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STAFF SUMMARY REPORT

AN ENVIRONMENTAL AND ECONOMIC STUDY
OF THE CONSEQUENCES OF PESTICIDE USE
IN CENTRAL AMERICAN COTTON PRODUCTION
1974-1976

Work performed by

Central American Research Institute for Industry
Guatemala City, Guatemala

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Board on Science and Technology for International Development
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1977

This staff summary report of a two year study on the environmental and economic consequences of pesticides use in Central American Cotton production arose from one of the recommendations of the Central American Workshop on Environment and Development held in Antigua, Guatemala, in August 1971. The Workshop was sponsored by the United States National Academy of Sciences (NAS) and the Central American Research Institute for Industry (ICAITI), and the study was directed by ICAITI under a grant from the United Nations Environmental Program. Funds for NAS involvement over the two year period of the study came from its contract AID/csd-2584, Task Order 1 with the Office of Science and Technology, Bureau for Technical Assistance, Agency for International Development.

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I
SUMMARY

This study of environmental and economic effects of pesticides use in Central American cotton production was made by the Central American Research Institute for Industry (ICAITI) in 1974-1976 under a grant from the United Nations Environmental Program (UNEP). A small group of specialists chosen by the U.S. National Academy of Sciences (NAS) and partially supported by the Agency for International Development (AID) collaborated with ICAITI in the work.

At the present time large quantities of chemical pesticides are used in commercial cotton production along the Pacific coastal plain of Guatemala, El Salvador, Honduras, Nicaragua and Costa Rica. Their use can have wide ranging and often undesirable side effects on the natural environment and the health of the people. The purpose of the study described in this report was to investigate the economic, environmental and public health impact of chemical insecticides used in cotton production. Equally important, the study examined the effectiveness of carefully integrated and managed pesticide control practices as alternatives to the routine (spray-by-the-calendar) use of pesticides in Central American cotton production. The overall approach was one of systems analysis; i.e., to treat the situation as an interdependent and dynamic environmental problem requiring a multidisciplinary team for the identification and analysis of the variables.

Perhaps the most striking result of the study was the demonstration that the use of integrated pest control techniques led to a reduction in the number of applications and amount of chemicals used while maintaining yields at high levels. In test plots throughout the region ICAITI specialists were able to

obtain an 11 percent increase in yields with 39 percent fewer pesticide applications per season in the integrated control plots as compared to plots subjected to current practices. Because cotton contributes so significantly to the economy of the Central American region, this demonstration of maintenance of yield plus decreasing the total amount of pesticides applied, has potential economic significance of great magnitude.

The study also linked the side effects of pesticide use in cotton with increasing resistance of the malaria vector Anopheles albimanus and higher pesticide residues in cattle production intended for human consumption. Qualitative indications were obtained of increasingly detrimental aspects of pesticides residues on soils, human water supplies, and the marine environment. Although progress has been made in reducing the number of pesticide poisonings (intoxications), the need for careful control of pesticide handling by farm workers was also demonstrated.

Most importantly this study points to the need for a continuing regional effort in Central America to:

- Explain the results of the ICAITI demonstration program to cotton growers and others so that integrated pest control practices will be better understood and more widely adopted in Central America,
- Train farm owners, managers and workers in integrated control techniques so that effective programs will be adopted in the area,
- Extend applied research and development of integrated pest control practices to meet the demands of the various micro-climatic regions and the dynamic changes in the environmental zones, and
- Establish a cooperative and well coordinated system for the regulation and use of chemical pesticides in cotton production.

