### Health Constraints to Rural Production

#### Action Decisions Approved by Mission or AID/W Office Director

<table>
<thead>
<tr>
<th>Action Decision</th>
<th>Responsible Party</th>
<th>Date Action to Be Completed</th>
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<tbody>
<tr>
<td>1. PACD: Extend date to 30 May, 1987.</td>
<td>AID/W/APR/RA</td>
<td>1 March, 19</td>
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<tr>
<td>2. Commodity Control: a) Correct computer printer malfunction, b) Return and/or reorder commodities procured by U.S. Procurement Service Agent, and c) Distribute laboratory supplies where needed.</td>
<td>USAID/S, AID/W</td>
<td>31 May, 19</td>
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<tr>
<td>3. Computer Training: Hold computer use course for senior BNHP staff in late 1983.</td>
<td>Dr. Rao</td>
<td>December, 1</td>
</tr>
<tr>
<td>4. Surveillance Design Symposium November, 1983: Panel examination of analyzed data to recommend a two year surveillance design inside and outside study zone to estimate parameters needed to calibrate transmission and control models for schistosomiasis.</td>
<td>Dr. Buck, Dr. Rao</td>
<td>November, 1</td>
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<tr>
<td>5. Final HCRP symposium, April 1987: Expert consideration of results from 4. above to recommend reliable,</td>
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<td>(See continuation sheet)</td>
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#### Inventory of Documents to Be Revisited Per Above Decisions

- [X] Implementation Plan
- [ ] PIO/T
- [X] PIO/C
- [ ] PIO/P

#### Project Staff

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
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<tbody>
<tr>
<td>Gary E. Leinen</td>
<td>USAID/S Project Manager</td>
</tr>
<tr>
<td>Dr. Asim Dafallah</td>
<td>MOH/BNHP Director of Research &amp; Training</td>
</tr>
<tr>
<td>Dr. M.S. Rao</td>
<td>PSC Biostatistician</td>
</tr>
<tr>
<td>Dr. Albert Buck</td>
<td>AID/W Tropical/Disease Specialist</td>
</tr>
<tr>
<td>Dr. Thomas Eighmy</td>
<td>USAID/S Evaluation Officer</td>
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### Evaluation Summary

<table>
<thead>
<tr>
<th>Evaluation Number</th>
<th>Period Covered by Evaluation</th>
<th>Date of Evaluation Hearing</th>
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<tr>
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<td>From (month/yr)</td>
<td>To (month/yr)</td>
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<td>02/83</td>
<td>04/83</td>
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AID 1930-15 (3-78)
practical surveillance techniques for the Gezira and to formulate a model of schistosomiasis transmission in irrigated farm schemes.

6. Biostatistic, Training:
Select candidate for long term training to commence in 83/84 academic year.

7. Medical Records Management Training:
Fund one year's training in US from HCRP budget

8. Statistical Assistants Training:
Nominate and train 3 statistical assistants at facilities available in Egypt.

9. New activity within Budget -- Case Control Study: Hospital data for schistosomiasis morbidity and mortality will be linked to Study Zone. Study protocol to be developed.

10. New activities which may require additional funding:
   a) Identify a Data Linkage System; develop a separate proposal to establish an identification system for people in the Study Zone creating linkage between BNHP, MOH and Agricultural facilities;

   b) Pesticide Exposure - Develop a separate proposal for biochemical examination of study zone population with high risk exposure to pesticides (cotton scouts, spray operators).

11. Determination whether additional funding is necessary.

USAID/S, Project Staff

Dr. Kheiri, June, 1983

Dr. Buck

Dr. Kheiri September, 1983

Dr. Buck, June, 1983

Dr. Kheiri

Dr. Buck, December, 1983

Dr. Buck, Dr. Rao November, 1983

Dr. Vandermer December, 1983

USAID/S November, 1984
Problem: Your signature is requested on the attached Project Evaluation Summary (PES) for the project Health Constraints to Rural Production (698-0408.2). It will then be distributed to AID/W, REDSO/ESA and RIG/ESA in accordance with the procedures set forth in Mission Order ADM-8 on Project Documentation, dated June 23, 1983.

Discussion: The draft of this PES has been circulated and cleared within the Mission. On the 5th of May, 1983 a review of the PES was held and attended by representatives of the Blue Nile Health Project and the Evaluation team members. There was a consensus that the evaluation effort went well and there were no disagreements on the Action Recommendations set forth on the PES face sheet.

Recommendation: That you sign the attached PES.

Approved: 
Disapproved: 
Date: 7/7/83
Attachments

PES - Part I, 698-0408.2
Executive Summary
p. 3

PES - Part II
Annex A. Evaluation Plan and Schedule of Activities
p. 5
- Exhibit 1. Revised Implementation Plan: Epidemiology & Biostatistics.
- Exhibit 2. Examples of Improved Record Forms.
- Exhibit 3. Data Linkage - ID System.
- Exhibit 4. Case-Control Study of Clinically Advanced Schistosomiasis.
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Annex D. Integrated Pest Management.
p. 34

Annex E. A Proposal for Monitoring the Blood & Serum Cholinesterase Levels of Cotton Scouts
p. 41

p. 44

Clearance: M VMicka:HO (Draft)
T. Eighmy:EEP (Draft)
P. Kranstover: PDI (Draft)
K. Sherper: DD
M. Van Doren: Cont.
EXECUTIVE SUMMARY

Health Constraints to Rural Production
Project Number 698-0408.2

1. What constraints does this project attempt to relieve?

   The Health Constraints to Rural Production Project (HCRPP) is assisting the GOS/MOH Blue Nile Health Project (BNHP) with collection and analysis of data and dissemination of results from the schistosomiasis research component of the BNHP. The work is being carried out in a Study Zone comprising two of the 107 farming blocks of the Gezira Managil Irrigation Scheme. Schistosomiasis is a major health problem afflicting about 60% of the 2.1 million people living and working in the farming scheme which produces the bulk of Sudan's export.

2. What technology did the project promote to relieve these constraints?

   A full time biostatistician and mini-computer have been provided to assist with systematic data collection, coding analysis and distribution of results. In addition two laboratories were renovated and training provided to 12 microscopists in order to improve diagnostic tests. These are critical inputs to developing cost-effective programs of schistosomiasis surveillance and control.

3. What technology did the project attempt to replace?

   The tabulation of data by hand with little if any analysis.

4. Why did project planners believe that intended beneficiaries would adopt the proposed technology?

   The use of computer analysis has allowed senior researchers to test various hypotheses and parameters in the disease control model for the Study Zone. With more sophisticated analysis now possible, researchers achieve a greater degree of job satisfaction. There is also a greater possibility of achieving the goal of a cost effective schistosomiasis control system.

5. What characteristics did the intended beneficiaries exhibit that have relevance to their adopting the proposed technology?

   Ultimate beneficiaries, the 2.1 million inhabitants of the Gezira Managil Irrigation Scheme, generally recognize schistosomiasis as a problem.

6. What adoption rate has this project achieved in transferring the proposed technology?

   The project has the full cooperation of the schistosomiasis research workers and has developed linkages with the University of Gezira, the Regional Ministry of Health and the Gezira Agriculture Headquarters. Cooperation of the inhabitants in the surveillance and control procedures, generally, has been excellent.
7. Has the project set forces into motion that will induce further exploration of the constraints and improvements to the technical package proposed to overcome it?

Through the coordination that has been developed among project staff, the BNHP researchers, the University of Gezira and the Central Region Ministry of Health (MCH) several proposals for additional studies have been written. These proposals aim at linking clinical data for inpatient schisto cases with matched controls from the same village. Approximately 100 such matched pairs will be studied to determine which characteristics and behavioral patterns precipitate the severe clinical manifestations of S.mansoni in the age group 19-40. Other proposals linking schisto to agricultural production and integrated pest management are also in developmental stages.

8. Do private input suppliers have an incentive to examine the constraints and to come up with solutions?

Yes, the problem of schistosomiasis, often with prevalence rates as high as 85% in tenant farmer groups, is of sufficient concern to the University of Gezira and the Gezira Farm Management Board (GFMB) and to private input suppliers to involve their energies and resources in attempts to lower the prevalence to 10% within the next five years. (Note: The Government of Sudan (GOS) considers the Gezira farm to be under private management. However, GFMB can also be classified as a parastatal organization.)

9. What delivery system did the project employ to transfer technology to intended beneficiaries?

The project has provided a biostatistician and computer and technology transfer will be facilitated by example, formal training and on the job training.

10. What training techniques did the project use to develop the delivery system?

- Long term training for one Sudanese in biostatistics.
- Short term training for three statistical clerks.
- A proposed seminar for all senior researchers to run various programs with their own data - (Planned for late, 1983).
- Training in the U.S. for senior researchers in Epidemiology and the current disease control models in use by Centers for Disease Control, Atlanta.
- On-the-job instruction and training for mid-level staff and schisto control workers.

11. What effect did the transferred technology have upon those impacted by it?

For senior-level health staff, the training afforded opportunities to meet with other professional researchers and obtain up to date publications. The isolation from professional interchange and lack of access to innovative techniques were overcome and the Sudanese returned refreshed and encouraged about their work. Surveillance and control methods have reduced schisto prevalence among treated residents of the Study Zone.
13. **Summary**: The Health Constraints to Rural Production (HCRPP) began in February of 1981 with AID assistance concentrating on one of the research objectives of the WHO-Blue Nile Health Project (BNHP) i.e. on the schistosomiasis research component. The BNHP has as its goal the control of malaria, schistosomiasis and diarrheal diseases in the Gezira-Managil irrigated farm schemes. Presently the BNHP is carrying out investigations in a Study Zone consisting of two of the 107 farming blocks in the Gezira-Managil scheme in which over 2 million people live.

AID support of the schistosomiasis research is expected to produce a sound cost effective strategy or strategies, based on the research results from the Study Zone for the surveillance and control of schistosomiasis. Progress to date has been impaired by the considerable time required to recruit a biostatistician (February 1981 until June 1982). Further delays were encountered with the GSA procurement and delivery of the mini-computer (May 1982 until March 1983). The computer finally arrived with French manuals, not English.

Originally the project planned to recruit and have in place the biostatistician and computer within the first year of the project (by February 1982). This has slipped forward by 13 months. The project was planned to continue four years with a PACD of 30 September 1985. At the time of this evaluation it is anticipated that the project will require additional time and possibly additional funding to insure that a systematic analysis of the large amounts of data from the Study Zone are properly analyzed.

