 to 1989 outbreak being as serious as any on record. Also, approximately one-half of the respondents rank locusts as the most serious pest in their area.[1]

Certainly locusts can devastate vegetation over sizable areas, especially if swarms are moving slowly and stay in one place for several days. The potential for national-level drops in agricultural production exists if swarms affect areas crucial to a country's economy. Any loss of food crops to locusts or grasshoppers puts some people at risk in localities where food supplies are already precarious.

For example, the African Migratory Locust destroyed 50 percent and 40 percent, respectively, of Kenya's wheat and corn crops in a peak infestation in 1931 (15), although this level of loss did not occur in the recent upsurge. In northwest Mali, crop losses to grasshoppers were estimated at 20 to 30 percent in 1985 despite spraying pesticides on 900 km^2 and, in 1986, some farmers' millet crops were destroyed three times before they eventually abandoned some fields or planted sorghum instead because of its resistance to these insects (93). The Variegated Grasshopper can

[1] Certain aspects of OTA's survey may have led respondents to exaggerate the magnitude of these problems: some questions were not precise enough regarding the time and geographic areas of outbreaks; the response rate was low (25 percent) and people who perceive the problem to be serious are those most likely to complete a lengthy form; many of the respondents are affiliated with locust and grasshopper control programs; and the questionnaire was sent at the peak of the recent upsurges.

cause up to 65 percent yield loss in cassava if it strips leaves, bark, buds, and shoots late in the season (93).

Overview of the Debates

Other experts, commonly entomologists who are not involved in control efforts, make quite a different assessment of the threat posed by locusts to African food security. They suggest that the severe, localized nature of these outbreaks almost ensures that their importance be improperly exaggerated relative to other pest problems. These experts note that locusts and grasshoppers occur in large swarms infrequently. For example, outbreaks occur often, but upsurges that lead to a plague are rare (93). In this, the analogy to a natural disaster such as a tornado is apt. In a given location, the situation may be disastrous but the impact, measured over a wider area and/or for a longer time period, may have little significance.

Thus, many in this second group of experts conclude that current public policies are based on questionable or faulty assumptions. A significant number of OTA'S contractors and reviewers agree, in general, with this position although they hold a range of views on specific aspects of the problem.

Assumptions provide a needed basis for preliminary answers to important policy-related questions in the absence of reliable data and:

> . . . 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. (72, p.2)

Unresolved, major discrepancies in how experts view locust and grasshopper problems now, however, have significant repercussions for congressional and other policy decision making. Moreover, the lack of debate on important issues outside a small group of scientists and control experts means that those who see the situation as disastrous, warranting massive spraying, often carry the day.

Specific, significant areas of debate include: 1) the insects' impact on food production; 2) the importance of locusts and grasshoppers in relation to other pests; and 3) whether or not these insects cause famine. Experts' judgments differ, too, concerning 4) the effectiveness of current control Programs based exclusively on the use of chemical insecticides, 5) the relative roles of climate and control in bringing about declines of insect upsurges; and 6) whether the benefits of control, in terms of crops saved, exceed the costs of control. Experts differ, also, in their opinions on the nature and severity of costs in terms of 7) human health and safety and 8) environmental impacts. People also disagree on 9) how control efforts should be organized and what strategies should be followed.

LOCUSTS AND GRASSHOPPERS' IMPACT ON FOOD PRODUCTION

Finding: The link between locust and grasshopper upsurges and food shortages or famine is questionable. In fact, locusts and grasshoppers are relatively minor pests in terms of overall crop losses, although they can devastate local areas for short periods of time. Thus, the high priority given to locust and grasshopper control programs is unwarranted.

Do Locusts Cause Famine?

USAID, like others, justifies its locust and grasshopper control program on the basis of averting famine. The 1987 USAID *Locust/Grasshopper Strategy Paper* defines the purpose of the strategy as:

> . . . dealing with one of the most serious exogenous factors adversely affecting agricultural production: the cyclically recurring infestations of locusts and grasshoppers, which can result in significant crop losses and periodically lead to plague and famine conditions in many parts of Africa. (113, p.1)

More recently, USAID stated that the goal of its $22 million African Emergency Locust Grasshopper Assistance (AELGA) project, fiscal years 1987 through 1989, is "to contribute to the improved nutritional status and well being of Africans by reducing the threat of locust and grasshopper plague-induced famine, and its associated economic and social suffering."

Key data are missing, but historical analysis (16) and recently acquired data (72) suggest that what is often considered fact–the connection between swarming insects and famine-is actually a questionable assumption.

Crop loss from locusts and grasshoppers may be severe in certain areas without having significant impact on national crop production. USAID country reports reveal little overall crop damage by Desert Locusts during 1988, the height of the recent plague–crop losses of 2 percent in Sudan and Mali (with some localized severe damage –and minimal or negligible losses in Niger, Chad (117), and Algeria (89). The authors of the Chad case study claim that effective control was the reason for the small losses, but also admit that no system exists for reliably evaluating crop damage by locusts.

The insects' impact is highly dependent on a number of variables, including the number of insects present, how long they stay in the area, and the amount each insect eats (16). However, the stage of crop development also determines the amount of crop loss. Total crop loss usually occurs only if the insects attack at certain stages in crop development. Young grain crops are highly vulnerable but replanting maybe possible if they are destroyed early. Damage to more mature crops is usually lower until just before grains begin to ripen; nevertheless, a swarm can cause partial or total crop loss (95) . At other stages, damage is substantially less. For example, one study of the African Migratory Locust's effect in Kenya showed that the pest caused 100 percent yield loss when attacking very young or flowering corn, 20 percent yield loss on corn with unripened ears, and no yield loss on corn over 30 cm tall (139).

Economic losses also depend on which plant species and what part of the plant locusts affect, e.g., consuming grain or foliage or breaking branches due to their weight. Grain crops are highly susceptible at the "milky grain" stage and 100 percent yield loss may occur if even low densities of locusts or grasshoppers attack then. Studies on the impact of locusts on sugarcane yields in several countries showed that the highest recorded crop loss was due to Red Locusts in Mozambique's sugarcane fields, where yield was reduced by an estimated 33 percent in 1934 (95). Sugar-cane losses of 12 to 18 percent were more usual (in South Africa in the 1950s and the Philippines in the 1930s), but in one case yield increased after defoliation (95). Also, the weight of roosting locusts may break branches of trees, affecting future yields of valuable commercial crops.

As a result, crop losses are unevenly distributed in space and time, even during upsurges. Within affected areas, sometimes all vegetation is stripped, especially in sites such as breeding areas and traditionally infested areas, e.g., in Sudan, Ethiopia and Somalia, or when unusual weather conditions trap locusts in one spot for an extended period of time. In most infested areas, however, damage is less than total and uneven due to swarms' mobility and other factors.

Comparatively small areas of the total area infested by Desert Locusts experience losses in excess of 10 percent (16). This occurred in the 1954 through 1955 season when nearly 90 percent of the total reported damage was in a small part of southern Morocco and in 1958, when a higher percentage was concentrated in two small areas in Ethiopia, causing severe, but localized, economic losses (16). The U.N. Food and Agriculture Organization (FAO) speculates that, on average, crop damage does not exceed 5 percent over the Desert Locust's whole invasion area during a plague (12). However, data to verify this percentage would be difficult to obtain. Grasshoppers, the Senegalese Grasshopper in particular, caused more generalized and heavier damage than locusts in recent years (12). No areas within nine West African countries studied have been affected severely enough by locusts and grasshoppers to be abandoned by cultivators (95), thus illustrating the temporary nature of damage.

The location and timing of grasshopper and locust infestations, along with the food preference of the species involved, means that damage is not evenly distributed among different types of farmers and herders. For example, orange trees were severely attacked by Desert Locusts in Morocco's Seuss Valley in late 1954 and early 1955, so commercial growers were hard hit. But the Senegalese grasshopper adversely affects most of the millet- and much of the sorghum-growing areas of the Sahel (71) and, thus, subsistence farmers bear much of the damage.

Some insect species prefer grains and pose a greater threat to farmers than herders. Generally, herders seem to be less affected by locust swarms than farmers, probably because swarms occur when rainfall is plentiful, thus providing abundant vegetation for grazing. Also, herders often can move their herds from damaged areas. Locusts and grasshoppers are more likely to affect herders adversely if their movement from devastated areas is restricted or if overgrazing already has reduced grass cover (95).