ORIGIN OF THE STUDY

A. Introduction

In August 1971, the Central American Research Institute for Industry (ICAITI) in Guatemala, Central America, and the Board on Science and Technology for International Development (BOSTID) of the United States National Academy of Sciences (NAS) sponsored the Central American Workshop on Development and the Environment. One result of the Workshop was a greater awareness of the increasingly detrimental effects of chemical pesticides that are routinely used for cotton growing along the Pacific coastal plain of Guatemala, El Salvador, Honduras and Nicaragua. Cotton growers and government authorities clearly needed better information about complex interactions of pesticides on target insect species, other insects, the natural flora and fauna, and the human population. ICAITI, which had the highly skilled technical staff and the necessary laboratory facilities to do quantitative and qualitative measurements of these interactions, asked the NAS to join with it in assessing overall parameters for a systems study of the consequences of pesticides abuse with a view to making recommendations that could reduce adverse effects upon man, cotton production and the environment. The systems study was designed to focus upon: (a) the measurement of pesticide residues in selected non-target species of plants and animals of the region, (b) affect of pesticide use on public health and environmental health problems such as malaria, (c) the economics of cotton production in the four countries including benefits and costs of various

pest management techniques, and (d) demonstrations of integrated pest control methods as an alternative to the routine application of chemical pesticides.

In 1973 a joint ICAITI-NAS study group prepared a study plan and in 1974 the United Nations Environmental Program (UNEP) approved a two year project with ICAITI and budgeted \$188,500 to help finance the activity.

This staff summary report describes the background of the problem of pesticides use in Central American cotton production, outlines the research method employed in the study, and summarizes results at the end of two years. For those readers who desire more details, attention is drawn to the ICAITI Final Report (1976) entitled "An Environmental and Economic Study of the Consequences of Pesticide Use in Central American Cotton Production" available in English and Spanish from the Central American Research Institute for Industry, Avenida La Reforma 4-47, Zona 10, Guatemala, Guatemala, Central America.

B. Background of the Problem

Since 1950 chemical pesticide usage in Central America increased markedly and by the late 1960s was considered by many to represent a significant threat to man and the environment. Major economic losses were recognized as one consequence of the excessive reliance on insecticides to control cotton pests. Yields declined with adverse effects on employment and balance of payments (Falcon 1971). Most serious, however, were environmental effects, including those associated with human health (Amado de Zeissing 1973; Adam 1972; Falcon and Daxl 1973; Peterson 1968a).

Central American cotton production is concentrated on the tropical Pacific coastal plain of Guatemala, El Salvador, Nicaragua, and Honduras. In 1964-65 at the then high point of production, approximately 372,000 hectares of cotton were planted; by 1970-71 the figure had dropped to 235,000 hectares (SIECA, 1971). The decline occurred in spite of the fact that insecticide applications per growing season had risen from 8 to as many as 40 (Falcon 1971). Increased use of insecticides represented the principal response of the cotton producer to growing insect resistance to chemicals and rising numbers of cotton pests that resulted from the destruction of their natural enemies. Accompanying the increased use of pesticides in cotton production was a parallel, and related increase in the levels of pesticide residues in meat (Peterson 1968a).

World Health Organization (WHO) statistics show that over 1,800 human poisonings requiring hospitalization due to pesticide use were reported in 1971 (Adam, 1972). High insecticide levels were found in various shellfish and fish along the Guatemalan Pacific coast; fish kills also were reported in the same geographic area. (Keiser, Amado and Murillo 1972; Amado de Zeissing 1973). Birds and reptiles had also been affected; their populations in the cotton-production regions and adjacent areas were reported to be reduced (Aguirre, 1973). No one has examined how many of the estimated 100,000 species of plants and animals in Central America had been affected by heavy pesticide use. Available evidence indicated that the level of pesticide use in cotton was an increasing hazard to many species in the life system.

Interest in an integrated control approach in cotton production was stimulated mainly by crop failures brought on by the almost total reliance on the routine application of chemical pesticides (Falcon and Daxl 1973). Integrated control offers an alternative because it is a broad ecological approach to pest control, using combinations of biological and chemical technologies. Using integrated control techniques everything possible is done to protect and preserve naturally occurring biota and beneficial agents such as parasites and predators. For a successful program, realistic economic injury levels must be known to determine the timing of pest-control actions. For example, the cotton plant can withstand up to 50 percent defoliation during plant establishment and before square (fruiting point) formation (0 - 30 days after planting) and boll formation (after 100 days). In the period of fruit formation (30 - 100 days) 20 percent defoliation is the lower economic injury level. (Falcon and Smith 1973).