14. **Evaluation Methodology**: USAID/Sudan scheduled the evaluation at this time in order to clarify the research design for the schistosomiasis data and to suggest improvements for the data collection and analysis. The evaluation team consisted of seven people:

**USAID/Sudan**
- Dr. Thomas Eighmy, Evaluation Officer
- Gary Leinen, Project Manager

**USAID/Washington**
- Dr. Alfred Buck, Tropical Diseases Advisor
- Dr. Hale Vanderner, Pesticides Specialist

**Health Constraints to Rural Production Project**
- Dr. Asim Dafalla, Director Research & Training, BNHP
- Dr. M.S.Rao, Biostatistician (contract)

**University of Michigan**
- Dr. Elon Gilbert, Agricultural Economist

They worked full-time for three weeks interviewing people working with the project, examining the existing data and its format for evaluation, conducting field visits and examining relevant reports. Attached in Annex A are the evaluation plan and scopes of work.

The health specialists focused on the evaluation guidelines in the Project Paper (pp 25-6) and on analysis of the Study Zone Area. The report is attached in Annex B. The agricultural economist was to assess the availability of data on productivity loss due to schistosomiasis and to recommend methods.
whereby costs and benefits of schistosomiasis control might be measured. The report is attached in Annex F. The pesticide specialist was included in the evaluation at the suggestion of AID/W to explore the possibility that the cases of extreme liver dysfunction witnessed in the Gezira may be linked to the exposure of chemical pesticides applied on the farm scheme. The report is attached in Annex E.

It is estimated that the evaluation cost $20,165:

- International air travel $5,800
- Salaries/per diem $10,300
- Petrol, in-country $425
- Travel $26d x $140/day $3,640

The Blue Nile Health Project staff were actively involved with the evaluation and assisted with transportation and accommodations during the field work. Central Region Ministry of Health (MOH) personnel, the Gezira Farm Scheme headquarters staff and staff from the Agricultural Research Corporation were interviewed. They provided the evaluation team with background information and tours of their facilities. Recent studies by the World Bank, Danish Schistosomiasis Laboratories and Euroconsultants for the Gezira Farm Scheme Rehabilitation were made available as references.

15. **External Factors:** None were found to be pertinent at this time.

16. **Inputs:** As was mentioned in item 13 above, nineteen months after the Project Agreement was signed the biostatistician arrived. This has caused a delay in identifying a Sudanese for long term biostatistics training in the U.S. The computer was delayed seven months in arrival and inoperable equipment has further delayed the coding and analysis of the study zone data. The laboratory items ordered were received but included several items not meeting specifications, e.g. wrong voltage, wrong size. These problems have been fully documented and Dr. Alfred Buck will assist in rectifying the errors in AID/W. USAID/S delayed four months in issuing purchase orders for two project vehicles. The remaining project inputs, as originally written in the project paper remain valid. The time originally allotted will produce the expected outcomes, i.e. three and a half years from the time there is a functioning computer system.

17. **Outputs:** The purpose of the evaluation was to clarify the assumptions regarding the collection and analysis of data that will produce a model for the control of schistosomiasis and a surveillance system for the disease in the Gezira-Managil scheme.

A measurement of specific project outputs was not conducted in this evaluation as the micro-computer had only just arrived and was still awaiting many of the consumable supplies.

18. **Purpose:** "To develop a multidisciplinary system for epidemiological surveillance (collection, analysis, interpretation of relevant data and then prompt dissemination to those concerned) of schistosomiasis in the study zone of the Gezira". It is expected that 2 - 3 years of work is now required to institute a functioning surveillance system in the study zone. An additional 6 - 10 months may be required in order to complete analysis and disseminate the results.
19. **Goal/Subgoal:** These remain valid. Assessment of progress toward achieving them was not done as it is too early in implementation to determine progress.

20. **Beneficiaries:** There are two categories of beneficiaries on the national scene. (1) The BNHP project staff funded by USAID through the HCRP have acquired new skills for conducting household surveys, collecting census data, collecting and testing of laboratory specimens, conducting mass chemotherapy, locating water contact points, gathering data on the sociological behavior of water use, collecting/identifying/testing for infectivity in snails, conducting mollusciciding operations and managing large scale disease control programs. In addition, some senior staff have obtained advanced training on tropical disease control and surveillance systems in the U.S. (2) The population of the Study Zone villages approximately 30,000, have been tested and treated for schistosomiasis. As such the treated population has had deterioration from the disease halted and in most cases the damage will be reversed, thus avoiding the late manifestations of schistosomiasis. They will remain productive members of society as long as reinfection is prevented by successful transmission control. The large number of school children who have been diagnosed and cured from this disease can thus remain as productive members of the society.

At the international level, the lessons learned for organizing a schisto control program using the available control measures will be useful in conducting similar control programs in the developing world.

21. **Unplanned effects:** No unplanned effects were detected.

22. **Lessons learned:** (1) The operation of research in a country such as Sudan must utilize the talents of mid level technicians, as they are less likely to depart for the high paying jobs in the Gulf. (2) The cooperation and coordination between research and health services is essential for the success of the project.

23. **Special comments:** The list of attachments to this PES is as follows:

- **Annex A.** Evaluation Plan and Schedule of Activities
  - Exhibit 1. Revised Implementation Plan: Epidemiology & Biostatistics.
  - Exhibit 2. Examples of Improved Record Forms.
  - Exhibit 3. Data Linkage - ID System.
  - Exhibit 4. Case-Control Study of Clinically Advanced Schistosomiasis.
- **Annex D.** Integrated Pest Management.
- **Annex E.** A Proposal for Monitoring the Blood & Serum Cholinesterase Levels of Cotton Scouts.
- **Annex F.** Assessing the Costs and Benefits of Alternative Strategies for Schisto Control.
ANNEX A

EVALUATION PLAN: HEALTH CONSTRAINTS TO RURAL PRODUCTION, 698-0408.2
April 21 - May 5, 1983

Project 698-0408.2 was authorized on December 19, 1980 for a four year life of project grant of U.S. $2.122 million. A Project Grant Agreement (PROAG) with the Government of Sudan was signed on February 7, 1981 obligating an initial $500,000. Subsequent PROAG Amendments have fully funded the project. The one person, long-term technical assistant (biostatistician) was hired in July 1982 and arrived in Sudan the end of August 1982. Thus, this evaluation is scheduled at a relatively early point in the project's life.

The project is involved in the schistosomiasis control component of the BNHP, a combined Government of Sudan/multidonor effort to control major diseases (schistosomiasis, malaria, diarrhea) associated with irrigation in the agricultural communities along the Blue Nile River. The evaluation will examine extensive data collection activities currently underway to assess if analysis of this data will lead to the determination, by project completion, of the most cost-effective method, or combination of methods, for reducing disease transmission of schistosomiasis. If current data collection activities seem inappropriate or poorly targeted to achieve the project goal, adjustment in nature of data collected may need to be made.

The evaluation will further review the progress to date toward the purpose and outputs and will develop recommendations regarding changes in direction, rescheduling of project activities and appropriate changes in management. It will assess whether the project inputs provided are sufficient and of the correct nature to achieve the project purpose.

In addition, the evaluation will review how well the project's interdisciplinary team members are working together and to what extent interorganizational linkages have developed between Wad Medani, Khartoum and Abu Ushar.

The terms of reference given to the evaluation team for the initial evaluation are contained in the Project Paper, page 26. They are as follows:

1. Should the project continue without change?
2. Is re-scheduling indicated?
3. Are the inputs provided sufficient and of the right types to do the job?
4. Is the project meeting the objectives specified?
5. Are the interdisciplinary team members working well together and utilizing the services provided to the fullest capacity?
6. Is the intra-organizational management effective?
7. Are the linkages between the Abu Ushar and Khartoum Units effective and harmonious?
8. What inter-organizational linkages have developed with other bodies interested in similar problems?
9. How do the representatives of various disciplines evaluate the data produced to date?
10. Is the budgeting appropriate if any changes have taken place?
Thus, the following statement of work (SOW) was developed for
Dr. Alfred Buck, Tropical Diseases Specialist:

1. Evaluate Study Zone for control/study capability, i.e. factors
which may influence the epidemiology and transmission of the
disease in a particular environment.
2. Evaluate efficacy of treatment modes and methods for sharing costs
and benefits.
3. Determine if existing data collection and analysis procedures
permit conclusions re: cost effectiveness of control measures
(applied singly and in combination) in a quasi-experimental design
situation carried out in an experimental zone and in the remainder
of the irrigation scheme. Does data collection permit longitudinal
and cross-sectional analysis? Are aggregation levels adequate
(households; registered vs. non-registered villages; etc.)?

In addition, the evaluation will examine the feasibility of
determining the cost effectiveness of schistosomiasis control in the
Gezira/Managil Scheme. It is estimated that 50% of the adult population
(tenants and migrant laborers) working on the scheme are affected by
schistosomiasis. This is manifested in an estimated 12-15% of the adult
population who die prematurely and an estimated 20-30% reduction in the
physical ability of the adult population to perform farm/household
labor activities.

Thus, the SOW for Dr. Elon Gilbert, Agricultural Economist, is as
follows:

1. Estimate the farm/household labor input losses (effective man days)
and the potential loss in crop output (quantities and value) from the
lack of schisto control.
2. In collaboration with the Blue Nile Health Project estimate the
effectiveness and consequent alternative levels of benefits (in terms
of ability to perform manual labor and the value of output produced)
which can be expected from each of 4 alternative schisto control
measures.
3. Utilizing available data on the cost per case treated and the
information generated under #2 above, calculate for each control
measure the net economic benefits that can be derived from increased
farm and household labor productivity.
4. Rank the cost-effectiveness of each alternative health control
measure and compare the projected economic efforts over the next
10 years with projected losses of no schisto control program.
ANNEX A

SCHEDULE OF ACTIVITIES - EPIDEMIOLOGY TEAM

April 21: Briefing in USAID

Meetings with Dr. Haridi, Director Biology and Malaria; Dr. Asim, Director R & T.; and Mr. Faisal, Economist.

April 22: Prepare plan of work and itinerary with team members.

Visit National Institute of Tropical Medicine; National Council for Research and Computer Facility.

April 23: Continued Discussions at USAID

April 24: Visit to the Institute of Tropical Medicine, meet Dr. Satti, Director of Institute for Tropical Medicine, visit of Michigan State University.

April 25: 7.00 AM. leave for Wad Medani

Discussions about the Project with the Drs. Gaddal and Jobin; H.E. the Minister of Health Dr. Mutamad Amin; staff of Evaluation Team; health education, Dr. Ahmed Babiker.

April 26: Visit to B.N.H.P Headquarters Wad Medani to discuss the evaluation requirements, objectives of evaluation.

April 26: Preparation of an itinerary for local visits.

Visit to the Wad Medani Provincial Hospital, demonstration and clinical discussions of patients with advanced stages of schistosomiasis.

Detailed analysis of the hospital-records system with special emphasis on data linkages.

Visit to the lab facilities.

April 27: Visit to Abu Ushar for field observations of villages and operation of weeding machines of 3 types in irrigation canals of different type.

Demonstration of routine application of molluscicides of snail breeding sites.

Collection of snails at selected sites; observations concerning water contact and fecal behavior of the local residents.

Meet with "observers" of fecal habits in study villages.