Substantial crop damage may lead to local adverse impacts on food security. Beyond this, little can be said with much certainty. Locust and grasshopper damage contributed to 1986 and 1987 food deficits in some countries but perhaps no more than other factors (72). In 1986, FAO estimated that crop losses due to locusts and grasshoppers in nine Sahelian countries was $31.0 million, 1.5 percent of the total value of agricultural production or 1.0 percent of total production. The relationship between this figure and that of other years or other outbreaks is not known (95).

The damage associated with locust and grasshopper outbreaks often results from the interaction of multiple adverse factors over time in addition to large numbers of insects: drought, loss of vegetation, civil strife, economic stagnation, etc. Most of these factors also contribute to famine or food shortages. Therefore, the impact of locusts and grasshoppers alone is difficult, if not impossible, to determine. On a countrywide basis, the recent locust or grasshopper upsurges did not have the negative impact that a drought would produce. Generally, the aggregate amount of damage reported was much less than feared and the losses were on the scale of localized, perhaps near-normal stress rather than national calamities (table 2-1). Some observers report that locust and grasshopper outbreaks often do not result in even local food shortages, because of replanting, regrowth of vegetation, use of resistant crops such as cassava and, especially, help from neighbors or relatives. Thus, the "popular image of a locust outbreak leading to famines seems to have little or no basis in fact." (95)

Famines have complex causes, as shown by recent examination of famines in Ethiopia from 1972 to 1974 (87) and the Sahel from 1968 to 1973 (86). Drought may set the stage, but other factors determine which groups are affected and by how much. The problem is more one of food distribution and food access than food production, since food shortages alone do not explain starvation. Neither aggregate food availability nor average consumption of food per person declined significantly in Ethiopia during one of the worst years of the famine (87). Apparently people starved because they could not afford to buy food from outside the area when their own farm output declined. Pastoralists were particularly hard hit in Ethiopia and the Sahel, but social, economic, and political factors, not the severity of drought, determined this. For example, the growth of commercial agriculture reduced herders' access to dry-season grazing areas in Ethiopia. In the Sahel, too, herders' traditional methods of ensuring against famine broke down: high taxes meant fewer herders could afford to store animals on the hoof; wildlife populations had declined so much that hunting could not replace domesticated animals; growing commercialization of agriculture had disrupted arrangements by which herders traded with farmers for access to cropland for dry-season grazing.

Given the complexity of such interactions, it is unlikely that the role locusts and grasshoppers play in famine could be assessed with aggregate food production data rather than information on local food availability. Data on local crop production losses and local shortages is essential but does not seem to exist, especially for food crops. Even national aggregate data commonly are only estimates. Locust and grasshopper control has taken place sporadically for decades and numerous organizations have been involved in this work. Yet the damage caused by these insects has not been documented accurately.

> ... the data is [sic] fragmented and episodic, reflecting outbreaks that were sufficiently large to merit the attention of an international agency or a government.... There exist no accurate crop yield and/or loss data for most of the area subject to attack by locusts. (95)

In 1987, Oregon State University began USAID-funded work to improve the assessment of losses due to these insects. However, USAID's expectation that the International Plant Protection Center, using a computer model, could determine crop losses among several other objectives, proved overambitious. Most of the required data were spotty, unavailable, or unreliable and, thus, the model could not produce an improved crop loss assessment (99).

The number of variables involved complicates estimating potential crop losses and helps explains why **the authors of so many published estimates of actual crops losses do not describe their methodology, having arrived at estimates subjectively. Measuring crop loss is difficult for migratory pests, especially the Desert Locust; people have made attempts in the past-and failed. Breeding areas are remote with access further limited by civil strife; upsurges can be large and widely scattered; and locusts are very mobile (16, 79). Experienced observers can estimate severe crop losses accurately in the local areas with which they are familiar, but miss more subtle yield reductions caused by these insects (16).**

Pest Problems in Context

The relative importance of grasshoppers and locusts compared to other pests has not been determined precisely. Grasshopper and locust losses may be significant in some years. Yet compelling evidence does not exist that they cause worse losses than other pests (37, 72, 95). For instance, plant protection experts often assume that all types of preharvest crop losses in the Sahel region are as great as 30 percent but sometimes larger. Of this, grasshoppers maybe responsible for 5 to 18 percent of crop losses each year (72). In 1986, grasshoppers were considered a major problem and large-scale control programs were undertaken. Yet the 1986 crop production losses caused by grasshoppers seems to be below this normal range (table 2-l). These data, compiled for the Famine Early Warning System (FEWS) are the best available, although somewhat unreliable.

However, the 1986 FEWS data correspond with earlier estimates, many made before large control-campaigns existed. Compilations of reports on damage to crops and livestock in 40 countries during major Desert Locust plagues were made by the Anti-Locust Research Center in London for 1925 through 1934 and FAO for 1949 through 1958. Analyzing this information, F.T. Bullen found that the Desert Locust caused, on average, about 1.4 percent of the overall crop loss due to insects in the same area (or about 0.2 percent of the total crop production) and only about 4 percent in a peak plague year (or, only about O6 percent of total crop production). He concluded, "Locusts and grasshoppers, even at their worst, constitute only a very small proportion of the overall crop protection problem." (16)

In fact, weeds cause greater food crop losses in Africa than insects–15 to 35 percent of potential production depending on crop (millet, sorghum, rice, or maize) versus 10 to 20 percent, according to a standard reference-and locusts are not a major insect pest when examined overtime (25, as cited in 95). OTAreviewers concurred, noting, for example, that birds are the worst pest (32), the weed *Striga* costs farmers more losses (31), and the armyworm causes losses to cereal crops up to 30 percent in Zimbabwe in some years (61).

Finally, losses due to pests also must be placed in context-many other factors cause economic losses for farmers. For example, postharvest losses often account for a significant portion of spoiled production. In 1987, in West Africa and the Sudan, despite severe grasshopper infestations, losses to farmers due to inadequate marketing and storage facilities were greater than those caused by insects (12).

THE EFFECTIVENESS OF CONTROL PROGRAMS

Finding: The efficacy, efficiency, and equitability of locust and grasshopper control programs are undocumented or rely largely on anecdotal information. While insecticides undoubtedly kill insects and can protect standing crops, insecticides' ability to end or prevent plagues is not clear. Nor have the economic benefits of control programs been demonstrated convincingly, especially for the low-resource farmers and herders who are most vulnerable.

The stated goals of control programs include preventing famine, saving crops and livestock, and preventing and ending plagues, but the link between the pesticide spraying campaigns and achieving these goals has not been demonstrated.

Control v. Climate

Many insecticides are effective for killing locusts and grasshoppers (95). However, the relationship between insect mortality and preventing crop or forage losses, in the area sprayed or distant from it, is uncertain. Also, it is not clear whether control campaigns prevent a plague from developing, hasten the end of a plague, or do not

Table 2-1—Crop Production Affected by Grasshoppers, 1986 (thousands of metric tons)

Country	Gross production	Production lost to grasshoppers 1,000s MT	Percent	Production saved[b] 1,000s MT	Percent	Production affected[b] 1,000s MT	Percent[c]
Burkina Faso	1,917.0	8.3	<1	91.5	5	99.8	5
Chad	685.0	24.0	4	30.0	4	54.0	8
Ethiopia	6,504.0	0.5	<1	0.5	<1	1.0	<1
Gambia	144.0	1.0	<1	1.0	<1	2.0	1
Mauritania	125.0	10.0	8	10.0	8	20.0	16
Mali	1,780.0	30.0	2	30.0	2	60.0	3
Niger	1,807.0	108.0	6	108.0	6	216.0	12
Senegal	964.0	50.0	5	70.0	7	120.0	12
Sudan	4,300.0	9.2	<1	9.2	<1	18.5	<1
All	18,226.0	241.0	1.4	350.2	1.9	591.3	3.2

NOTES:
[a]Original data from USAID, FAO, CILSS/FAO.
[b]Original data from FAO, FEWS estimates.
[c]Percents lost and saved do not always equal percent affected due to rounding errors.

SOURCE: Price, Williams & Associates, "1986 Grasshopper and Locust Infestations," FEWS Special Report No. 1, contractor report prepared for U.S. Agency for International Development, March 1987, pp. 4-12.

affect it. Some note the danger of broad-spectrum insecticides killing natural predators of these insects and the potential for developing pest resistance (which has not yet been known to occur for locusts). In these cases, insecticides could increase threats from locusts and grasshoppers indirectly.