An example of an effective integrated control program is one initiated by the United Nations Food and Agriculture Organization (FAO) and the Government of Nicaragua (Comité de Control 1975). Following an extensive period of declining cotton production (1965 - 1970), total production increased (ca 340,000 bales 1970-71; 460,000 bales 1971-72); yields per unit area reached record levels in 1971-72 (ca 4 bales/hectare), the area planted in cotton, which had decreased by about 40 percent in 1965 - 1970 increased by nearly 25 percent in the 3 years ending in 1973.

About 97 percent of the over \$10 million spent on chemical pesticides imported yearly into Nicaragua was used on cotton in 1971 (Falcon and Daxl 1973). The integrated control program succeeded in reducing the average number of applications per season from 28 to about 18. Correspondingly, pest control

costs were reduced by about 40 percent and with it the number of human poisonings declined. Pesticide residues in adjacent crops, in dairy products, and in livestock also declined.

The development and implementation of an integrated control program for cotton in Nicaragua involved extensive collaboration and interaction among many organizations. FAO provided technical assistance and support; the National Bank of Nicaragua (BNN) established a project of technical assistance to growers (PRATA) and provided local financing and loans to participating cotton farmers; the Ministry of Agriculture (MAG) assisted the research and extension work; and the National Autonomous University of Nicaragua (UNAN) helped with both high-level and technician training programs.

While good progress has been made toward establishing the integrated control approach in Nicaragua (ca 35 percent reduction in the use of insecticides), a continued effort is required to develop its maximum potential. The training program at the university and the approach to research and extension in the field has provided an effective means for extending integrated control technology in Nicaragua and to other countries in the region with similar conditions and problems (Costa Rica, Honduras, El Salvador, and Guatemala). The program serves as a working model for adaptation in developing countries of Central America and other regions of the world.

Although demonstrating the effectiveness of integrated control was considered to be the key element in the study outlined by the ICAITI-NAS

study group, the approach also critically examined environmental problems associated with pesticide use and looked at economic and public health effects using a multidisciplinary systems approach.

C. Research Approach

1. Environmental Impact

The objective of the environmental impact portion of the study was to trace the probable path of pesticides in the environment and measure the residues wherever it was possible. Because the impact of pesticide use is so extensive and complex, the investigation had to be limited to the following:

- Pesticide contamination of food and feeds. This was primarily an analysis of selected samples of cotton seed oil (used for human consumption) and cotton seed cake (used for cattle feed) from the various cotton growing areas of Central America.

- Pesticide contamination of water. This was a project to analyze surface water used for washing and drinking by humans in cotton growing regions. Although ground water was in all probability not contaminated, samples were analyzed from wells in cotton growing areas.

- Pesticide contamination of wildlife. There are an estimated 100,000 species of plants and animals in Central America. Obviously, it would not be possible to measure residues in many species but certain non target groups were sampled to provide a quantitative measure of the contamination. Included in the project were populations of shrimp, fish, predatory birds, lizards, and earthworms.

- Relationship of insecticide application technique to environmental pollution. Because 90 percent of the pesticides applications in Central America are carried out with aircraft, studies were conducted to determine the amount of pesticides drifting into the air and moving off into the environment.

Population data on nontarget species. Data on contamination of fish and shrimp populations and resurgence of malaria were assembled and assessed for reliability.

2. Human Health

The intensive use of insecticides for cotton production in Central America has also led to a growing concern with its effects on human health. Three main objectives were included in the ICAITI study of pesticide use.

- Identification and assessment of available information (vital statistics) on public health effects of insecticides used in Central American cotton production.