Return to Wad Medani for discussion of the experiences made during the day.

April 28: Visit to Abu Usher Hospital with detailed assessments of the management of clinical cases of schistosomiasis; review of record-keeping. Discussions of the diagnostic capacity of local facilities and problems of differential diagnosis schistosomiasis.
Visit to mollusciciding site and mass chemotherapy campaign at Wad Bahai Village.

Demonstration of a simple system of rural water supply adopted for use in un-registered village.

Visited Hasaheisa field station of sanitary inspector to see the production of concrete slabs for latrines.

April 29: Writing of Drafts.

April 30: Visit to Rahad Scheme and Fau Hospital to see the medical records and management of schisto cases.

May 1: Multidisciplinary approach of the evaluation team. Report drafting.

May 2: Briefing the BNHP staff on the findings and recommendations of evaluation team.

Meeting with Minister of Health for the Central Region for discussions of the functions of the provincial health services and their role in the B.N.H.P.

Return to Khartoum.

May 3-4: Writing of the final Report.

May 5: Evaluation Review with USAID Director and staff and BNHP staff. Departure of outside evaluation team members.
The Health Constraints to Rural Production Project (HCRPP) (698-0408.2) which started in February 1981, has planned for two evaluations over the four year life of project. The first is to take place in 1983, and the second at the end of the project.

The objectives of the HCRPP is to enable the (GOS) to develop a cost effective schistosomiasis surveillance and control strategy in the Study Zone of the Blue Nile Health Project. This strategy might also be applicable in other African Countries. The HCRPP concentrates on the development of a comprehensive system of surveillance of schistosomiasis which encompasses various measurable stages in the life cycles of the two local species of human schistosomiasis, Schistosoma haematobium and S.mansoni. The surveillance system includes information on intensity of infection and severity of disease in man; habitats, bionomics and dynamics of snail populations, environmental features conducive to transmission; characteristics of sanitation and water supply; characteristics of human behavior associated with water contact. Three villages in the Study Zone have been selected for intensive study on these items. Other villages are monitored less intensively.

In order to achieve the objectives of the project within the allowed time frame, HCRPP provided a biostatistician who is assisted by a Sudanese counterpart, statistical clerks and field coders. The project provided Hewlett-Packard Computer model HP-87XM has sufficient capacity to handle the wealth of data generated by the project in the Study Zone.

In order to enhance statistical competence and diagnostic reliability, HCRPP has made provisions to improve the field diagnostic tools and has upgraded the laboratory of the field station in Abu Ushar. In addition the project will provide fellowships for one biostatistician to be trained at a master's level in a US university and for the senior scientists involved with the Project to have appropriate short term training.

This report is concerned exclusively with the epidemiological and biostatistical aspects aimed at the development of schistosomiasis surveillance system (SSS) in the Study Zone. The schedule of activities for the epidemiological evaluation team is included in Annex A.

Observations and Conclusions

In response to the Evaluation Plan questions (Annex A), the following is a summary of observations and suggestions for remedial action.

1. Should the project continue without change?

Major changes of the inputs and outputs and objectives of the AID component of the project are not indicated. However, a few modifications are needed to strengthen the project.

   A. Statistical assistants should receive short term training on the use of micro-computers in biostatistics.
   B. Create a mechanism for linking data across disciplines and across impatient and outpatient facilities.
C. Provide long term training in the U.S. in medical records management.
D. Develop a case-control study of advanced schistosomiasis.
E. Develop a study proposal for biochemical examination of Study Zone population with high risk exposure to pesticides.

Further detail on these recommendations is found in the following sections, notably items 3. and 4. Recommendation E is discussed in Annex D.

2. Is rescheduling indicated?

The team feels that the late recruitment of the biostatistician and the long delay in obtaining the computer and related accessories necessitate rescheduling of the Project Agreement Completion Date (PACD) from 30 September 1985 to 30 May 1987.

3. Are the inputs provided sufficient and of the right types to do the job?

A. AID INPUTS

Technical Assistance: U.S. manpower is adequate for the project.

Commodities:

a) There has been a considerable delay in the procurement of essential equipment for the project. The computer hardware ordered through AID/Washington (W) arrived only in March 1983 and is just now ready to accept field data for analysis. While the computer itself is functioning properly, there remain adjustment problems with the printer output. It is thought that either the internal printer settings may be set incorrectly or that the computer-printer connecting cable may be of the wrong type. The internal check of the printer itself showed no detectable malfunction in the standard self-test procedures.

Appropriate spare parts should be purchased for computer components known to require frequent replacement.

b) Software and consumable supplies ordered through AID/W have not yet been received. The software ordered is sufficient at this stage. However, it is expected that additional needs for special software programs may arise when cross tabulations, matrix and multivariable analyses of the data are needed for identification of risk factors in transmission and snail bionomics and development of gradients of morbidity in schistosomiasis.

c) Other items ordered through a procurement service agent for use in the field station were found, on arrival in Sudan, to be technically incompatible for local use despite correct specifications in the original order. Two generators and other electrical equipment were 110 volts rather than 220v.

d) Various items needed for the field work, including microscopes, scales for measuring body weight, hemoglobinometers, sphygmomanometers, etc. were received by the BNHP headquarters as early as December 1982. These are still uncrated. However, provisions for distribution to the field research stations have now been made.

e) Two AID Vehicles ordered for the project arrived in Port Sudan as early as December 1982. They are still sitting at the docks.
Training:

a) While the provisions for training Sudanese nationals are sufficient, implementation of long-term training for the Sudanese biostatistician in the USA is not yet synchronised with the scheduled departure of the US specialist in September 1984. Provisions will be made to facilitate the late admission of the Sudanese candidate into the biostatistics-computer science program of a highly reputed US university for the academic year 1983-1984.

b) With the high rate of brain drain from the Sudan to the Gulf, efforts must be made now to train a sufficient number of mid-level health workers in epidemiologic-statistical methods of surveillance. Thus, there is a plan to train three statistical assistants in a two-months training course on the use of the micro-computer in biostatistics, either at the High Institute of Public Health in Alexandria or at another scientific institution in Cairo.

B. INPUTS BY THE GOS
Manpower: Adequate for the project.
Office Support:
Although the biostatistician arrived in September 1982, completion of the office space, provision of secretarial assistance and transport were not completed before March 1983. But they are now satisfactory.

C. REMEDIAL ACTIONS REQUIRED
1) Contact Hewlett Packard (HP) Headquarters for Africa, Europe and the Near East in Geneva ASAP to obtain immediate telex advice about the technical modifications needed to connect and operate the HP printer properly.

2) Additional software needed for the expanded epidemiological analysis can be purchased from WHO, NIH, CDC and others. Dr. Rao will be on R&R June-July 1983 when he can select the required software. It would also be important to spend a few days in the HP Regional Office in Washington to get assistance for systems modifications and problem solving in the maintenance of HP equipment.

3) Correct errors in commodity procurement.

4) Distribute laboratory supplies.

5) Select candidate ASAP for long term US training in biostatistics. Dr. Buck will make arrangements for admission to US university.

6) Select three statistical assistants for training in the use of micro-computers in biostatistics in Egypt. Emphasis should be put on practical training for computer maintenance and diagnosis of malfunctioning which can easily repaired by the non-specialist. Dr. Buck will initiate arrangements for this type of training during his subsequent visit in Egypt.
4. Is the project meeting the objectives specified?

The project can meet the objectives with some modifications and improvements in the data system. A revised Project Implementation Plan: Epidemiology and Biostatistics for the next 15 months is found in Exhibit 1 to this Annex.

A. QUALITY OF THE PRESENTLY AVAILABLE DATA SOURCES FOR COMPUTER ANALYSIS

In order to improve the quality of data available for computer entry, a hands-on training course for senior project staff is scheduled for December 1983. The course will feature data collection, editing, processing retrieval, analysis, interpretation and subsequent dissemination using computer techniques. Special efforts will be made to design and institute an adequate, economic and foolproof surveillance system for schistosomiasis (SSS). First the SSS will be limited to the Gezira Study Zone but later it will be modified for wider usage. The system will enable the health authorities to monitor continuously the efficacy of the various control methods against schistosomiasis.

The data forms currently being used in the Study Zone have already been modified to enable multidisciplinary linkages of communities. With the cooperation of the Directors of Units of BNHP, precoding and rearrangements of data for entry on standard forms are presently in progress. However, there remain some protocols which require additional changes, especially those for environmental assessment, clinical evaluation and laboratory results from screening. The final versions of the forms to be used throughout the Study Zone are expected to be completed by the end of May. Examples of these forms are found in Exhibit 2.

There remain three problem areas for which further remedial actions are recommended. These problems relate to introduced bias, incomplete data and absence of mortality data for integrated analysis. The details and recommended actions follow.

1) Potential for Bias

The function of the surveillance system supported by AID is to monitor changes in incidence, prevalence and intensity of endemic schistosomiasis in the Gezira area, regardless of the cause of the changes. Thus the introduction of bias must be minimized.

a) There are considerable flaws in the current epidemiologic analysis because it is based on grossly incomplete samples which introduce bias. Participation of the population in the various aspects of the study is relatively low. The exact reasons for this delinquency are unknown. In addition, present mass treatment administration practices influence the composition of the population sample that becomes available for re-examination, because it selectively excludes large segments of the general population, i.e. children under 5 years, travellers, persons working in their fields and as well as the true refusals.

b) The likelihood of systematic bias is also enhanced by the current practice of having assigned each of the three study villages to only one of the three independent scientists.
2) Incomplete data

a) The laboratory technicians now working in the various health centers in the Study Zone are assigned to the MOH facilities by the BNHP. They have to wait for instruction from the local health assistant to receive and examine stool, urine and blood specimens of a patient. The daily work load, as judged from the records seen, hardly exceeds 10 specimens per day. Despite this low demand for the technicians' skills, no quantitative results are given to estimate the intensity of the infection by ascertaining egg counts. This is the more regrettable as the techniques used for diagnosis recommended by the TDR Program of WHO.

b) The record system in the field laboratories consists of little more than a list with the names, type of specimens submitted and the simple notation of whether the result of the examination was positive or negative. There is no way of using this information for systematic comprehensive analysis of the data on persons belonging to the study population.

3) Absence of Mortality Data for Integrated Data Analysis

a) This is, perhaps, the least satisfactory aspect of presently available data sources. Data from the health clinics and hospitals in the Study Zone, i.e. all data on morbidity, are not available for epidemiologic assessment. There appears to be complete lack of integration of vital data sources between the health facilities that fall under the jurisdiction of the Regional MOH and those of the Epidemiologic Study Unit of the BNHP. Hospital statistics and patient files in current use in Wad Medani, Abu Ushar and Rahad, as well those of the health centers in the Study Zone offer no means for a record search by diagnosis, name, place, record number, etc.. In a project that addresses the issue of the health constraints that are specific to schistosomiasis, vital data on patients with the advanced stages of the disease and on disease-specific mortality are thus lost.

b) Only a small portion of people with severe cases of schistosomiasis actually die in hospitals. Most patients approaching death, return home. Thus, hospital mortality statistics alone will be an incomplete data source.