Experts point out that control with chemical insecticides is the only effective method presently available for preventing locust and grasshopper outbreaks from becoming widespread (34, 38, 95). Generally, grasshopper control is considered less effective (95).

Some credit monitoring, surveillance, and control methods developed after World War II with reducing the duration and incidence of some species' plagues or of reducing the intensity and geographic size of other species' outbreaks when they do occur (54, 93). They contend that control efforts prolonged recessions between plagues of the Red Locust (5), the African Migratory Locust (2), and the Desert Locust (79). Generally, however, analysts admit that evidence was sometimes incomplete and circumstantial and that control sometimes has not been effective (4).

FAO contends that present control measures, properly applied, can prevent upsurges from developing into plagues or considerably shorten the duration of those that do develop (12). Furthermore, the failure to mobilize adequate resources and the inaccessibility of target areas, rather than ineffective methods themselves, caused several missed opportunities to prevent the Desert Locust upsurges from developing into a widespread plague in 1987 and 1988 in FAO's view (106).

Others find, however, that control efforts have had negligible impacts on plague populations and that their decline is due almost entirely to natural causes (135). Support for this view comes from reviewing past Desert Locust and Brown Locust plagues. Plagues occurred for both insects at times when chemical control measures were used extensively (9, 52). For example, the Desert Locust plague from 1949 to 1%3 (when chemical controls were being deployed) was no less intense and lasted twice as long as plagues earlier in the century, which occurred before these control techniques were available (138, figure 1-3).

Climate is known to have a controlling effect on many aspects of locust and grasshopper behavior. Most believe that climate can retard locusts and grasshoppers as much as control (95). But some believe that climate alone controls insects and that locust plagues end whether they are treated or not (135). If so, locust upsurges could be allowed to run their course at considerably less financial and environmental expense than current massive interventions. Such an approach would be analogous to the U.S. Forest Service's practice of usually letting forest fires bum, except where fires threaten lives or homes.

Not surprisingly, OTA'S reviewers similarly have points of view ranging from insect declines are entirely due to weather (63) to the control program was the major factor in curtailing the plague (44). Others (61, 79) believe that control campaigns definitely suppress plague development and hasten the end of a plague, but admit adverse weather may play a crucial role.

As a result, several conclusions are possible: "the question of whether the decline of the plague was due to [human intervention] or . . . nature remains unresolved" (71). Or, *"There* is no firm evidence that control campaigns have appreciably affected the declines" (9). The French research agency PRIFAS conjectured that 20 percent of the Desert Locust population was destroyed by control efforts in late 1988 and early 1989,30 percent perished in storms over the Atlantic, 30 percent were killed by low temperatures, and 20 percent by insufficient rainfall (76). FAO's Brader (13) concluded that:

> **While climate appears to be the dominant factor determining the fate of locust plagues, chemical control may play an important role at least on the national scale.**

Currently, FAO is supporting research by the British Overseas Development Natural Resources Institute examining the roles of weather and control in the sequence of events leading to the upsurge, spread, and decline of the Desert Locust plague between 1985 and 1989. The scientist coordinating that research said:

> **The usual view of those involved in control campaigns is that control measures are key in ending plagues. The more objective view–that of most scientists not involved in control-is that weather is key, that weather has as much if not a greater role than control. (54)**

Key data for resolving these differences of opinion regarding the impact of control programs are lacking. This includes accurate surveys of: the numbers of insects present in a given location and time during an infestation; baseline numbers of insects present during recessions; the percent of total production actually at risk; the actual amount of damage done to crops and other vegetation; the impact of this local damage on local and aggregate crop production. Similarly, specific information is needed on weather and control variables. For example, experts at a 1988 World Meteorological Organization workshop on meteorological contributions to locust control stressed the need for more case studies as well as improved coordination between weather and locust control operations (112). This missing information is key to making informed decisions regarding whether chemical control efforts are economically justifiable, where resources should be directed and when, the appropriate nature, timing, and quantity of emergency aid, and the amount of preparation needed to meet threats in succeeding years (73).

However, historical data can support previsional decisions and some data syntheses have been completed (e.g., 4). Based on these, it appears that, in some places and at certain times, certain kinds of control may help break a sequence of events that could lead to a widespread insect upsurge; under other circumstances, control can have negligible impact. For example, a kill rate of 95 percent might be required over a vast area when weather favors insect build-up; once rains decline, a lesser effort properly administered, can hasten what nature started (55). Other generalizations regarding the effectiveness of locust control are highly suspect and some costly decisions are being made with little data to support them.

"Pesticides of Choice" and Their Effectiveness

In August 1988, USAID waived Regulation 16 and identified malathion, carbaryl, and fenitrothion as the "pesticides of choice" and listed others that could be used in locust and grasshopper control (table 2-2). As a result of the waiver, USAID was not required to prepare an environmental assessment before pesticide use. The waiver was justified on the basis of a declared emergency and other environmental research planned and underway. For instance, the Agency had contracted with TAMS Consultants, Inc. (with technical input from the Consortium for International Crop Protection (CICP) headquartered at the University of Maryland) to conduct a Programmatic Environmental Assessment regarding locust and grasshopper control throughout Africa and Asia.

Also, USAID contracted with a private firm, Dynamac, to conduct trials of 6 to 8 insecticides for their efficacy; impact on nontarget, beneficial organisms; and residues in soil and on vegetation in Mali (against the Senegalese Grasshopper) and Sudan (against the Desert Locust) in 1987 through 1988. It was known that the relative effectiveness of various ingredients, formulations, and applications of insecticides must be assessed under field conditions and balanced against harmful effects, but this had not been done adequately. USAID hoped that the Dynamac trials would fill in some of these gaps.

With the reinstatement of Regulation 16 in August 1989 and based on the completed Programmatic Environmental Assessment, USAID expanded the number of insecticides that could be purchased or used-most with a number of restrictions and qualifications-to include propoxur, acephate, and cypermethrin (122).

USAID's approval only overlapped in part with the Environmental Protection Agency's (EPA) list of pesticides registered for use in the United States against grasshoppers and locusts. EPA registers malathion, carbaryl, diazinon, lindane, acephate, chlorpyrifos, and tralomethrin (with Zyme) but not some others commonly used in USAID-approved locust control efforts, e.g., fenitrothion and propoxur. USAID's list allowed the United States to match other donors' approved pesticides more closely, at least for the major chemicals. However, lack of clarity existed in the field about which were best and why some pesticides approved for use in the United States were disallowed overseas. Advice from Washington regarding these policies was sometimes too slow in coming and voluminous to be helpful (120).

No single organization seems able to provide complete or accurate information on the quantities or types of pesticides used in Africa for any purpose, and some past estimates are known to be inaccurate (95). However, indications are that the total amount of pesticides used in 1986 to 1989 for locust and grasshopper control was formidable. Insecticide use seems to vary widely among countries, ranging from 34 to 1,014 metric tons in 7 individual Sahelian countries in 1986, for instance (95), and between regions. In 1988, the 4 northwest African countries of the Maghreb region used 11 million liters of insecticides and the 4 most affected Sahelian countries, 2 million liters, at a total cost on the order of $100 million (109).

Fragmentary data exist on the total amount of insecticides supplied by donors during the 1986 through 1989 locust and grasshopper control campaign, but it is not clear how accurate these figures are. Donors provide the same pesticide indifferent formulations so figures are difficult to summarize and compare. Also, FAO'S information does not include the amounts of pesticides purchased by African governments; these amounts are significant in the Maghreb but negligible in the Sahel (12).

U.S. assistance during the last campaign consisted principally of pesticides, airplanes, and equipment for spraying (figure 2-l). The United States provided 605,518 liters and 450 metric tons of insecticides in 1986 and 1987, according to the OFDA database (table 2-3). This was mostly malathion, carbaryl, and lesser amounts of propoxur and fenitrothion, at a cost of approximately $3.2 million. Apparently, carbaryl was purchased but not used (99) because some African officials doubted its effectiveness and wanted quicker-acting chemicals.

The United States exempts emergency efforts, i.e., those supported by OFDA, from "tied aid" provisions, but these requirements apply to pesticide choice for longer-term efforts, e.g., those funded by USAID missions and bureaus, for which waivers are more difficult to obtain. In fact, most OFDA funds spent on pesticides went to U.S. manufacturers.