- Strengthening the data base so that conclusions and recommendations could be made to reduce exposure (risk) and human poisoning from insecticide use. The data were divided into urban and rural population groups and further separated into categories based upon high, intermediate and low exposures to insecticides.

- Making an ongoing epidemiologic study with special emphasis on the problems of malaria and vector Anopheles albimanus resistance in cotton growing areas.

3. Economics

Insecticide application and materials have been major items in the direct costs of Central American cotton production for several years. The

situation was further aggravated when the purchase price of insecticides accelerated dramatically due to the rising cost of petrochemicals and associated inflation. The high number of applications used in standard spray programs (up to 45 applications per season) justified a careful economic study of pesticides use.

The objectives of the economic analysis portion of the study were:

- To establish, with the assistance of integrated control specialists, the economic thresholds for major pests for various crop stages, cotton prices and control efficiencies.

- To compile consistent data (by major insecticide product) of the unit prices and application rates per hectare per year for each of the four Central American countries.

- To analyze economic and agronomic characteristics of farms and develop an understanding of actual and recommended insecticide treatments.

- To evaluate the potential loss (in dollars) of reduced sales of fish, shrimp and beef attributable to insecticide contamination.

4. Integrated Control of Cotton Pests

Integrated control has been defined as "a pest management system that, in the context of the associated environment and the population dynamics of the pest species, utilizes all suitable techniques and methods in as compatible a manner as possible and maintains the pest populations at levels below those causing economic injury." (FAO 1968).

The concept of integrated control has gradually gathered momentum during the past 20 years as a practical and sensible way to deal with pest problems. Programs have been developed for different crops over the years in various parts of the world. One successful experiment was for cotton

in Nicaragua where the objectives of the program were: (1) to reduce the excessive use of insecticides and minimize associated undesirable effects, particularly attenuating problems of insect resistance and pesticide residues; (2) to lower cotton production costs; and (3) to increase cotton yields.

The integrated control concepts tested in Nicaragua were extended and adapted, as necessary, for testing in Guatemala, El Salvador and Honduras. Demonstration programs in cotton growing areas were conducted the first year (1974) of the ICAITI study. The approach to integrated control by the ICAITI project consisted of: (1) training local cotton specialists and farmers to follow specified procedures, (2) establishing plots to demonstrate integrated control, and (3) establishing field study plots to further refine the integrated control programs. The approach relied upon monitoring and evaluation of insect abundance and activity, cotton plant growth and fruit development in the field. Plots subject to growers standard chemical pest control methods were compared to plots utilizing integrated control procedures. Integrated control methods are described in Guidelines for Integrated Control of Cotton Insect Pests (Falcon and Smith 1973) and Guía de Control Integrado de Plagas del Algodonero (Comité de Control Integrado de Plagas del Algodonero 1975). No attempt will be made in this staff summary report to outline the procedures in detail. It is sufficient to state that the traditional technique of routine spray-by-calendar is replaced using pesticides only when needed. Much effort is made to withhold the first insecticide application of the season as long as possible so as to retain and protect biological control agents in the cotton fields for a maximum period of time. Integrated control synchronizes planting dates so that the periods of fruit formation and maturation in the cotton plant do not coincide with periods of high pest activity; attempts to reduce pest populations to low levels

through the use of trap crops before the cotton growing season begins; accurately determines the density of pests at which treatment is necessary (treatment thresholds); utilizes chemical insecticides in a selective a manner as possible so as to minimize the impact upon beneficial parasites and predators, and on the environment in general; and produces a cotton crop in the shortest possible time.

5. Systems Analysis

The chemical pesticide pollution situation in Central America presents a highly complex environmental problem. Because of the importance of cotton as an export crop and its major contribution as a source of foreign currency earnings, there is ample incentive to reduce pest losses while maintaining high yields. Use of chemical pesticides on cotton, however, has brought about directly and indirectly by harmful effects upon (a) other agricultural crops; (b) humans living in cotton growing areas and, through the food chain, upon those far from cotton production areas; (c) malaria control programs; (d) water supplies; (e) marine estuarine areas; and (f) the natural flora and fauna. The main goal of the ICAITI study was to design a systems management program to reduce the negative effects of pesticides while maintaining high yields from cotton production on the Pacific coastal plain.