B. REMEDIAL ACTIONS RECOMMENDED:

1) a) Only the complete population, or a representative random sample thereof, permits meaningful calculations of the frequency (incidence and prevalence), intensity, clinical severity and distribution (by age, sex, locality) of schistosomiasis.

1) b) It would be much more beneficial to the epidemiologic investigation if the study village scientists would focus their activities on the systematic supervision of the work of more junior staff members and if the evaluation of the 3 villages were rotated among the three scientists.
2) a) A systematic effort should be made to reach all members in the population sample, through home visits, distribution of stool and urine containers on the evening before examination day and by utilizing the local BNHP laboratory technicians in the more conveniently located health centers. Thus, these technicians could do the examinations for which they have been trained. Latecomers, rather than becoming dropouts, could bring specimens directly to the local laboratory.

2) b) To achieve an essential data linkage, the type of the identification (ID) system used in the 3 study villages needs to be extended to the health service facilities in the Gezira. This ID system assigns an individual permanent number to each person. To find the most practical and reliable way to achieve this goal of data linkage, field trails are needed. This action is discussed further in Exhibit 3.

3) a) The ID system proposed above to facilitate data linkages will also help resolve this problem related to integrated data analysis. In addition, it is important to establish in the health clinics and hospitals in the project area a medical records system to enable the retrieval of data on schistosomiasis. It is recommended that the project add a training component for medical records management.

3) b) Develop a case-control study of 100 cases of advanced schistosomiasis to be carried out in Wad Medani and Abu Ushar Hospitals. Further details are found in Exhibit 4.

Consider the possibility of adding a histopathology component to the study of advanced schistosomiasis; see Exhibit 5.

Consider the possibility of adding a pesticide exposure surveillance component. See Annex E.

5. Are the interdisciplinary team members working well together and utilizing the services provided to the fullest capacity?

The interdisciplinary team members of the project are cooperating effectively on a personal basis. Nevertheless, there is greater need for the integration of the data bases collected independently for the various disciplines included in the project. The actions being taken to resolve this problem are discussed under item 4 above.

6. Is the inter-organizational management effective?

Yes. This is extremely well handled under the direction of the Project Manager, Dr. A.A. Gaddal.

7. Are the linkages between Abu Ushar and Khartoum units effective and harmonious?

The relations are harmonious. Effectiveness of communication can be improved considerably by early installation of the two-way communication equipment furnished by AID. This would establish regular information links between Khartoum, Abu Ushar and the BNHP Headquarters in Wad Medani. All the above would facilitate
the SSS data monitoring, editing and feedback. The laboratory services for diagnosis of schistosomiasis in the health centers and hospitals of the Study Zone need to be improved and standardized. Streamlining of the data collection forms used in the 3 intensive village studies and in 28 monitored villages (20% population sample) are being undertaken by the biostatistician.

8. What inter-organizational linkages have developed with other bodies interested in similar problems?

Excellent inter-organizational linkages have developed with WHO, UNEP, UNDP, World Bank, Edna Clark Foundation and Danida. At the national level linkages were established with the Sudan Gezira Board, Universities of Gezira and Khartoum, Central MOH, Central Region MOH, the Institute of Tropical Medicine, Agricultural Statistics and Planning, Ministry of Irrigation, National Water Corporation and the National Council for Research.

9. How do the representatives of the various disciplines evaluate the data produced to date?

So far the analysis of data in each discipline has been made independently by those who have carried out the studies (Annual reports of BNHP for 1981, 1982). Therefore, comprehensive cross-tabulations of data from various disciplines and control activities are urgently needed for a better understanding of the persons at high risk of infection; identification of transmission foci, seasonality and agriculturally dependent transmission dynamics; water contact; occupational human behavior; efficacy of control measures. The comprehensive analysis of the multi-disciplinary data described above is now possible using the large storage and operational memory capacity of the HP-87 computer, provided that all generated field data are promptly and completely submitted to the Statistical Unit in the formats appropriate for immediate data entry.

10. Is the budgeting appropriate if any changes have taken place?

Since the implementation of the project was delayed, the budget may require minor changes arising from inflation and other incidental expenses to be incurred during the extension period from September 1985 to May 1987. It is as yet too early to make a final determination. However, there may be no need for additional funding since the project has received from the GOS an allocation of 690,700 Sudanese pounds from CIP generated local currency.

18-
EXHIBIT 1.

HEALTH CONSTRAINTS TO RURAL PRODUCTION PROJECT, No. 698-0408.2
REVISED IMPLEMENTATION PLAN: EPIDEMIOLOGY & BIOSTATISTICS

1. May 31, 1983  Completion of forms for integrated data collection for the study zone.

2. May 31, 1983  All schistosomiasis data from the technical staff of BNHP to be received in the statistics section in Khartoum for computer processing.

3. July 30, 1983  Obtain estimates for costs of establishing an ID system for the residents of the study zone. Final proposal costs to be presented for review in August, 1983.

4. September, 1983  Biostatistician begins MS training at Tulane.

5. Sept. 30, 1983  Completed analysis of data collection from 3 villagers including age-sex specific prevalence, infection rates and distribution of infection by locality.


7. October 31, 1983  Hands on computer course for the technical staff of BNHP on the use of computer for data analysis.

8. October 31, 1983  Selection of 100 study zone residents with advanced cases of schisto from the hospitals in Wad Medani/Abu Ushar. Matched controls to be identified.

9. October 31, 1983  Consultation by Dr. Buck about case control study on schisto patients during the meeting of steering committee on epidemiology in Geneva.


11. Dec. 31, 1983  Design of questionnaires; key informant data about participants and non-participants in the mass chemotherapy trails.

12. Jan 1, 1984  Commence case control study of advanced schisto cases and neighborhood controls.

13. February, 1984  Completion of training in Egypt of three statistical technicians on computer usage.


15. June 30, 1984  Completion of long term training of biostatistician in a school of public health in USA.

16. Aug. 31, 1984  Technical review and comprehensive analysis of study villages. Descriptive analysis of surveillance system for schisto (SSS),
Exhibit 2

EXAMPLES OF IMPROVED RECORD FORMS

Rationale:

For epidemiologic analysis by computer, much better utilization of the already existing information on schistosomiasis can be made by modest improvements of the already existing field study protocols and record forms. Two items deserve special consideration:

1) Space on the record forms to allow entries for the fields in the irrigation scheme that are owned or leased by each of the households included in the study, as well as their spacial relationship to the snail collection points and water contact sites.

2) A code for the relationship of the individual household member, as the index case, to the HEAD of HOUSEHOLD.

These changes will permit calculations of familial aggregation of infection, clinical manifestation and gradients of severity of schistosomiasis, by distinguishing between acquired, genetically-determined etiologic factors and certain environmental factors of infection to which all members of the household are exposed similarly, regardless of family relationship. They would also allow linkage to Sudan Gezira Board agricultural production data by tenant and field. (These data are available at block headquarters.)

Examples of the improved record forms follow in Tables 1-5.
TABLE 1

Number of Eggs per 5ml per person at each survey and Treatment of Positives

ZONE :

BLOCK :

VILLAGE #

<table>
<thead>
<tr>
<th>House #</th>
<th>Person #</th>
<th>Identification</th>
<th>Survey 1</th>
<th>Survey 2</th>
<th>Survey 3</th>
<th>Survey 4</th>
<th>Survey 5</th>
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<td></td>
<td>Name</td>
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<td>Egg Count</td>
<td>Egg Count</td>
<td>Not Present</td>
<td>Egg Ct</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sex Age</td>
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<td># Who Died</td>
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<td># Moved Permanently</td>
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<td># Never Examined</td>
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<tr>
<td></td>
<td># Not Treated</td>
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<td></td>
<td># Fully Treated</td>
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<td># Cured</td>
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<td># of Conversions</td>
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</tbody>
</table>

[This kind of table will be made for each of the Villages]
TABLE 3

Participation after 2nd chemotherapy campaign by Treatment Category Age and Locality; Lost — Those who have Died or moved permanently since 1st Survey; Never examined, Newly Registered & Registered before but never examined, and Inactive at Survey, first Survey.

Block: __________ Zone: __________

Study Zone (Village Name) ______________

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Never Examined</th>
<th>Neg Before 1 Survey</th>
<th>Not Treated</th>
<th>Incomp Treat</th>
<th>Full Treat</th>
<th>Total</th>
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<td>10 - 14</td>
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<td>15 - 24</td>
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<td>25 - 34</td>
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</table>

[This kind of Table will be done for the entire Study Zone.]
TABLE 4
Participation, Prevalence & Geometric Mean Egg output by Age, Sex, Ethnic Group & Geographical Village Groups'. 2nd Survey

<table>
<thead>
<tr>
<th>Zone</th>
<th>Block</th>
<th>Village</th>
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<tbody>
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<table>
<thead>
<tr>
<th>Ethnic Group</th>
<th>Age</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
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<tbody>
<tr>
<td></td>
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<td>Pop.</td>
<td>Partic</td>
<td>Pos.</td>
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</tbody>
</table>

24-26
Table 5

Prevalence Rates After 2nd Survey of Chemotherapy Campaign by Treatment Category, Age, and Locality. Never examined - Newly Registered & Registered before but Never examined and inactive at Survey #2

<table>
<thead>
<tr>
<th>Village Name</th>
<th>Age</th>
<th>Active</th>
<th>Pop</th>
<th>Never Examined</th>
<th>Neg before Survey 2nd</th>
<th>Not Treat</th>
<th>Incomp. Treat</th>
<th>Full Treat</th>
<th>Total</th>
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</tbody>
</table>

25
Exhibit 3

DATA LINKAGE

Problem:

In order to permit linkages of data between those generated by the services provided by the Central Region MOH, i.e. hospitals, health centers, dispensaries, etc., and those of the study project of the BNHP, an individual identification (ID) number, specific for each person must be used to string up data. Such ID numbers are already in use in the Study Villages, but there are no identifying numbers or symbols in hospital records and clinic files.

Action:

It is proposed to carry out a small field study with experimental ID cards containing the individual ID numbers now used in the Study Zone. Whenever a person enrolled in the present population sample visits a local health facility, his or her ID number will be entered on the file or record. The files must be marked also for easy retrieval at fortnightly intervals.

A cheap Polaroid ID-card system with plastic seal should be used, as has been done with considerable success in other field studies, including those carried out by the WHO-TDR epidemiological studies on schistosomiasis and malaria in a number of villages in Zambia. The Polaroid equipment purchased for the Zambia study was bought at a considerable discount, for less than $ 1000.
CASE - CONTROL STUDY OF CLINICALLY ADVANCED SCHISTOSOMIASIS

In the 4 hospitals located within the Study Zone, which cater to most of the local residents in their catchment areas, the following numbers of in-patients were reported:

1. Wad Medani, 1981, 386 severe cases of whom only 8 died in the hospital.


3. Fau had 11 hospitalized cases out of a total of 530 patients seen in 1982. It has been the practice to send "the incurable" patients home.