The use of U.S. manufactured pesticides and U.S. procurement requirements affected pesticide selection, control costs, and the speed with which pesticides reached Africa. USAID usually selected

Table 2-2–International Registration Status of Locust/Grasshopper Insecticides in Selected Developed Countries

					United States		
Insecticide	**Canada**[1]	**France**[2]	**U.K.**[2]	**West Germany**[2]	**Approved by AID**[3]	**Registered by EPA**[4]	**Registered by EPA for grasshopper/ locust**[4]
Main:							
Malathion	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Carbaryl	*Yes*	*Yes*	*Yes*	N/A	*Yes*	*Yes*	*Yes*
Fenitrothion	*Yes*	*Yes*	*Yes*	N/A	*Yes*	*Yes*	*No*
Propoxur	*Yes*	N/A	*Yes*	N/A	*No*	*Yes*	*No*
Diazinon	*Yes*	Yes	*Yes*	Yes	*Yes**	*Yes*	*Yes*
Lindane	*Yes*	Yes	**Yes**	Yes	*No*	*Yes*	*Yes*
Dieldrin	*No*	No	*No*	No	*No*	*No*	*No*
Acephate	*No*	Yes	N/A	Yes	*No*	*Yes*	*Yes*
Others:							
Bendiocarb (Ficam)	*Yes*	Yes	**Yes**	**Yes**	*Yes**	*Yes*	*No*
Chlorpyrifos (Dursban)	*Yes*	Yes	*Yes*	*Yes*	*Yes**	*Yes*	*Yes*
Cyhalothrin (Karate)[a]	*No,* **(pending)**	N/A	N/A	N/A	*Yes**	*No,* **(pending)**	*No*
Tralomethrin (scout)	**No**	N/A	N/A	N/A	*Yes**	*Yes*	*Yes,* **in combo with zylene**
Cypermethrin	**Yes**	Yes	*Yes*	*Yes*	*No*	**Yes**	**No**
Carbosulfan	**No**	Yes	*Yes*	**N/A**	*No*	**Yes**	**No**

NOTES:

N/A = not available.

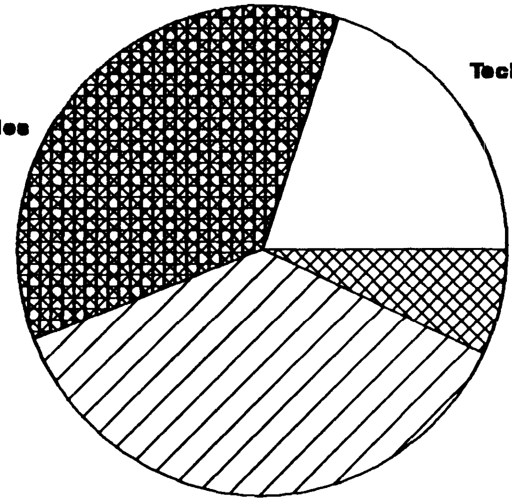
* Approved with the qualification that use be monitored or justified.

[a] No approved common name exists for Karate, a trade name for a synthetic pyrethroid, according to *Farm Chemicals Handbook* 1989 (Willoughby, OH: Meister Publishing Co., 1989).

SOURCES:

1. Dr. Peter Bennett, Chemical Evaluation Division, Bureau of Chemical Safety, Food Directorate, Ottawa, Ontario, Canada, KIA OL2, January 1988.
2. European Directory of Agrochemical Products, Part 3, Insecticides and Acaricides, Royal Society of Chemistry, The University, Nottingham, England, NG7 2RD, 1984.
3. Insecticide approved from Aug. 1, 1988-Aug 15, 1989. Charles Gladson et al., “Waiver of Pesticides Procedures for Locust/Grasshopper Control Programs in AFR and ANE Regions," action memorandum for AID Administrator, Aug. 15,1988, Attachment A pp. 6-7. This differs from direction on pesticide selection in the *Locust/Grasshopper Management Operations Guidebook (1989). New* information requires that the list be updated constantly.
4. TAMS Consultants and Consortium for International Crop Protection, *Locust and Grasshopper Control in Africa/Asia: A Programmatic Environmental Assessment,* Main Report, contractor report prepared for USAID, March 1989, p. D-56.

Figure 2-l-Uses of U.S. Assistance for Locust/Grasshopper Control: $7.5 Million in Fiscal Year 1987



SOURCE: John Gelb, Office of Foreign Disaster Asistance, USAID, "U. S. .A.I.D. Support, Desert Locust Task Force, FY1987," June 22,1989.

Table 2-3-Pesticides Purchased With USAID Funds for Locust/Grasshopper Campaign: Fiscal Years 1986 and 1987

Pesticide	1986[a] Value[c]	1986[a] Volume[d]	1987[b] Value[c]	1987[b] Volume[d]
Carbaryl	0	0	*258,802*	*%,690* L
			217,739	50 t[f]
Fenitrothion	260,000	50,000 L[e]	205,000	5,000 L
Malathion	199,305	60,000 L	1,382,959	393,828 L
Propoxur	0	0	600,000	4oot
Unspecified	115,000	N.A.	0	0
Total	574,305	110,000 L	2,664,500	495,518 L 450 t

NOTES: N.A=Not available
[a]Recipient countries listed in 1986: Mali and Senegal.
[b]Recipient countries listed in 1987: Burkina Faso, Chad, Ethiopia, Gambia, Guinea Bissau, Mali, Senegal, Sudan, and Yemen.
[c]Often "value" includes the cost of ocean and/or air freight.
[d]Active ingredients vary considerably (e.g., between 1 and 4 pounds per liter depending on the formulation).
[e]L=liter
't = metric ton.

SOURCE: Dennis King, USAID/OFDA, "O.F.D.A. Commodity/Service Report," Washington, DC, June 27,1989.

malathion and carbaryl because the pesticides are U.S.-manufactured and technical advisors from USDA had long-term experience using them for U.S. grasshopper control. Generally, U. S.-produced insecticides are more costly than those manufactured in other countries so tied aid provisions increase control programs' costs (30).

Also, various USAID procurement requirements affectin bureau admission money, including the need for competitive bids, were a major cause of delays in U.S. programs. USAID/Morocco noted that approximately 5 months were needed to purchase and ship insecticides in 1988 and 1989 because of these requirements (120). In Chad, the insecticidal arriv date also, but in this case the delay was not detrimental because the locusts had "mysteriously disappeared" (117).

Operational Effectiveness of Control

The use of insecticides may protect standing crops from grasshoppers and locusts. However, few detailed studies have been made of the operational effectiveness of the recent spraying campaigns, e.g., insecticides' efficacy in killing resects was not monitored. Also, insecticides were often used in ways that reduced or negated their effectiveness (54, 99).

Incorrect application methods and careless tar et selection reduced the effectiveness of control. Some areas were sprayed too late in the day or when temperatures or wind speeds were beyond recommended ranges or that had already been sprayed. Mounting targeted control efforts was not a priority of USAID and others during this campaign. Some swarms were treated that posed little threat because they were not expected to reach croplands or because they had already laid eggs and their populations were in decline (54, 115). Opportunities to spray hopper bands, when the insects are more vulnerable and concentrated, were missed. Where hopper spraying was attempted, areas needing treatment were sometimes bypassed or unaffected areas sprayed because often hopper bands were not visible from the air.

This occurred, in part, because USAID, in its 1987 Strategy Paper, approved control operations against swarms wherever they might be, rather than emphasizing focused operations at specific places and insect life-stages.

The 1986 to 1987 spraying program was difficult to execute due to the widespread extent of infestations, lack of preparedness of staff, wars and civil strife, impassability of roads after rains, donors' diverging policies, lack of transport and communications, and late ordering and arrival of equipment and pesticides. Air shipments of supplies were more timely in 1987. Yet, some 1987 operations were not justified, necessary, or economical. Over-dosage of pesticides occurred in many ground and aerial operations. And parceling out the program among many donors meant that ground support was duplicated and sometimes efforts were not concentrated when and where they were needed (95).

The Economic Costs and Benefits of Control

The economic cost of control programs varies with insecticide, formulation, and application method. For example, carbaryl costs at least twice as much as malathion and fenitrothion ($4.50 v. $2.00 per ha). Ground application costs ranged from $6.00 to $8.50 per ha for ultra-low volume (ULV) spraying, $8 to $12 per ha for baits, to $18 to $26 per ha for dusts in Senegal in 1986. Aerial and ground ULV spraying cost approximately the same per hectare. However, farmers treated only 0.5 ha per hour, the crop protection service treated 8 to 12 ha per hour with ground spraying, whereas aerial spraying averaged 450 to 470 ha per hour (118). Multiengine aircraft are most costly per hour but can cover the largest areas; using smaller, single engine aircraft costs about $1,000 per hour.