III

Discussion of
Research Results

A. Introduction

Pesticides are at the present time heavily used for commercial cotton production in Central America. Their use has had wide ranging and often undesirable side effects on the natural environment and the health of the people. Until the results of the ICAITI study were released the extent of the side effects of pesticide usage in growing cotton were not well known.

While a two-year study of the consequences of pesticide use in Central America cotton production cannot be expected to provide final and definitive answers, the results clearly demonstrate that applying careful management techniques can:

- Reduce insecticide applications to the benefit of growers, workers, and the general environment,
- Maintain high yields of cotton,
- Educate farmers regarding economic and environmental significance of using modern technologies for agricultural production, raising of livestock and practicing soil conservation.

B. Environmental Impact

Pesticides are widely disseminated throughout the cotton growing regions of Central America. Most of the samples analyzed in this study were contaminated with DDT, many with toxaphene and some with ethyl and methyl parathion.

In 1974 about 27,300 metric tons of pesticides were consumed in the four countries under study. El Salvador and Guatemala were the highest consumers in absolute terms (11 thousand metric tons each), followed by Nicaragua (nearly 5 thousand metric tons), and Honduras, a relatively small cotton producer, distant fourth (approximately 160 metric tons).

Over 1,600 samples of water (ground, surface, estuarine); plants and plant products (corn, rice, beans, cottonseed, etc.); and other consumer food products (milk, cheese, fish, shrimp) were sampled. In addition over 1,800 meat samples were analyzed. Although meat and milk appear in many cases to contain DDT above tolerances established in some countries, the different dietary habits of Central Americans make any conclusion on human health effects very difficult to judge. More specific studies are needed to arrive at standards for the area.

The aerial application of pesticides under unstable weather conditions is a key event in the movement of pesticides through the environment. It was found that with the use of aerial spraying and the so-called "ultra-low volume" application system 50 - 75 percent of the pesticide material fell outside the target area under conditions of temperature inversion and moderate winds. For a 20 hectare field treated under similar conditions, one may expect about 56 percent of the chemical applied will fall outside the target area. These results demonstrate a primary way that pesticides are spread over large areas. Since \$70 million is spent annually on cotton pesticides, the economic losses from drift in aerial application appear to be very substantial.

Pesticide drift also increases sub-clinical intoxication and the possibilities for clinical poisons among the population living near the cotton fields. Drift also contributes to the contamination of neighboring areas

and to the development of resistance by the malaria carrying mosquito. Over the past 15 years beef exporters are estimated to have lost between \$1.7 and \$2.0 million because of meat contamination by DDT.

C. Human Health

The consequences of pesticide use are only one of the many ills that affect the Central American rural working population, with the difference that their cause can be easily traced to pesticide use in cotton. It is, therefore, possible to work specifically on the reduction of pesticide hazards at the farm level through adequate preventive measures.

From 1972 through 1975, the total number of reported human clinical poisonings in Central American cotton production due to pesticides decreased each year as shown in the following table:

Table 1

Total Human Poisonings due to
Pesticides in Cotton Production

<u>Year</u>	<u>Number of Cases</u>
1972	6,078
1973	3,630
1974	2,401
1975	2,074 (Estimate)

Most of the poisonings were attributable to the non-persistent, highly toxic organophosphorus pesticides. The majority of cases occurred because (1) workers entered treated fields too soon following application; (2) workers ate, drank and smoked in contaminated fields; and (3) they bathed in contaminated drainage ditches. Unfortunately, over 75 percent of the workers interviewed were illiterate; consequently, they were unable to read and/or understand posted warning signs, pesticide use instructions or instructions on the use of

protection equipment. Furthermore, shelter for temporary workers in cotton production areas is inadequate, poorly constructed, without toilet facilities, no running water and no way for bathing after returning from working in the fields. While there is often times little concern for the welfare of field workers, the cost of treating intoxicated persons, which averages \$32, provides a substantial direct financial incentive to improve worker conditions and provide meaningful instruction through simple educational techniques about pesticide hazards and proper first aid measures.