4. Hassa Heissa: The team was unable to secure hospital statistics.

Advanced cases of schistosomiasis present with portal hypertension of the liver, ascites, enlargement of the spleen, edema of the legs, pronounced anemia, varicose veins of the lower intestines and esophagus. They enter the hospital most often after a severe hemorrhage, either by vomiting blood (hematemesis) or by rectal bleeding (melena). Treatment at this stage aims at symptomatic relief and, at the restoration of vital functions. This includes blood transfusions from compatible donors, the willing relatives, and administration of the locally, very expensive modern diuretics and vitamin injections. Most patients are males between 19 to 45 years of age, forming the economically most active group of the farming population. They may experience a number of episodes before they eventually succumb to severe bleeding, coma or renal failure. Episodes may, however, be separated by periods of relative well-being lasting up to two years. During this time, men carry their regular work load on their farms to the best of their ability, often being forced to hire additional help. When they die, they leave a family with 3 to 7 children, disrupted farm management, depletion of financial reserves and, perhaps, a measurable drop in family farm productivity.
Because the patients are usually considered incurable, the dark chiffre of unreported cases seeking medical help outside of the government establishment, in one or more of the omnipresent private practices, is probably large.

It is proposed that a case-control study of at least 100 indigenous cases of advanced schistosomiasis be carried out in Wad Medani and Abu Ushar Hospitals, as the sources for identifying the Index Cases. They and their entire family will then be examined and the results compared with those of a group of control subjects drawn from the neighborhood or block and matched for age, sex, occupation and ethnic affiliation. Criteria for comparison will be selected carefully, but should include medical histories, occupation, places of residence, length of residence, diet, use of drugs, native medicines and stimulants, etc. They should also include the examination of all family members for schistosomiasis by intensity, antigen and antibodies and genetic markers, as well as a blood status. The physical examination and laboratory tests need to be followed by treatment, as indicated.

Using the appropriate statistical tests for matched samples, observed differences will be examined for their role as determinants of disease in the complex etiology of schistosomiasis. Moreover, the sample can also be used prospectively for cohort studies on specific types of morbidity, spontaneous cure and excessive mortality.

The study will also enable linkages to investigations of socio-economic parameters to gain better insight into the economic burden of schistosomiasis on the family and on small communities. The heavy costs of the long lasting medical treatment of chronic schistosomiasis can also be estimated by this method. The case-control study has been a useful, cheap method of solving problems in "chronic epidemiology", i.e. cardiovascular diseases, cancer, etc. It is usually forgotten that the tropical endemic diseases, including schistosomiasis, are "chronic diseases" despite their infectious nature.
CLINICAL-PATHOLOGICAL INVESTIGATION
ON THE SPECIFICITY OF THE DIAGNOSIS OF SCHISTOSOMIASIS
IN ADVANCED CASES IN HOSPITALS OF THE GEZIRA

The number of males aged 20-45 years entering local hospitals for treatment of advanced cases of schistosomiasis is high, but represents only a fraction of the true incidence for a number of reasons. Foremost among them are overcrowding of the hospitals with specialists' services, the assumed incurability of advanced schistosomiasis, high costs for treatment of this chronic disease and ignorance in the medicine preventing and arresting the progressive course of the disease.

The severe clinical stages of schistosomiasis can be prevented! In the absence of a vaccine or other measures of primary prevention, secondary and tertiary prevention is the approach. To know more about the etiology of the chronic, disabling stages of the disease as it appears in the Sudan, various concomitant public health problems must be considered in the differential diagnosis. All of these diseases which may have an impact are targets of major prevention efforts in their own right: hepatitis, alcoholism, kala azar (indigenous and migrant imported), hepatotoxic cirrhosis of the liver (aflotoxins, pesticides, etc.), mixed infections between S. mansoni and hepatitis-BAg or pronounced malnutrition.

A systematic clinical investigation using some clinical standard laboratory tests in addition to those presently available in the local laboratory program, supported by histopathology from needle biopsies of the liver would provide differential diagnostic information of significant value to health planners who design preventive medicine projects. Needle biopsy of the liver could be done, either clinically or immediately post-mortem with a Silverman Needle or a 3mm viscerotome. The tissue cylinders removed by the needle can be preserved and examined histopathologically with appropriate stains. An easy arrangement for cooperation with a highly experienced US Institution could be made at practically no cost to the project, other than shipping of the specimens. If approved, the additional costs for training of a Sudanese pathologist in the histopathological techniques in the USA, Cairo or the UK might be considered. Since Sudanese law and custom prevent autopsies, permission of relatives would be obtained to perform the biopsy.

* See Annex E.
Layman's Guide to Cost Effectiveness Issues and Schistosomiasis Control Procedures in the Gezira

By: Dr. Thomas Eighmy

A basic familiarity with the transmission cycle of schistosomiasis is assumed on the part of the reader. However, an introduction to the actual procedures carried out in the Gezira Irrigated Scheme may be useful in understanding the cost effectiveness issues. The goal of the schistosomiasis component of the larger BNHP, with the assistance of HCRPP, is to reduce the prevalence, incidence and intensity of schisto by application of a series of control methods which are cost effective enough to be applied outside the Study Zone. Prevalence, incidence and intensity are dependent on response variables affected by a series of control procedures. A definition and brief discussion of both the response variables and control procedures may assist the reader in understanding other annexes in this report.

Prevalence: The number of persons with a given disease at a particular point in time per 1,000 population at risk, i.e. those with Schistosomiasis egg presence in stool (S.mansoni) or urine (S.hematobium) samples. Old and new cases are included.

Incidence: The number of persons contacting the disease over a given time period (usually one year) per 1000 population at risk.

Intensity: Egg count per gram of mixed stool or per 10 milliliters of urine for a given infected person.

The seriousness of the disease and the effectiveness of control efforts are assessed by the above measures. The measurements themselves are subject to sampling variability. Thus, single measurements are not considered reliable. Gathering prevalence, incidence and intensity data representative of the Gezira population of over 2 million (with considerable internal variability in the disease measures) is itself a costly, time-consuming, intensive operation.

Presently utilized health and agricultural procedures which can reduce schisto may be categorized by the site of operation.

In the Villages

1. **Mass Chemotherapy** - The population is treated with a schisto specific drug, Praziquantel.

2. **Stool and Urine Testing for Follow-up** - Schisto specific, but part of normal primary health care in the Gezira.

3. **Provision of Pure Water Supply and Latrines** - Primarily a measure to prevent diarrhea and a labor saving measure to improve quality of life. However, there are schisto control benefits in the containment of infected feces and urine and in the reduction of contact with infected water, e.g. for drinking, bathing, dish and clothes washing.
4. **Health Education Campaigns** - These sensitize the population at risk to the (1) dangers of schistosomiasis; (2) indications of the disease; (3) available treatment and means of prevention, e.g., avoidance of contact with infested water; care in urination and defecation; allowing household water to stand for 24 hours.

**In the Canals**

1. **Mollusciciding** - Bayluscide is specific against the snail host. It is harmless to humans and livestock but kills fish who are potential anti-schistosomiasis or anti-malaria agents. Studies have shown that infected snails concentrate at deadends of side canals and focal points of human contact with canals. For this reason, focal points, rather than the entire length of the canal system, are treated.

2. **Canal Deweeding** - This is generally done mechanically by a variety of machines, not by herbicides. It is agricultural activity carried out by the Ministry of Irrigation to improve water flow and distribution, but it also has anti-schistosomiasis benefits because (1) snails and snail eggs are removed with the weeds; (2) reduction of the weeds reduces the snail food supply for remaining snails and (3) swiftly flowing water inhibits snail regrowth by removing hatching sites for eggs, washing away eggs and snails and diluting their concentration. Deweeding sometimes misses focal points so, as presently carried out, it may not be highly effective in reducing the population of infected snails. Some weeds provide casual livestock fodder (an additional agricultural benefit) but there is presently little systematic use of the weeds as mulch, fuel or fodder.

3. **Bank Trimming** - An agricultural activity generally carried out in conjunction with deweeding to speed water flow. The anti-schistosomiasis effect derives from removing privacy for urination and defecation near stream banks with the resulting hand washing in canals. Variable water levels and livestock trampling the banks can introduce infected fecal matter into the canal.

4. **Canal Drying** - Agricultural activity is sparse during the dry season when few crops except vegetables are in the field and water is scarce. If incompletely dried, the procedure may concentrate infected snails and serve as a breeding place for mosquitoes. If drying is complete, weeds are killed off (a cost effective means of deweeding) and the snails with them. With intensification of agricultural production, canal drying is less common and has coincided with increasing schistosomiasis prevalence.

5. **Biological Control** - Use of weed-eating grass carp and snail-eating lung fish is at an experimental stage. There are problems of breeding and multiplication in the Gezira environment. In principle, grass carp could also serve to keep weed growth down and thus provide an agricultural benefit. But, run off and spraying from crop pesticides, as well as mollusciciding is usually fatal to the fish.
6. **Mechanical Control** - These have proven ineffective. Even if the snail is blocked, eggs or cercariae can pass through wipes or other mechanical control devices.

In the Study Zone, virtually all of the above control measures have been applied. In an attempt to reduce the schistosomiasis, adequate attention to experimental design has been slighted in favor of application of control measures. Because of this, it may not be possible to sort out the effectiveness or cost-effectiveness of individual or combinations of control procedures through a retrospective multivariable analysis. BNHP is committed to extending control measures beyond the Study Zone to the whole Gezira as resources permit. These resources, even under the Gezira Rehabilitation Project (GRP) will probably not permit the "Total Intervention Strategy" of the Study Zone to be applied to the remainder of the Gezira (The GRP health component is expected to reach about 60% of Gezira's population). The BNHP goal of reducing schistosomiasis will best be met by specifying cost effective control measures.

The most cost-effective control method will probably include mass chemotherapy and retesting to reduce the pool of infection and to save lives in the future. The question for cost-effectiveness research is what combination of methods with what intensity and with what time-phasing will be used next. Mass chemotherapy followed by focal point mollusciciding with continued health education and public health measures is proposed as part of the health component of the GRP, a joint GOS-World Bank Project.

In the future, a cost-effective control strategy might combine these purely health interventions with measures which have joint health and agricultural benefits. For example, deweeding of main canals (with year round water) extended to focal points could be combined with thorough drying of side canals. Focal-point mollusciciding would logically follow mechanical deweeding rather than preceding it since smaller amounts of molluscicide would be needed where the weed and snail population were already reduced. These two operations could be followed later by the upstream introduction of grass carp (if they can be propagated successfully). The fish would be cost effective in reducing future needs for both deweeding and mollusciciding. (Food value would, of course, be an additional income and nutritional benefit).