These estimated costs for ULV spraying are comparable to current U.S. costs of grasshopper control, which range from $5.50 to $9.00 per ha. But these estimates assume that the pesticides are in place where needed and do not account for the freight of formulated chemicals. Air freight was a substantial cost in 1986 at the beginning of these campaigns. More realistic estimates of total donor and local costs in Africa range from $15 to $30 per hectare in 1986 (95). Thus, the actual costs of control programs in Africa are high.

The direct benefits of control campaigns can be assessed by estimating the value of crops threatened, or saved. Indirect benefits, e.g., institutional development of national crop protection services, also exist but are largely unquantifiable and, thus, not included.

The value of crops threatened depends on the crop, with cash crops' value more easily measured than those such as sorghum and millet, grown for direct consumption on the farm (15). Yet, much of the invasion area of the Desert Locust in Africa is devoted to subsistence farming and herding. Thus, the economic benefits of control programs for the most vulnerable are even less clear than those for large-scale commercial farmers. By and large, the micro-level economic and sociological research needed to make this determination has not been done.

The value of crops saved is more relevant than value of crops lost, a conclusion reached by the 1989 Programmatic Environmental Assessment and the Anti-Locust Research Centre in London in the 1960's (15). However, crops threatened is no easier to determine than crops lost.

The Programmatic Environmental Assessment summarizes the best available estimates of the costs of grasshopper and locust damage, but it provides little basis from which to derive the benefits of control. Existing measurements of benefits are subject to wide margins of error (92, 95). Economic estimates of potential agricultural losses to the Desert Locust commonly are based on hypothetical calculations rather than field data on crop losses and insect biology. Also, some underlying assumptions are faulty, such as assuming that damage is evenly distributed and total in a given area. Or, estimates maybe based on worst-case scenarios. For example, potential damage from Desert Locusts in Morocco was estimated at $125 million to $250 million in 1988, the value of all crops produced in the Seuss Valley and southern Morocco (115). But this estimate assumed that the intensity and scope of the damage in 1988 would equal that of 1954 and 1955. A technical advisor to the Moroccan Government present at the time believes that what occurred then was a freak event due to unusual weather that trapped 14 immature swarms in the narrow Seuss Valley for 6 to 8 weeks and its probability of recurrence is low (41).

Resultant claims of the value of crops saved due to control are questionable at best when based on faulty assumptions, hypothetical figures, and/or worst-case scenarios.

No estimates exist of what the cost would be of letting an infestation run its course, although some instructive historical evidence exists, such as records of damage in average and plague years before control campaigns were mounted. Costs of not controlling an infestation would include the value of the crops lost plus resulting relief and rehabilitation costs, e.g., food aid and seeds for replanting.

When costs v. benefits are examined, the monetary costs of the 1986 through 1989 control program may not have yielded a favorable net return in terms of the amount and value of crops saved. USAID's mid-term evaluation of its AELGA project found that data was not available to assess the value of crops and livestock saved (99). Some evidence, however, shows that the value of production saved in 1986, generally did not equal or exceed the value of inputs received for treatment in five of the nine Sahelian countries (72). Overall, donor contributions of $40 million for control seem high compared to the estimated $46 million of production saved. These findings were based on the best available, but admittedly unreliable, national-level aggregate data. USAID's 1989 Programmatic Environmental Assessment of grasshopper/locust control incorporated the findings and underlying assumptions of this 1987 study. Thus, USAID accepted the conclusion that the costs of the control program in 1986, barely exceeded the value of the crops saved Furthermore, historical data show that increases in control rests do not necessarily result in decreases in crop losses. Data from earlier Desert Locust plagues show that average annual crop damage increased 175 percent between 1930 and 1955 even though control expenditures climbed an average of 600 percent (15).

The costs of control relative to the value of benefits is also affected by the efficiency of operations and the way that costs and benefits are defined in space and time. Inappropriate spraying and target selection increase the cost of control. Early treatment is costly if benefits are defined for local or national areas. Yet, early treatment may be considered economically efficient if it prevents a plague (95). In that case, estimated benefits increase because they accrue to a number of countries over a longer time period.

The cost-effectiveness of locust and grasshopper control programs has not been demonstrated convincingly. This is due, in part, to the scarcity of data, and that is understandable, given the constraints of data-gathering in vast, remote areas, the few people and other resources that national governments can devote to the task, and the emergency nature of the situation. No single organization is responsible for collecting the kind of data that would be required to provide a thorough evaluation of the costs and benefits of control operations. Groups have concentrated on implementing control operations without asking whether those efforts were, in fact, economically justified and without using part of their resources to collect data on crop losses and control costs. Without such data, sound policymaking is impossible.

After-the-fact cost/benefit analysis reinforces the impression that control programs are expensive and ineffective (95). Yet, this assessment may be unfair because cost/benefit analysis is more appropriately used to evaluate options before one is selected. Also, cost/benefit analysis assumes that money not put into one use would be available for other uses. This is not the case here because money available for disaster assistance is not necessarily available for other uses.

A number of issues, such as local knowledge and acceptance of the risks of control, are not well captured in cost/benefit analysis yet may have important implications for the effectiveness of programs (131), for the growth of institutions, and for U.S. interests (97). In addition, donors' responses to perceived emergencies do not follow a strictly economic rationale. This assumes, however, that: 1) locust and grasshopper outbreaks or upsurges are truly emergencies and 2) emergency responses are effective. These are questionable assumptions (95).

Certainly if control operations cannot be justified on the basis of monetary costs alone, it would be hard to justify such efforts based on broader definitions of effectiveness that account for additional costs (or hazards and risks) such as environmental and health hazards. For example, attempts to calculate the costs and benefits of current control programs have not estimated the real or potential costs of loss of beneficial organisms, onset of insect resistance, and general environmental contamination.

Regardless of debates about cost/benefit analysis, it remains clear that control costs in Africa can be reduced. Spraying efficiency can be improved. In addition, considerable room for improvement exists in determining provisional economic thresholds for making pesticide application decisions (95).

HEALTH AND THE ENVIRONMENT

Finding: Safe, environmentally sound use of insecticides was not ensured during the 1986 through 1989 grasshopper and locust control programs and human and environmental exposure were, at times, dangerously high. Application, storage, and disposal of insecticides were not monitored adequately, nor were the cumulative effects of other health and spraying programs taken into account.

Human Exposure

Evidence from a variety of sources suggests that direct and indirect human exposure to insecticides was sometimes dangerously high in recent campaigns. At least half of the respondents to OTA'S survey indicated that either accidental Poisoning of humans or adverse environmental impacts due to pesticide use had been detected. Frequent instances of contamination in ground spraying crews were observed in the Gambia, resulting in some poisonings (114). The AELGA mid-term evaluation cites a story of flies dropping on contact with a control technician even after he washed thoroughly (99). Insecticide poisoning was reported in Niger as a result of people eating treated locusts (99). Also, human poisoning occurred when "empty" pesticide containers were reused to store water or food (77).

Numerous pesticides, known to be toxic to grasshoppers and locusts at different formulations, rates of application, temperatures, etc., also constitute various levels of hazard to people, according to the U.N. World Health Organization (111):

- extremely hazardous (parathion),
- highly hazardous (aldrin, dichlorvos, dieldrin, DNOC),
- moderately hazardous (alphacypermethrin, bendiocarb, BHC (or HCH), carbaryl, carbosulfan, chlorpyrifos, cyhalothrin, cypermethrin, DDT, deltamethrin, diazinon, fenitrothion, fenvalerate, heptachlor, lindane, phoxim, propoxur, tralomethrin),
- slightly hazardous (acephate, malathion).

The health effects of insecticides can be acute or chronic, depending on the amount, extent, and duration of exposure, chemical concentration, and individual sensitivity. With sufficient exposure at sub-acute levels, some chemicals produce chronic health effects, including cancer and neurological and reproductive disorders. For example, aldrin, BHC, dieldrin, and lindane accumulate and remain in the human body for considerable periods of time, with the potential for chronic effects. USAID has prohibited the use of these persistent pesticides for health and environmental reasons since the late 1970s (43). The impact of long term exposure of entire populations in given areas to pesticides from a variety of agricultural and health spraying programs is largely undocumented. However, the fact that large numbers of people may unknowingly experience subclinical, chronic changes without having been offered information or risk-reducing choices is worrisome (95).