Resistance of Anopheles albimanus, the malaria vector, to chemical control by DDT is well documented and is particularly high where cotton is grown. Average resistance in Guatemalan cotton areas went from 58 percent to 86 percent between 1972 and 1975 (a 48 percent increase). In El Salvador it has remained above 80 percent in recent years. Malaria control agencies, therefore, must apply other, more expensive pesticides in an effort to keep the disease in check. In Guatemala this procedure reduced malaria rates in cotton areas from 6.34 cases/1,000 in 1972 to 2.21 cases/1,000 in 1975. Control in El Salvador has not been as effective and malaria rates have increased from 39.2 cases/1,000 to 65.7 cases/1,000 between 1972 and 1974. Therefore, the control of malaria (significantly higher in cotton areas) is increasingly costly in Central America. In 1975 the four countries of Central America had costs estimated at about \$12 million greater than the previous year because of the use of more expensive, less persistent chemicals for malaria. Although not all of the resistance can be attributed to pesticide use in cotton (since DDT use in malaria itself may create resistance), the increased expenditures are almost exclusively made in cotton producing areas. In the absence of alternative explanations this leads to the conclusion that pesticide use in cotton is

the major cause for greater overall expenditures in malaria control programs in Central America.

D. Integrated Control of Cotton Pests

Since its inception, the ICAITI project has advocated the use of alternative cotton pest management procedures as a major solution to pesticide problems. Specifically, the project has emphasized the development of integrated cotton pest control as a technically feasible and economically profitable way to promote a more rational use of pesticides. What makes integrated pest control particularly desirable is its potential to reduce the adverse consequences of pesticides on the environment and upon human health while sustaining more profitable cotton production over the long term. Thus, integrated control directly supports the important economic activity of cotton growing in Central America.

As explained in the previous section of this report, integrated control is a comprehensive ecological approach to pest management which is tailored to a particular ecosystem. It must rely upon a knowledge of local conditions and the preservation and encouragement of natural control agents such as parasites, pathogens and predators of cotton pests. Although the technique has been rather thoroughly developed in one Central American country (Nicaragua), its application is incomplete even there. Most farmers in the region are unaware of its exact methodology and economic implications. The two year ICAITI study was a valuable means to spread information more widely throughout the cotton growing region. Moreover, the study demonstrated the soundness of the techniques and the feasibility of their wider application. Nevertheless, an extensive effort needs to be undertaken to train more people, conduct wide-spread tests and demonstrations, publicize the results, encourage farmers to participate and to convince the

Governments to give incentives for the use of integrated pest control methods in cotton production.

To highlight the results of the two year study most succinctly one need only point to the fact that for the areas where integrated control techniques were applied, the average yield for the demonstration plots was 3,359 kilograms of seedcotton per hectare with 15.25 pesticide applications/year. In the plots employing traditional pest control techniques, the yields were 3,038 kilograms of seedcotton per hectare with 25 pesticide applications/year. Integrated control therefore obtained 11 percent higher yields with 39 percent fewer pesticide applications.

E. Economics

Cotton contributes significantly to the economy of the four Central American countries where it is grown. To cite just one statistic, cotton gives employment to half a million agricultural laborers for a total of 36 million man-days/year.

The yearly contribution of cotton production to the gross international product (GIP) of the four countries range between US \$82 and 117 million in 1974 and 1975. This represented payments to the three large factors of economic activity - land, labor and capital. It included salaries, wages, profits, land rentals and payments for services. In absolute terms it was large for the economies of the countries, being second only to coffee and bananas. Its added value represents about 10 percent of that portion of the GIP generated by the agricultural sector and nearly 3 percent of the total GIP for the four Central American countries. In general, cotton brings an important impact to employment in Central America, a factor of increasing importance due to the increasing population entering the labor market yearly.