Ultimately, cost-effective control strategies will require not only consideration of multiple measures and different intensities of application but consideration of both time-phasing and a coherent spatial pattern in their application. For this reason, HCRPP has planned for a surveillance design symposium in November 1983. The symposium will examine the analyzed data collected to date to recommend a two-year surveillance design for the Study Zone and areas outside it in order to estimate parameters needed to calibrate transmission and control models for schistosomiasis.

Team members attempted to find evidence of labor shortage and resulting productivity shortfalls directly attributable to schistosomiasis. The evidence may be there but it was too difficult to document. With the increased cropping intensity and the higher production of the last two years, concurrently with introduction of reforms in price policy and cost sharing known as the "Individual Account," the losses in productivity due to schistosomiasis may become readily apparent in the futures once the data linkage problems are resolved (Annex B).
There is a basic operations research principle to be considered:

"The cost of finding the best solution shall not exceed the benefits of using it". Thus, integrated pest management is introduced in Annex D to assist in operationalizing a matrix to help rationalize the public health and agricultural factors which are involved.

A matrix with blocks or villages as rows could be prepared with disease measures, health procedures and related agricultural procedures as columns. Dates for each entry would be noted. Maps and transparent overlay sheets with multiple color codes could be prepared in which the various health and agricultural activities, both completed and planned, were plotted by date. Activities to be plotted in the matrix include presumed and tested focal points, mollusciciding sites, mass chemotherapy campaigns, latrines and water supply sites, functioning health committees, monitored villages, canal drying, bank clearing and weeding operations. This mechanism could facilitate planning and scheduling of activities as well as the completion of a quasi-experimental design as the SSS is applied outside the Study Zone.
Integrated Pest Management (IPM) in its most common form, usually applies to the control of agricultural pests through the combined use of chemical, biological, and mechanical measures. This triad of control reduces the probability of becoming totally dependent on chemical control and the consequent development of pest resistance. In addition, by lessening the use of chemicals the opportunity for predator species to flourish is enhanced. IPM is also a semi-passive effort which has great cost/benefit potential. In the Gezira Scheme an additional dimension has been added to the traditional IPM concept, this being the application of IPM techniques to public health and the control of the vectors of schistosomiasis. The addition of public health considerations increases the variables in the IPM strategy to be employed, but also increases the potential benefits to be realized from a successful application of IPM techniques simultaneously to agriculturally significant pests and pests of public health importance.

This evaluation of the IPM techniques presently being applied in the Gezira was accomplished strictly through on-site visitation, discussion, interview, report reading, and casual techniques. It is strictly an observational effort and should be considered as the author's opinion. The evaluative utility can only be measured by its use as general guidance to BNHP managers, researchers, and technical staff in their attempts to control schistosomiasis in the Gezira. It is in the attempt to fully implement a strategy of IPM across the public health and agricultural sectors that I see the greatest challenge and the greatest potential benefit of IPM.

The BNHP, the Agricultural Research Corporation (ARC) and other Agencies, with cognizance and interest of the Gezira Board, are testing or implementing IPM techniques. The following is a listing of some, but not all, of the IPM measures which are currently underway in regard to the control of cotton pests and the vectors of schistosomiasis in the Gezira.

**ACTIVITIES IN CONTROL OF SCHISTOSOMIASIS**

<table>
<thead>
<tr>
<th>Type of Activity</th>
<th>Status</th>
<th>Results</th>
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<tbody>
<tr>
<td>Biological:</td>
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<tr>
<td>1. Testing <em>Lanistes varinatus</em></td>
<td>Preliminary lab tests done,</td>
<td>Lab tests show some promise in control of B. pfeifferi.</td>
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<tr>
<td>as a control measure of</td>
<td>field testing needs to be</td>
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<tr>
<td>B. pfeifferi.</td>
<td>done.</td>
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<td>2. Testing <em>Bulinus truncatus</em></td>
<td>Unknown</td>
<td>Unknown</td>
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<td>as a control measure of</td>
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<tr>
<td>B. pfeifferi.</td>
<td>Marisa snails now being</td>
<td>Promising but unknown at this time.</td>
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<tr>
<td>3. Testing <em>Marisa Cornuarietis</em></td>
<td>Propagated in Gezira.</td>
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<tr>
<td>as a control measure of</td>
<td>Some field trials have</td>
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<tr>
<td>B. pfeifferi.</td>
<td>been started.</td>
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<td>Type of Activity</td>
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<td>Results</td>
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<td>4. Lung fish, <em>Protopterus annectens</em> as a control measure of <em>B. pfeifferi</em></td>
<td>Lab tests have been done</td>
<td>Unknown six live fish released. Some promise of fish eating <em>B. pfeifferi</em>.</td>
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<td><em>Grass Carp</em> are also in the process of being tested, but there are no reports</td>
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<td>on this activity at this time.</td>
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<tr>
<td>Mechanical</td>
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<td>5. Mechanical weeding and dressing of canals will reduce the abundance of</td>
<td>The abundance of snails has been demonstrably</td>
<td>Effective snail control measure requiring continuous effort, promising if water contact points are included.</td>
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<tr>
<td><em>B. pfeifferi</em>.</td>
<td>reduced by this effort, including competitor snails.</td>
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<td>6. Building of latrine slabs to prevent re-introduction of schistosomes to the</td>
<td>75 improved slabs produced experimenting with light</td>
<td>More latrines are in place, but a long way to go.</td>
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<td>canals.</td>
<td>ferro cement model.</td>
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<td>7. Provision of water supply systems to the villages to control contact with</td>
<td>Patay double acting diaphragm pumps placed in 4</td>
<td>Much cleaner water for village, no need to travel distances to canals and exposure to schistosomes.</td>
</tr>
<tr>
<td>schistosomes in canals.</td>
<td>villages and accompanying sand filters in place.</td>
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<td></td>
<td>Villagers screened for schistosomiasis.</td>
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<td>This is an old practice, but still being utilized</td>
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<tr>
<td>8. Drying up of canals will kill snails and schistosomes (Ministry,Irrigation</td>
<td>3 liters of chemical applied by drip feed to nearest</td>
<td>Effective temporary control measure.</td>
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<td>Activity)</td>
<td>sluice gate site upstream. 486 liters applied, also</td>
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<td>spot treatment of contact site has been done.</td>
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<tr>
<td>Chemical Control</td>
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<tr>
<td>9. Focal molluscidoring with Bayluscide applied to potential contact sites along</td>
<td>3 liters of chemical applied by drip feed to nearest</td>
<td>Sampling of snails showed good results in reducing their numbers.</td>
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<tr>
<td>and in the canals.</td>
<td>sluice gate site upstream. 486 liters applied, also</td>
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<td>spot treatment of contact site has been done.</td>
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<tr>
<td>10. Mass chemotherapy of villages with Praziquantel to free population of active</td>
<td>All registered villages in one block and working on</td>
<td>Positive results with some re-infection of persons noted.</td>
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<tr>
<td>schistosomiasis.</td>
<td>the second block.</td>
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</table>
## ACTIVITIES FOR CONTROL OF COTTON PESTS

<table>
<thead>
<tr>
<th>Type of Activity</th>
<th>Status</th>
<th>Results</th>
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<tr>
<td><strong>Biological</strong></td>
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<tr>
<td>1. Propagation of parasite wasp (Encarcia) as control of boll worm and white fly.</td>
<td>Experimental trials underway, IPM technique tried in three fields</td>
<td>Shows some promise may have built in resistane to the pesticide MITAC (a synthetic pyrethroid).</td>
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<tr>
<td>3. Introduction of OKRA leaf (SUDAC-K) cotton hybrid to decrease canopy, increase the temperature and reduce white fly and increase effectiveness of pesticide spray to the cotton plant.</td>
<td>Ongoing field research</td>
<td>Research has shown effectiveness of this technique in reducing W. flies and B. worms, thus reducing dependence on pesticides.</td>
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<tr>
<td>4. Identification of the natural species of arthropods which predate of the B. Worm, W. flies and other pests.</td>
<td>Work has been done, but this should probably be an ongoing activity.</td>
<td>A list of natural predators has been compiled.</td>
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<tr>
<td><strong>Mechanical</strong></td>
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<tr>
<td>5. Use of cotton scouts to enumerate the cotton pest in the field on the plants before making a spray decision, also measuring wind speed, direction, and temperature</td>
<td>Ongoing activities in the growing of cotton</td>
<td>Decreases the number of applications results in timely application and may decrease the amount of insecticide applied.</td>
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<tr>
<td>6. Burning of the cotton stalks and trash after picking to reduce cotton pests chance for survival to the next growing season</td>
<td>Ongoing Activity.</td>
<td>May decrease pest infestations next year, and need for insecticide.</td>
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<td>7. Careful calibration of spray equipment and careful monitoring of the equipment and spray swaths.</td>
<td>Ongoing Activity.</td>
<td>Reduces excess spraying, accuracy of spray, and helps eliminate drift.</td>
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<tr>
<td>8. Approximately 20 pesticide products composed of organochlorines, organophosphates, carbamates, synthetic pyrethroids, and other chemicals are regularly applied to cotton.</td>
<td>Ongoing (Seasonal)</td>
<td>Kill cotton pests effectively and other living organisms, over use may develop pest resistance.</td>
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</table>
Even a casual reading of the previously listed BNHP, ARC, Ministry of Irrigation and other agency control measures being employed or tested reveals numerous activities which are counter productive if attempted in the same field or plot within similar time periods. However, for a more precise diagnosis of these inherent conflicts see Figures 1, 2, and 3, which are included with this report. Some of this counter productivity is associated with the incompatibility of chemical and biological control. As long as cotton fields are being heavily sprayed with chemical pesticides the probability of predator species surviving to accomplish its purpose is minimal.

Other lists or additions to the activities listed above should be compiled for such public health disease erradication programs as malaria. In fact, all public health programs utilizing biological, mechanical and chemical means to control disease in the Gezira should be included, in order for the above to be considered as a comprehensive IPM strategy development tool.

The consequence of not broadening the IPM strategy to include both the agricultural and public health sectors would be to move forward with the development of an agricultural production enhancement scheme without regard for the input from the public health sector. Therein lies the risk of unknowingly, or unwittingly, negatively impacting human health in the Gezira and potentially laying the ground work for a future negative impact on agricultural production. Likewise, if the public health sector chooses to ignore the agricultural sector in its attempt to develop an IPM strategy, it runs the risk of negatively impacting agricultural production in the near term with a subsequent negative impact on human health.

Recommendations: That the BNHP, the ARC and the Ministry of Irrigation coordinate in the development of an IPM strategy to avoid the counter productive measures which now evident.
Figure 1. Public Health IPM versus Itself (potential intra conflict)

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<th>IPM ACTIVITIES 1 thru 10</th>
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PC = Potential Conflict among internal IPM activity.
OK = Activity is probably not counterproductive
Figure 2. Agricultural IPM versus Itself (potential intra conflict)

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PC = Potential conflict among internal IPM activities.