People can inhale or ingest insecticides directly or absorb these chemicals through their skin. Also, people can be exposed to insecticides indirectly through food or water supplies. For instance, locusts and grasshoppers are used as food in many African countries, especially by children, and they may ingest chemical residues by eating sprayed insects. However, the relative importance of locusts in people's diets is not known, nor do data seem to exist on the amount of pesticide residues on insects prepared as food.

People are likely to be exposed to significant levels of pesticide residues in other ways, also. USAID-funded field trials of six pesticides' residues in Sudan detected levels high enough that researchers recommended that bendiocarb should be limited to areas not used for agriculture or grazing, and that post-spray harvesting be restricted after fenithrothion and chlorpyrifos use (28). The dangers of exposure to insecticide residues in food and water supplies are known but were not routinely monitored as part of the spray campaigns in Africa. Insufficient attention was paid to the danger of contamination of already-scarce food, groundwater, and surface water in the recent campaigns. Insecticides that break down relatively quickly, such as malathion, are less likely to reach water sources than more persistent ones, such as lindane, but pesticide choice has not, by and large, been dictated by criteria such as potential environmental contamination.

Accidental exposure to pesticides can occur in a variety of ways: when spraying equipment malfunctions, when chemicals are stored with little regard to long term safety, or when containers are reused inappropriately (14). Technicians and herders have the highest probability of significant chemical exposure in locust and grasshopper control programs (27). Technicians are more likely than the general population to be aware of insecticides' hazards but few were trained to avoid them. Also, pesticides are often used in developing countries with inadequate safeguards for operators. Protective gear (goggles, face masks, respirators, boots, gloves and special protective clothing) is often unavailable. Or, its use may not be perceived as worth the discomfort in tropical climates. Soap and water for washing after handling or applying pesticides may be scarce.

Some contamination does occur, especially in areas where pesticides are not widely used and technicians are unfamiliar with them. Lack of training increases the risks of improper application and, thus, dangerous levels of exposure. Over-application of malathion occurred, for example, because control personnel mistakenly expected it to be a fast-acting insecticide and sprayed until insects dropped (99). While some training in safe pesticide use was developed during the recent campaigns, too few people participated for it to reach the people most in need.

Some believe that the public's exposure to pesticides used for locust control is likely to be quite small, especially because spraying often takes place over sparsely settled areas. However, USAID evaluators observed that "pesticide poisonin of humans and livestock is a more immediate lethal threat than the presence of locust swarms and hopper bands in isolated areas" (99). Widely dispersed pastoralists and subsistence farmers constitute a sizable portion of the population where locusts and grasshoppers occur, and their exposure to spraying is unrecorded. Although officials attempted towarn people inhabiting areas to be sprayed not to eat locusts, radio and print messages did not reach many seminomadic people and low-resource farmers (99).

Collecting age and gender disaggregated data is especially important in monitoring health impacts of pesticide spraying. Some chemical residues may affect nursing mothers, but not other people in the area.

Environmental Effects

Just as different insecticides pose various levels of hazard to humans, some insecticides, dosages, and methods of application are potentially more harmful to the environment than others (table 2-4). The extent of damage that insecticides inflict on the environment is not well-understood although certain chemicals seem to be preferable to others, given a region's environmental characteristics.

Aerial application of fenitrothion have been, reported to be phytotoxic to sorghum and reduce its yield (84). Malathion and carbaryl (like others) are highly toxic to insect pollinator. Some evidence suggests that the organophosphate pesticides generally have adverse effects on nontarget terrestrial organisms. For example, fenitrothion and diazinon can kill birds (58) and malathion applied to mallard eggs adversely affected hatchlings (42).

Several examples of harm to nontarget organisms and the environment were reported due to the recent campaigns in Africa. In Tunisia, substantial numbers of honeybee colonies were lost (50), damaging economically important apiculture and extending to the country's produce production because bees are important fruit tree pollinators. The most dramatic case of animal loss reported was the death of 30 sheep grazing in pesticide-contaminated areas (50). Also, chemical residues were found in the soil following spraying programs in Mali and Morocco (12). But no systematic program exists for monitoring the control program's effects on humans or the environment, so the extent of the damage is unknown. USAID's recent Dynamac-run field trials were expected to provide additional information on these types of environmental risks, but a recent evaluation found the design, implementation, and analysis of the trials faulty due to lack of baseline data, the insufficient involvement of the national crop protection services, and the absence of locusts in the Sudan trials (99).

"Many species may beat risk" based on potential impacts of the insecticides and given what is known about their effects from American and European research (95). The fenitrothion dosage recommended by FAO is near the threshold at which aerial applications cause immediate mortality to birds (93). Environmentally sensitive habitats (such as wetlands and lakes) are located in important control areas such as the outbreak areas of the African Migratory Locust and the Red Locust and certain of the Desert Locust's breeding areas. At least thus far, locust and grasshopper control has taken precedence over protecting environmentally sensitive areas.

Storage and Disposal

Many feel that inadequate pesticide storage facilities are an acute problem (46, 48, 101). Generally stores are poorly ventilated and need repair. For example, the 19 storage facilities in Somalia had leaking roofs, poor ventilation, and cracked earth floors (l).

Improperly stored pesticides may lose their effectiveness as well as pose a hazard. Undoubtedly some old stocks were used in the recent campaign without verifying whether ingredients were still active (37). And the leaks and spills that result from improper handling and storage can lead to major sources of contamination (95). For example, 25 200-liter barrels of malathion were badly dented, some were leaking, and they were stored in direct sunlight at a site in Algeria (89). A mound of approximately 2,000 five-liter cans of dimethoate have corroded and leaked outside of Khartoum, Sudan (49) and all of Sudan's provincial stores needed complete overhaul when they were examined in the mid-1980s (101). Twenty-six

20-954 0 - 90 - 3 : QL 3

Table 2-4-Toxicity of Various Pesticides to Non-Target Organisms

Chemical	Persistence	Bioaccumulation	Birds	Mammals	Fish	Aquatic invertebrates
Carbaryl	L	L-M	L	L	L	L
Diazinon	M	M	M-H	L	M	H
Dieldrin	H	H	H	H	H	M
Fenitrothion	L	M	H	L	L[a]	H
Lindane	M-H	H	M-H	M	M	M
Malathion	L	L	M	L-M	L	L
Propoxur	L-M	L-M	L-M	M	L	H
Acephate	L	L	L	L	L	L
Bendiocarb	M	M	M	M	M	M
Chlorpyrifos	M-H	M-H	--	M	L-M	H
Cypermethrin	M-H	H[b]		L	H	H
Lambda-cyhalothrin	M	H[b]	L	H	H	H
Tralomethrin	M	H[b]	L	L	H	H

KEY: L = low
M = medium
H = high

NOTES:
[a]Fenitrothion is moderately toxic to fish, Foster L. Mayer, Jr. and Mark R. Ellersieck, *Manual of Acute Toxicity: Interpretation and Data Base for 410 Chemicals and 66 Species of Freshwater Fish,* Resource Publication 160 (Washington, DC: U.S. Department of the Interior, Fish and Wildlife Service, 1986), pp. 224-230.
[b]Based on log P.

SOURCE: TAMS, Inc. and the Consortium for International Crop protection, *Locust and Grasshopper Control in Africa/Asia: A Programmatic Environmental Assessment,* Executive Summary, contractor report prepared for the U.S. Agency for International Development, March 1989, p. EXSUM-25.

metric tons of old fenitrothion, dimethoate, and heptachlor formed a toxic lake outside the Desert Locust Control Center in North Yemen (48).

Many experts find that improved storage facilities are urgently needed, along with the training to manage them, because sizable stocks of insecticides, including the more hazardous organochlorines, exist in a number of countries. For example, 60,000 liters of dieldrin are stored in Mali, 56,000 liters in Mauritania, 35,500 liters in Somalia, 30,000 liters in Ethiopia, and 21,000 liters in Niger (13). In some cases, lindane and dieldrin are kept by the national crop protection services to use as a last resort only if other insecticides are not available or if infestations reach critical levels.

Suitable disposal facilities are lacking for these and other pesticides and their containers. As a result, only a portion are destroyed following recommended procedures and excess stocks and containers may be discarded in ways that make human, land, or water contamination virtually certain. Many of the estimated 10,000 200-liter metal drums used in the recent campaign probably have been used to store water, fuel, or grain or for a variety of other purposes (77). Disposal procedures are highly variable among countries and various donors also assess the situation differently.