Also, chemical pesticide used in cotton production reduce the economic potential because they must be imported and thereby drain foreign currency reserves; pesticides have undesirable and costly side effects such as human poisonings and residues in food and animal feed; and the use of pesticides requires sophisticated inputs of manpower and machinery that are not necessarily required for other economic crops.

Central American cotton production is labor-intensive. The largest share of production costs goes to labor, especially that used for harvest. Even though salaries are low, the large number of workers employed results in a large absolute contribution to rural incomes. Daily wages for Central American agricultural laborers range between one and two dollars. The total number of work-days paid by cotton is about 36 million. If average salaries are \$1.50, the annual payment of cotton to labor is about \$54 million, a sizeable sum by Central American standards. The average laborer work in the cotton fields about 72 days per season. Even this small cash sum is important since the rest of the time the laborer usually is a subsistence farmer on his own small plot of land. Thus wages from working in cotton represents a source of income which can be used to purchase other necessities that he is unable to produce on his own land.

F. Systems Analysis

After nearly two years of careful investigation, many elements of a more balanced environmental systems management program were identified for possible implementation. Before proceeding more generally on any one program, however, additional analysis should be made to be certain that any proposed new management program does not inadvertently lead to added environmental, economic or social problems.

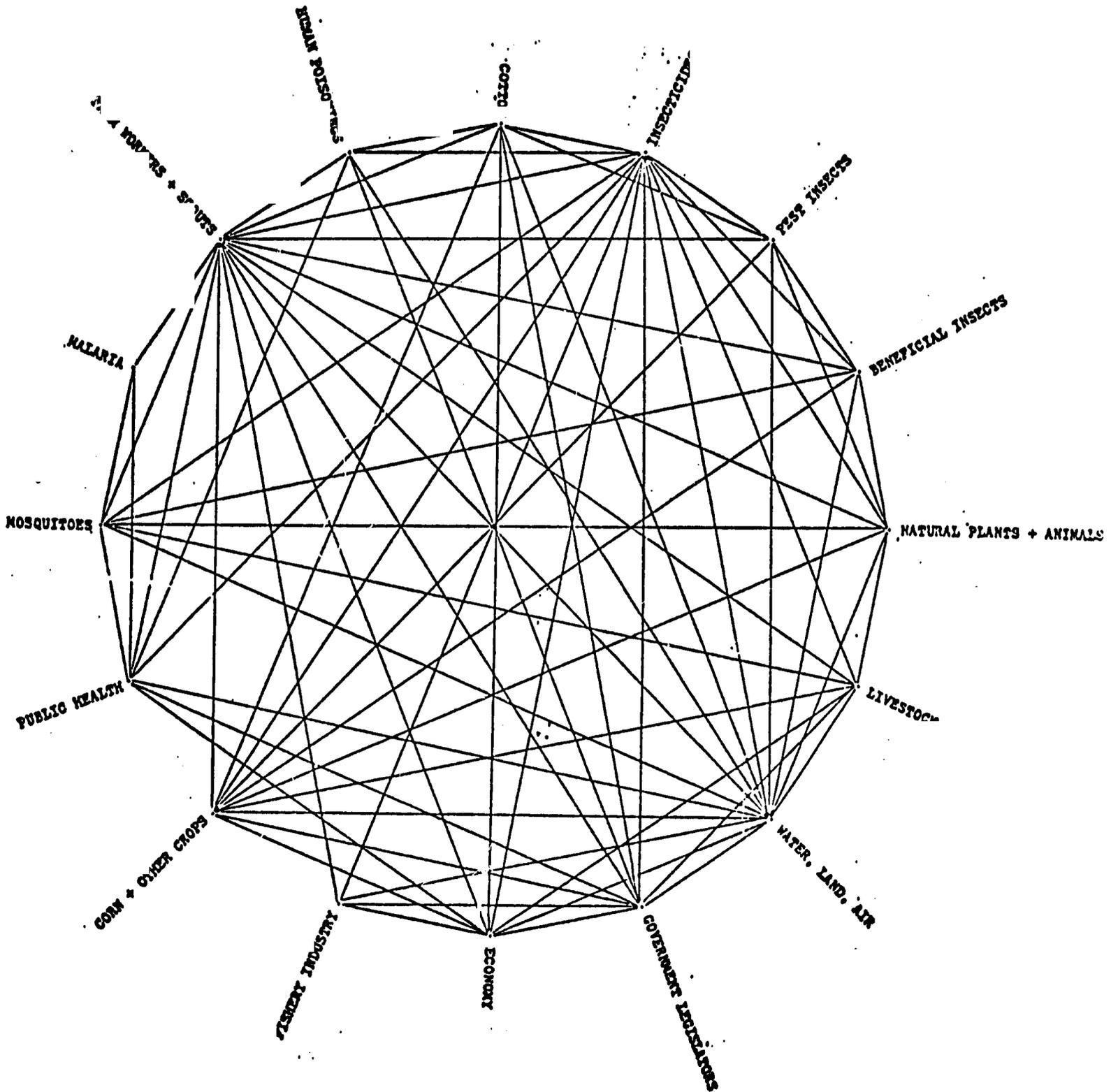
The procedure used by the ICAITI group was to model ways and means of implementing each recommended action. Each element of a management program must be continuously examined in terms of costs and benefits relative to the environment, public health, agricultural production, the wider economy and, finally, to society as a whole in Central America. One hundred thirty major factors were identified and aggregated into 16 categories as illustrated in Figure 1. The lines indicate major interactions among the categories. Costs and benefits of each model were evaluated quantitatively whenever possible, in terms of economics, labor, land, energy, and human health. Where quantitative measurements could not be made, careful qualitative analyses were examined.