OK = Activity is probably not counterproductive.
Figure 3. Public Health IPM versus Agricultural IPM (inter program conflict)

Agricultural IPM Activities 1 thru 8.

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<td>PC</td>
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</table>

PC = Potential conflict among inter IPM activities.

OK = Activity is probably not counterproductive

* = There seems to be no realistic way to expect to propagate fish in the presence of high pesticide residues which are found in the canals especially during the cotton spraying season.
Annex E

A Proposal for Monitoring the Blood & Serum Cholinesterase Levels of Cotton Scouts

By: Dr. Hale Vandermer

Background

The Gezira scheme is divided into 13 agricultural regions, each one with a chief entomologist who is responsible for the decision to aerially spray the crops. Each regional entomologist has 3 bachelor level assistants. And each assistant entomologist has a crew of 8 workers who act as cotton scouts for part of their responsibility. The cotton scouts go into the fields walking in a diagonal pattern counting leaf infestations of pests on the number of cotton plants predetermined by the chief entomologist. These teams of workers also carry out other functions associated with the application of pesticides including checking the mixing and loading of pesticides into the spray planes. Consequently, these workers are exposed to measurably high levels of pesticides. In discussions with a chief entomologist and other knowledgeable persons, it was indicated that sub-acute and occasional acute exposures do occur.

Currently, about 27 pesticides are being used on the Gezira/Managil Scheme including: organophosphates, carbamates, organochlorines, synthetic pyrethroids and naline/urea herbicides. Large amounts of organophosphates and carbamate insecticides are used to combat the white fly and cotton boll worm. These chemicals are cholinesterase inhibitors allowing accumulation of acetylcholine at neurom-effector and skeletal muscle junction. The cholinesterase enzyme is critical to normal transmission of nerve impulses to the innervated tissue. Organophosphates also cause impairment of nerve impulse transmission in the brain. These effects are the very mechanisms which make these chemicals effective pesticides. Also, some of the organophosphates are lipophilic causing a slow release back into the blood stream and requiring a longer period for recovery or conversely enabling a person to appear to be recovered when his nervous system is still being dosed with small sub-acute doses of organophosphate material.

The situation with carbamate pesticides is somewhat different. While they inhibit acetylcholine, this inhibition is quickly reversible via dissociation of the carbamyl - enzyme combination. While this change may produce less severe toxicities from carbamates, it is likewise harder to measure the cholinesterase depression in the blood or serum unless the exposed individual is tested within a few minutes or hours of the exposure. To my knowledge there is no evidence that carbamates are stored in the fat. They are actively metabolised by the liver and the metabolites are excreted by the kidneys.

Both of these chemical groups are efficiently absorbed by inhalation, ingestion and dermal penetration. In addition some of the degradation products of these chemicals are more toxic than the parent compounds i.e. some organophosphates are converted from thions to oxons in the environment, in the presence of sunlight and in the human body, by the action of liver microsomes.

While carbamate materials might appear to be relatively safer because of the body’s ability to quickly detoxify the material and reverse the depression of
acetylcholinesterase; they nevertheless present the opportunity for acute, immediate poisoning. Temik (aldicarb), a pesticide which has seen limited but effective use against cotton pests in the Gezira in the past two years, has an LD 50 of 9mg/kg body weight in male rats. This is one of the most toxic chemicals in the pesticide arsenal. Temik exposure in the low parts per million range can elicit acute symptoms in man.

Given the past and present use of organophosphate and carbamate pesticides in the Gezira and an already existing order for enough Temik to apply to 80,000 feddans of cotton, human exposure to these hazardous materials is likely to continue during the 83/84 growing season. This is especially true if the GOS request is approved for $7 million worth of Temik from Union Carbide financed through AID's Commodity Import Program.

PROPOSAL

It is proposed that a study of pesticide exposure and the consequent effects be considered. While the literature is replete with studies of this type, the Sudan presents some interesting variables that are not well documented in the literature.

1. With temperatures rising often to 40-45°C or higher, plus intense sunlight, the opportunity for volitilization and photo-degradation are considerable. This has been demonstrated by Zorgani, an ARC entomologist, in several studies of DDT in soils and cotton seed.

2. There exists no baseline data on cholinesterase levels within the Sudanese population. This study would provide an opportunity to acquire important data and strengthen this occupational monitoring capability within the Sudan.

In addition to all of the aforementioned hazards, there remains another potential threat to human health from this agro-medical problem. Dr. Alfred Buck, AID/STT/Health, an internationally known and respected authority in tropical medicine, has reported on numerous occasions that schistosomiasis, which is endemic with more than 50% positives in most villages in the Gezira Managil Scheme, presents unusual and particularly severe symptoms among those persons who are infected in the heavy pesticide use areas of the Gezira. Dr. Buck has posited for sometime that there must be an unknown factor in the severe sequelae associated with cases of schistosomiasis in the Gezira. His observations lead him to conclude that there is an abnormally large number of young men 19 to 40 years of age in the prime of their productivity, who progress quickly to the terminal stages of schistosomiasis. (During a site visit to the Wad Medani Hospital, there were 350 cases of schistosomiasis in the hospital at that time; 15-20 appeared to be in the advanced if not terminal stages of schistosomiasis). Considering the damage to the liver which is done by S.mansoni and the important role the liver plays in the detoxification of organophosphate, carbamate and other pesticide chemicals, it is suspected that pesticide exposure might be that unknown factor.

In order to begin systematically the task of testing the hypothesis associating high pesticide exposure with synergistic, potentiating, or accelerated lethal effects of schistosomiasis, this investigation is proposed.
Objective 1.

Develop and expand the present basic biochemical capability of BNHP personnel to quickly test for the effects of cholinesterase inhibiting chemicals in the field.

A. Evaluate available cholinesterase field test kits and select the most appropriate kit. (The one kit presently available at the BNHP needs further evaluation. Three BNHP personnel are trained in its use and presently test malaria spraymen once a week during the mosquito spray season.)

B. Design field monitoring of cholinesterase project: sample size, data report form, etc.

C. Purchase appropriate field monitoring kits and related supplies.

D. Provide further training to BNHP field monitoring personnel in use of kits and underlying biochemistry.

E. Implement the cholinesterase field monitoring.

Objective 2.

Develop and implement a laboratory quality control check (QC) system to support the cholinesterase field monitoring activity.

A. Select a CH.E. Titration or similar system and method.

B. Secure laboratory equipment and reagents.

C. Identify and select laboratory to provide the QC backup and to provide any training needed.

D. Develop in conjunction with BNHP statistical unit, a QC check system.

E. Implement the QC check system using standards blanks and spicked samples, if possible.
Annex F.

Assessing the Costs and Benefits of Alternative Strategies for Schisto Control
By: Dr. Elon Gilbert

This Annex begins with some general observations on the BNHP, its current status and factors impeding the attainment of project objectives as seen through the eyes of an agricultural economist. The final section reviews and comments on plans for assessing the costs and benefits of schisto control.

A. General Observations

Although the HCRP Project is regional in its intent to develop and design strategies which will have application throughout areas of Africa affected with schistosomiasis, it is unlikely that the resulting control strategy will be applicable without modification outside the Gezira. In fact, the optimal overall strategy within Gezira likely will involve a number of sub-strategies reflecting differences in the characteristics of groups and areas, including differences in disease prevalence, water conditions (existence of water year round in canals, availability of clean water), migratory behaviour and economic status of different groups.

Gezira, the largest irrigation scheme of the African continent, represents one of the most serious situations in the world today. As a general illustration, Gezira has one of the lowest cropping intensities of any large irrigation scheme in the world (less than 75). Limited water availability combined with water-intensive irrigation practices are major factors influencing present cropping patterns and the resulting cropping intensities. Increases in cropping intensities may well take place and more canals might have water in them the year round, increasing suitable year round snail habitats. From an economic perspective an increase in cropping intensity is desirable and probably inevitable. However, such developments may further complicate health problems and, if anything, increase schisto prevalence. Thus, there is a need not only to identify the set of optimal control strategies applicable under current conditions (including prices and technologies), but also to leave behind by the conclusion of the project an established capacity to collect and analyze data to facilitate adjustments in the control and surveillance procedures.

B. Project Status

Inputs provided under the project have in theory focused upon the collection and analysis of data related to schistosomiasis. But AID is providing support of a general nature (recurrent costs such as petrol) which is vital to the continuing operation of BNHP. There is little question that BNHP would not have made the progress it has made to date without AID inputs. However, progress in achieving the more specific objectives of the support, namely to devise and test in systematic fashion a control strategy for schisto in the Gezira, has been rather limited to date. Large quantities of data have been collected. However, early data collection was not undertaken with a view to computer processing. Some analyses have been performed. Control measures have been instituted, based more on logic and intuitive assessment than on careful testing of alternative strategies. In the Study Zone, virtually all control measures of a public health or joint health-agricultural nature (with the exception of experimental biological control measures) have been applied, but their application has not been within a systematic experimental design. Therefore a retrospective multivariate statistical analysis
to sort out cost-effectiveness of individual control measures or their combinations (especially when differential intensity and time phasing strategies were pursued) may not be possible. Part of this difficulty is traceable to the late recruitment of the biostatistician and the late arrival of the computer.

BNHP has made progress, particularly in the Study Zone, in identifying and demonstrating strategies which appear to be controlling schisto. More specifically, BNHP is currently implementing a series of measures including mass chemotherapy, focal point mollusciciding, improved water supply, latrine construction and health education which collectively appear to be having a rather dramatic effect upon lower schisto prevalence. To their special credit, BNHP has extended treatment efforts and control measures beyond the tenant farmers and registered villages to include unregistered villages and labor camps. The strategy is least well articulated (and implemented) in the case of migrant laborers, but BNHP is presently attempting to advise ways of dealing with this group as well. Inclusion of migrants and unregistered villages in the disease control stands in contrast to years of official neglect of these groups. It is imperative that all groups be included in any schisto control strategy which intends to have anything more than transitory impact on health status of the Gezira population.

BNHP activities to date in schisto control are providing the basis for a schisto control component in the proposed Gezira Rehabilitation Project (GRP) to be funded by the World Bank. Thus, the USAID supported research is most timely and can have a profound effect upon the implementation of the GRP which can improve upon and refine the strategy currently incorporated in the BNHP. A number of modifications in research protocols and data collection/analysis procedures should be considered for early implementation in hopes of yielding some results by the start up of the World Bank project. Specific suggestions in this regard were contained in Annex B.