In some cases, donors contribute to the storage and disposal problems. Often, donated insecticides are inadequately packaged for ship-

ping, storage, and use in the tropics, with labeled instructions not understandable to the persons handling them. For example, Kenya and North Yemen received dimethoate in leaking drums in the late 1970s and were unable to use it. Now, the old stocks remain, creating a disposal problem (47,48).

Cumulative Effects

Pesticide use for locust and grasshopper control programs should be put in the context of total developing country pesticide use. Chemicals applied for locust and grasshopper control, while substantial, may be overshadowed by broad-scale applications for other agricultural purposes and for disease control. The amounts used for such different purposes vary considerably, making it difficult to sort out the potential impacts of each. Generally, more pesticides are used in agriculture than for health-related vector control. For example, estimates exist that Sudan uses 100 times more pesticide on cotton crops than in malaria control programs (95). Many of the same chemicals are used in both programs, as well as for grasshopper and locust control. For example, dieldrin, DDT, malathion, fenitrothion and propoxur are, or have been, used for malaria control (14) and dieldrin for tsetse fly control (34). Some fear that the overlap of various spraying programs may lead to unanticipated human health effects, increases in resistant disease vectors, or greater likelihood of certain epidemics (14, 95).

Pesticide use seems to be on the upswing. The current shift from persistent organchlorines to organophosphate and carbamate compounds requires more frequent application. With the amount of arable land available for new cultivation diminishing, many African countries can only increase their agricultural production through more intensive agriculture. Increased use of pesticides is often a key strategy and African farmers are using increased amounts of pesticides each year (loo).

The Special Case of Dieldrin

Of those pesticides used for locust and grasshopper control, dieldrin's use is the most debated, with the United States at odds with FAO and French officials. In the United States, concerns are over the potentially "fearsome" (95) negative effects of dieldrin's widespread and long-term use in locust and grasshopper programs.

European and U.S. studies, beginning in the 1960s, found substantial traces of dieldrin in human tissue. Problems of environmental persistence and negative effects on nontarget species also surfaced. As a result, EPA canceled most dieldrin uses in the United States (133) and a number of European countries followed suit (53).

Currently, USAID gives reference to short-lived, nonpersistent materials and to chemicals having EPA registration, particularly if registered for the intended use. Dieldrin meets neither criterion. Therefore, USAID supports no efforts in which dieldrin is used. In large part, this restriction has led other donors and African governments to abandon use of dieldrin in grasshopper and locust control.

On the other hand, FAO (104) claims that the severity of the 1988 desert locust infestation is partly attributable to donors' unwillingness to supply dieldrin in 1987. As a result, FAO contends, swarms escaped on two major occasions from restricted breeding areas, and gave rapid rise to the expansion of the plague.

> **While the United States may regard [the effective withdrawal of the use of dieldrin] as a victory, the fact is that Desert Locust hopper control using nonpersistent pesticides will be much more time-consuming, must less effective, and much more expensive than it was with dieldrin. Our prediction is that this will substantially increase the likelihood of seasonal upsurges developing into major upsurges and plagues, at least until such time as some of the postulated alternatives prove effective. (13)**

French officials, relying on recommendations of a French research agency (PRIFAS), also disagree with the U.S. position to withhold dieldrin. **However, as African countries become more aware of dieldrin's harmful effects, they have become more supportive of the U.S. position, even impounding donated stocks of dieldrin. For example, Cape Verde now bans all pesticides that are prohibited in the United States (99).**

Dieldrin is no longer produced in sizable quantities, except perhaps in Libya and India (121), so continuing debates regarding its use center on whether existing stocks should be destroyed or used in remote areas with special guidance. The

most recent estimate is 380,000 liters stored in West Africa(77). Currently, FAO policy is that use of available stocks is left to countries in which they are located, as specified in the International Code of Conduct on the Use and Distribution of Pesticides.

INSTITUTIONAL AND POLITICAL ASPECTS OF CONTROL

Finding: Most institutions–whether African national or regional or donor-am not equipped to deal with grasshopper, locust, or other pest problems on a long-term basis. Development needs are often sacrificed in favor of crisis management. Disputes within, between, and among African countries and donors constrain the effectiveness of short-term emergency programs and longer-term preventive ones.

Institutional Factors

A variety of institutional problems related to pest management are commonplace in Africa. Many countries lack the resources–operational aircraft, vehicles, communications and spraying equipment, and fuel–to deal with pests. Also, many lack the legal structure for regulating import, application, and disposal of pesticides. Few have medical facilities to treat pesticide poisoning or extension programs to train farmers how to use pesticides properly. Most countries lack personnel trained to detect environmental damage from insecticide use, to assess economics of locust control, and the effects of changing land use, etc. Coordination between agencies is difficult to achieve, and many other agricultural problems compete for scarce research attention.

These conditions are true for many countries, but wide variations exist also. Generally, the northwest African governments have more well-developed infrastructure, more trained personnel, and far more resources than Sahelian governments.

Teng (96) documented shortcomings of African national plant-protection services m 15 tropical West and Central African countries (table 2-5). Some problems were common to most public institutions, such as cumbersome decisionmaking and staff reductions accompanying policy reforms. But others were specific to these services. Major forms of plant protection infrastructure are not in place in many African countries, for example, only five African countries have pesticide laws (%).

A variety of additional factors affect locust and grasshopper programs specifically, especially due to the episodic nature of upsurges. Much of the infrastructure built for grasshopper and locust research and control gradually lapsed after the last major Desert Locust plague ended in 1%3. Many European experts with valuable field experience gained in earlier campaigns had retired or died without training replacements. As a result, little institutional memory remained when the current upsurge began and the new generation of entomologists had not faced problems of this kind or scale before. Thus, existing African and donor infrastructure was incapable of handling this emergency effort well, let alone mounting a longer-term approach that would emphasize upsurge prevention.

An examination of these specific problems was made in Chad, highlighting problems of imprecise data on the extent of the problem, vehicle breakdown, poor training, shortage of survey materials and other equipment, lack of preparation before the rainy season, inaccurate treatment figures, and no records of undesirable environmental effects (11). Donor-supported programs may not be sustainable given such conditions. For example, USAID's 1987 training-of-trainer efforts broke down when Sahelian governments did not allocate sufficient funds for travel costs and other expenses needed for these newly trained personnel to train field-level staff, in turn (95).

National crop protection services benefit from the international support that follows a disaster and national governments may exaggerate the locust and grasshopper problem in an effort to obtain resources. Often crop protection services rely on these funds for maintaining their staff, vehicles, and spraying and communication equipment. Governments take the opportunity to restock imported insecticides that could be used against insects other than grasshoppers and locusts (114). Even under the best of circumstances, locusts and grasshoppers are difficult to count. For example, hopper bands in remote areas are difficult to detect and maybe undercounted, but migrating swarms are sighted in many areas and are easily overcounted. FAO, like other U.N. agencies, compiles information from individual countries rather than collecting independent data. With no means to verify data supplied by individual

Table 2-5-Strengths of Fifteen West and Central African Countries[a] in Various Areas of Plant Protection

Area of plant protection	Percent of Countries in category: Good	Moderate	Poor
Plant protection personnel	7	40	46
Pest control equipment	0	47	47
Support facilities	0	13	80
Plant protection laboratories	0	47	47
Pest diagnostic laboratories	0	47	47
Plant quarantine buildings, equipment	7	40	40
Pesticides available locally	0	43	20
Plant protection service	7	20	40
Agricultural schools, training facility	7	66	20
Specialized plant protection curriculum	7	33	53
1nstitutionalized research	7	53	20
On-farm, applied research	0	13	74
Pest lists	13	47	33
Pest distribution knowledge	0	47	40
Pest biology knowledge	7	7	13
Economic loss knowledge	0	27	40
Pest control knowledge	0	20	80
Overall strength:			
Extension	7	40	40
Research	20	54	13
Training	7	46	40

NOTE: [a]Countries in survey were Benin, Cameroon, Central African Republic, Congo, Gabon, The Gambia, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Liberia, Nigeria, Sierra Leone, Togo, and Zaire

SOURCE: P.S. Teng, "Plant Protection Systems in West and Central Africa-A Situation Analysis," unpublished report to U.N. Food and Agriculture Organization's Plant Protection Service (Rome, FAO) August 1985.

countries, neither technical errors nor institutional incentives for over-stating can be balanced.