A final step in the study which remains to be done, is publication of literature which presents the results of the project in lay terms. The main purpose of this endeavor would be to educate cotton growers, government administrators, legislators, and the general public about environmental and economic consequences associated with pesticide use in Central American cotton production. Only in this way can the proper decisions and appropriate actions eventually be made to redirect the current approaches for the betterment of all individuals and the associated environment.

Figure 1

ENVIRONMENTAL SYSTEMS OVERVIEW

Central American Cotton Production System



IV

Summary of Recommendations

The ICAITI Environmental Systems Study was a research and demonstration project to examine the consequences of pesticide use in Central American cotton production and to show that carefully managed integrated pest control can:

- Reduce the quantity of pesticides and at the same time maintain high yields,
- Reduce the number of human insecticide poisonings,
- Reduce significantly the side effects (social and economic costs) of pesticide use, and
- Help restore the quality of environment.

As a result of the research and field work, the following management actions are recommended by ICAITI:

1. Implement an expanded program of integrated cotton pest control through Central America to reduce reliance on chemical pesticides,
2. Educate farmers regarding the economic and environmental significance of planting cotton in suitable lands, applying pesticides efficiently and practicing soil conservation,
3. Adopt occupational safety procedures that can reduce worker's exposure to pesticides and other toxic substances,
4. Improve and expand existing first-aid field clinics for prompt and effective treatment of human poisonings,
5. Establish an environmental monitoring program for pesticides in Central America.

The above recommendations can be implemented by three types of institutions in each country working in cooperation with one another and throughout the Central American region:

- Cotton grower's organization in each of the four countries and the Central American Cotton Grower's Front,
- Human health or worker health and safety institution,
- Environmental or resource management agency.

Some of the above institutions and organizations exist in each country, but some remain to be created. It is for the latter reason that a wider program of education and public information is needed to create greater awareness of the consequences of pesticide use. To that end, an important first step would be the wide distribution of the results of the ICAITI Environmental Systems Study both in its present technical detail and in a non-technical style for the general public.

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