In sub-Saharan Africa, locust and grasshopper control is unlikely to ever be the sole responsibility of national crop protection services or other national groups, even under the best of circumstances. First, many locust and grasshopper breeding areas, especially that of the Desert Locust, are in remote and uncultivated areas that the national crop protection services have neither the resources nor clear mandate to reach. Also, extensive seasonal migration patterns mean that insects originating in one country threaten crops in another. The long recession periods between insect upsurges mean plans can go untested for long periods of time and scarce national resources can be diverted to other efforts.

The regional African institutions in the Sahel, established to pool scarce technical resources and to accommodate the regional nature of these migratory pests, also are beset with funding and management problems. In addition, they are subject to conflicting and changing approaches of member states and donors. For example, institutional weaknesses of the Permanent Interstate Committee for Drought Control (CILSS), a regional intergovernmental organization in the Sahel, were cited as a major reason for the disappointing performance of the regional integrated pest management project of the 1970s (128).

Similarly, shortcomings in donor programs have been documented. Donors and insecticide manufacturers were unprepared for the recent upsurges, like their African counterparts. As a result, technologies selected for the recent control effort did not differ significantly from those used in the early 1960s. Newer insecticides and containers had not been tested in Africa, and the latter proved inadequate in the African setting. USAID had little scientific capacity to carry out a long-term, technically sound locust and grasshopper control program. U.S. entomologists were brought on as temporary consultants, interns, or borrowed from other agencies. Few had field experience dealing with locust and grasshopper upsurges in Africa. Fewer spoke French, and most of the area affected in the recent upsurges is Francophone.

Locust and grasshopper programs became crisis management, in part, because of this lack of preparedness. And, the high costs of crisis management are nearly unanimously cited as a problem (99). Generally, emergency assistance has not been done with an eye to future development needs; nor has development assistance usually incorporated disaster mitigation (68). The locust and grasshopper programs were no exception.

Developmental goals of locust and grasshopper programs are not well defined and tend to be overshadowed by the attention to the emergency effort. Emphasis on crisis management can narrow other opportunities due to direct competition for funds within donors' budgets, shifts to more readily funded short-term research, etc. For example, USAID mission buy-ins for emergency activities reduced the amount available for long-term development projects, and particularly adversely affected countries with small USAID programs (99). Similarly, USAID-funded training programs were suspended in 1988 because resources were redirected to emergency control. A related result was confusion over roles and responsibilities, especially within USAID missions. For example, the USAID missions' locust and grasshopper staff performed the duties of other staff, often for the sake of expediency (114). Generally, an emphasis on short-term emergency management has also meant that donors and African agencies missed opportunities to tap local resources such as people's indigenous knowledge of pest biology (57).

Crisis operations do not lend themselves well to institution-building and the present campaign was no exception. For example, due to the lack of preparedness of the African regional institutions such as the Joint Locust and Bird Control Organization (OCLALAV), expatriates under the auspices of FAO ran the control operations, especially aerial spraying, in much of the Sahel. This parallel organization resulted in a technically effective control program that, inadvertently, further undermined OCLALAV (99).

Differences in strategy and tactics among donors led to confusion among African officials regarding technical approaches and to costly delays and duplication of effort. Also, differences increased pressure on the African officials who dealt with the oft-conflicting requirements while attempting to manage national campaigns. For example, field personnel had to be trained in the proper use and maintenance of several different kinds of spraying equipment for the same use.

Donors agree that emergency relief has substantial popular appeal. Further, USAID and FAO agree that lack of funds constrains them from implementing key components of a more preventive approach, e.g., long-term institution building of crop protection services, providing equipment and training for surveillance and monitoring of insects, pre-positioning of pesticides to reduce costly air freight expenses, and setting up mobile units to survey and control locusts in "strategic" breeding areas in remote areas.

These institutional perspectives, combined with the lack of important information, help explain the tendency to exaggerate locust and grasshopper problems and to take a crisis management approach. Acting in one's self-interest is appropriate, and acting in the interest of one's organization is normal. The common good, however, requires balancing individual self-interest and the interests of others. To do this, leaders need an accurate view of overall problems. Sometimes this view was lost during the recent campaign. For example, frequent assertions by representatives of FAO, USAID, and African governments that the recent upsurges were the

worst locust **lague** ever recorded are not **documented** (see **igure** 1-3).

The Politics of Locusts and Grasshoppers

There are those who claim that locusts and grasshoppers are primarily "political pests" because of political pressure to mount a control campaign. Some of this pressure is readily understandable: locusts are highly visible, swarms can create panic, they can cause severe damage in localized areas, and large-scale aerial spraying is more easily undertaken and provides more visible results than alternatives.

Memories of devastating incidents caused by Desert Locusts and other swarming insects in the 1940s and 1950s can lead political leaders to respond urgently to the perceived threat of disaster. This, combined with popular perceptions that these insects cause severe crop damage, increases political pressure to mount an aggressive control effort. For example, during the recent upsurge, Moroccans and others often referred to the near-total damage caused in 1954 and 1955 by Desert Locusts in the Seuss Valley where orange trees are the most valuable agricultural product. This damage was estimated at $14 million in 1954 dollars (13); at least 10 percent of Morocco's farmland was affected mostly in the south and Seuss Vaney (115). Moroccans feared that the insects would cause similar serious damage even though swarms of the Desert Locust came to the Seuss Valley in 29 of the 55 years up to 1968 (79) without causing such damage. A crisis mentality and perception of imminent disaster can lead people to act hastily and may account for some of the carelessness in pesticide use and over-spraying that occurred in the recent campaign (99).

Emergency Control programs are popular, like other disaster assistance efforts. Of all kinds of foreign aid programs, Americans support disaster relief the most; three quarters of Americans surveyed recently gave it top priority (23). Thus, donors, like their African counterparts, come under political pressure from legislatures and the public to act during locust and grasshopper upsurges.

Also, donors do not want to be left out or appear unresponsive when African governments request disaster assistance. USAID, like the national crop protection services, benefits from support garnered during a disaster. USAID officials can readily justify requests to Congress for additional funds to stop a plague of locusts, and those funds generally are forthcoming.

Other vested interests come into play during locust and grasshopper campaigns, such as preferences for bilateral over multilateral programs, tied aid requirements, or funding programs in certain countries but not others for political reasons. These factors often override decisionmaking based on technical considerations. For example, some advocate sharply curtailing fenitrothion's use because of potential environmental damage. Political factors are likely to enter into such a decision-whether made by USAID, FAO, or African Governments. The United States would be seen as advocating U.S.-manufactured alternatives (American Cyanamid produces malathion and Union Carbide, carbaryl) to the Japanese- and German-produced fenitrothion.

The most public differences among donors in this recent campaign related to pesticide selection and application methods. However, many less visible differences existed regarding overall development goals and strategies. For example, donors disagreed on the relative importance of increasing net agricultural production, increasing yield, increasing farm income, building democratic institutions, developing a more equitable distribution of power, or supporting sustainable agriculture. Different donors also assessed the locust and grasshopper situation differently and proposed different control strategies-e. g., the highest priority sites for treatment, whether ground or aerial spraying should be done, what types of aircraft should be used, whether or not to emphasize training or environmental monitoring, etc. Also, donor agencies disagreed internally on many of these items.

Finally, coordinating a regional response is made more complicated by political problems within and between affected countries. Civil strife and wars in Ethiopia, Sudan, Chad, and Mauritania prevented survey and control campaigns from reaching locust breeding areas before swarms grew large and began migrating. For example, in 1987 the Ethiopian Government did not allow the Desert Locust Control Organization for Eastern Africa and the Red Cross to conduct survey and control efforts in the Tigre, Eritrea, and Wolla provinces due to civil war. These are seasonal Desert Locust breeding areas where the

upsurge might have been contained. Nor was the national crop protection service able to carry out control efforts in these areas, although the Eritrean Liberation Front trained and equipped its members to conduct effective ground control operations (19).

Land mines in the Western Sahara precluded ground survey and control efforts; a USAID-contracted spray plane was downed by a Polisario missile there, killing the five on board. Also, longstanding border disputes constrained cooperation between countries. Morocco, frustrated by ineffective control efforts in Sahelian countries that resulted in swarms invading the southern part of Morocco, proposed sending their survey and control teams into Mauritania in military-like missions.