There may be opportunities for more systematically measuring the effectiveness of specific and/or combination of control measures as BNHP implements its strategy beyond the Study Zone during the initial implementation stage of the GRP. In this regard, BNHP staff might develop a monitoring system for GRP schisto control efforts which would facilitate the systematic assessment of various measures. This might include some selective phasing of interventions in different combinations by location, with a view to making some comparisons. A quasi-experimental design and associated questionnaire might be developed with computer analysis of the results in mind.

C. Factors Impeding the Attainment of Project Objectives

1. Multiple Objectives of Agencies Involved

One problem that is common to many projects funded by a number of different donors as well as the host government, is the difficulty of accommodating a large number of related but not necessarily identical sets of objectives USAID intends to support research which identifies and tests an optimal strategy for schisto control. This objective involves different type of research; determining the cost-effectiveness of different combinations of control measures; designing and testing new control measures; the effects of disease, transmission mechanisms, etc. which can provide the basis for the design of more effective control measures.

BNHP, on the other hand, is concerned with research in the entire range of water-borne diseases affecting the populations of Gezira/Managil/Rahad. BNHP is charged with devising and implementing a comprehensive set of control measures for malaria and diarrheal disease in addition to schisto. These complementary
objectives may present conflict. As an example, a particular control strategy (such as clean water provision) may be sub-optimal from the perspective of schisto control alone, but optimal when considering the entire range of water-borne diseases. Further, the efforts to implement various control strategies encompassing the range of water-borne diseases may complicate data collection and analysis efforts aimed at understanding schisto and the effects of specific measures. Thus, it may be quite difficult to unravel the contributions of various control measures for each water-borne disease, to say nothing of distilling lessons learned and definitive research results which might assist schisto control efforts more generally throughout Africa.

2. Difficulties in Attracting and Retaining Quality Staff

This problem is endemic in the Sudan and is likely to remain so for the foreseeable future. Not only is it difficult to retain trained and experienced Sudanese but it is also difficult to recruit technical assistance for long periods to work in the Sudan. The staff currently at post is impressive, but it is probable that there will be turnovers in key positions prior to the end of the project. There is provision for training in the project, but the question remains whether BNHP will realize major benefits from the training and whether the training will make up for the turnover in staff.

At issue is whether the research program should reflect the probability of significant staff turnovers during the next five years. While the staffing situation would seem to favor research projects of relatively short duration (one to two years), there are a number of research issues on schisto which are not effectively handled on a short term basis.

3. Difficulties in Achieving Multidisciplinary and Interinstitutional Collaboration

The Technical Assessment, Annex B, has made recommendations to improve and extend the quality of multidisciplinary and interinstitutional collaboration for the various research programs. There appears to be a general appreciation of the need for collaboration across discipline and institutional lines to avoid segregation along disciplinary lines.

To enhance multidisciplinary collaboration the research programs should include i) periodic meetings of the research team to review progress (at least once a month during the data collection and analysis periods) ii) regular procedures for field monitoring of data collection efforts by two or more senior members of the research team representing different disciplines. The field studies are only as valuable as the quality of the insights gained through the interaction of team members. Too often data collection is left entirely to teams of rather poorly trained and loosely supervised enumerators who generate large quantities of data which research teams find nearly impossible to interpret.

D. Estimating the Cost Benefits of Schistosomiasis Control

A number of efforts have been made to estimate the impact of schisto (and hence the benefits from its control) with only very limited success to date. Rosenfield in her study of the Management of Schistosomiasis concludes that efforts to measure benefits have produced inconclusive and/or controversial results.
Prescott suggests three sets of major benefits of the control of Schisto including:

i) consumption benefits (individuals and society place a positive value on health for its own sake)

ii) investment benefits (improvements in health lead to increases in productivity)

iii) externality benefits (good health reduces costs of medical care)

The following discussion focuses on the problems and prospects for estimating benefits in the context of BNHP. From the cost side it is necessary to know the activities and physical inputs (labor, materials, travel, etc.) associated with certain levels of effectiveness. Yet, the most difficult item to measure with a fair degree of accuracy is the effectiveness of specific control measures and combinations of the control measures.

Estimating the benefits which individuals and society place on good health is much more problematic. It is hoped that justification of the most cost effective control measures will not require recourse in attempting to measure this.

The benefits from Schisto control are highly sensitive to morbidity and mortality rates. These rates are not known at present. Suggestions on how to improve their estimation are included in Annex B.

There are a number of special problems involved in sorting through sets of shared costs and benefits associated with the different disease control measures which were indentified in Annex E. It is suggested that great efforts not be made to sort out shared costs and benefits. The feasibility of schisto control will, hopefully, not rely upon finely tuned estimations of benefits and distributed costs which in many instances depend upon a series of fragile assumptions.

Some crude distinctions might be made which should eliminate some of the major distortions stemming from shared costs and benefits. Certain control measures, overwhelmingly or solely impact on schistosomiasis, notably chemotherapy and snail control through mollusciciding. The costs of such measures can be assigned to schisto control alone. Other control measures such as canal weeding appear likely to have only limited impact on schisto. It is suggested that none of the costs or benefits of weeding (given current weeding practices) should be assigned to schisto control efforts. It is assumed that the feasibility of canal weeding rises or falls on the basis of its more direct impact upon the availability of water, for agricultural and human purposes.

Of the major control measures, only provision of latrine slabs and clean water appear to present possible problems in sorting through shared costs and benefits. Both are part of general BNHP strategies to control water-borne diseases. A possible approach might involve deducting a portion of the cost of these measures equivalent to the easily estimated benefits from the associated control of non schisto diseases.

Some of these benefits may become apparent from the study discussed in Exhibits 1 and 2 of this annex. Alternatively, the costs and benefits can simply be lumped together as part of a more general assessment of the control of water borne disease, an approach which is more consistent with the general mandate of BNHP.

A simple cost benefit format is proposed which does not require advanced modeling or computer skills to operate, i.e. using the Visacalc software program with the HCRP mini computer. This program includes a net present value.
sub-routine which is comparable to that utilized by the World Bank and other agencies in determining the economic feasibility of projects. This is a very simple procedure which translates the annualized flow of costs and benefits into net present value or internal rate of return. In theory, the cost benefit comparisons should include adjustments for price distortions between official and market exchange rates and this can be done fairly simply within the Visacalc format.

BNHP staff have recently completed a series of discussion with the World Bank regarding the optimal set of control measures and the associated unit costs in preparation for the GRP. It is suggested that BNHP use these costings as a point of departure for cost benefit comparisons and specify the basis of the unit costings. These can be easily updated periodically using the Visacalc program. The cost information prepared to date and completed by 2 of the 5 BNHP units for one month should be completed by the other 3 units. This could be summarized annually as illustrative of costs associated with existing control methods.

In keeping detailed records of the costs associated with various control measures, the following items should be considered:

i) unit costs for trial efforts in various locations and on a limited scale are likely to be higher than unit costs for more extensive efforts as envisaged under the GRP;

ii) the costs of various items change from time to time (including salaries, drugs, petrol, etc.) and these costs changes can best be accommodated through a Visacalc format to the costs of control measures used on a large scale;

iii) the important information from the field that needs to be updated periodically is the actual physical inputs - the labor time by various types of staff and the materials;

iv) physical input estimates are unlikely to change dramatically over time unless a different method is employed, aimed at increasing the efficiency of the operations.

Data collection on costs should focus on the physical inputs when procedures are changed. Where no such procedure changes are made, there is little point in routinely collecting information on costs. The comparison of costs and benefits of various control measures thus will be done only episodically. It can be done fairly quickly by simply updating the costs and prices in the computer and working them through the Visacalc program.

For example, there is data suggesting that mass chemotherapy covers 90% of the eligible population (defined as total population less under fives and pregnant, lactating mothers) in a village. There are also some less refined results which suggest inverse relationships between latrines and pure water per capita, on the one hand, and schisto prevalence on the other. Each of combinations of these control measures has an associated set of physical inputs which are known or can be readily estimated.
E. Recommendations

To more fully develop the costs and benefits of schistosomiasis control the following recommendations are offered:

1. BNHP should devise and implement a simple research plan to compare the costs and benefits of schisto control using the Visacalc Program on the HCRP computer.

2. Inputs (expressed in physical terms per capita assuming a large scale program) associated with each control measure should be put into a Visacalc format. The total cost of a given strategy at a given point in time can be quickly calculated (and expressed in terms of a cash flow) by plugging in an annualized schedule of the population to be covered and the current/projected unit costs.

3. Detailed cost information on various control measures does not need to be collected on a regular basis. Data relating to costings should be collected only as changes occur in procedures that are aimed at improving the efficiency of control measures being tested.

4. The major task of field research should focus on determining the effectiveness of various control measures (and combinations thereof). The result of these investigations can also be entered into the Visacalc format and will indicate the changes in prevalence among the target population associated with various strategies.
FOOTNOTES

1/ The schisto control component of these Gezira Rehabilitation Project (GRP) includes a $6 million loan for a five-year program of chemotherapy and mollusciciding which will cover an estimated 68% of the population of the Gezira. In addition, GRP includes provision for improved water supply and pit latrine construction which will reach 55% of the population. This will contribute to a lower level of schisto infection through reductions in water contact/transmission.

The GRP has been approved and is scheduled for final negotiations this year. The project should get underway in 1984 although the formal commencement of field operations in schisto control are not scheduled to commence until the second year of the project, (e.g. sometime in 1985).


Exhibit 1

Comments on the Research Proposal, "Impact of Schistosomiasis and Malaria on Agricultural Productivity" by Dr. Elon Gilbert.

A. Background

BNHP has obtained support from TDR/WHO for a research effort aimed at measuring the impact of schistosomiasis upon agricultural productivity. BNHP proposes to collect farm management and health status information on 300 farm families in the Study Zone over the nine month period of the main 1983/84 farming season (June - Feb.) Labor inputs by family and hired labor will be recorded through weekly visits by enumerator. Non-farm activities will also be recorded. The sample will be comprised of tenant families who rely primarily on family labor for agricultural activities, since it is hypothesized that the impact of disease will be greatest among this group.

B. Comments

This is a major undertaking from the farm management perspective. The sample size is much larger than is needed to record and analyze major variations in productivity. However, from the disease impact perspective the sample may be too small. Malaria control measures over the past couple of years have reportedly reduced malaria prevalence to below 2%. Prevalence rates for schisto are 60% in the Study Zone, but are higher among hired labor and residents of unregistered villages than among tenant families in registered villages who are the focus of the sample. More significantly, morbidity rates are not known, but may be as low as 5% among tenant farmer families. There is also little basis at present to predict future morbidity and mortality rates in the absence of schisto control. Thus, the research project as it now stands may find that it is extremely difficult to measure the impact of schistosomiasis on agricultural productivity given the large number of variables affecting yields.

The sample as proposed will be comprised of tenants who rely primarily on family labor; this group may be expected to be relatively better off than sharecroppers. Even where the sharecropper is above average in terms of income and agricultural productivity are likely to be as high as tenants where the decision maker of the unit is affected. Sharecroppers may be operating more marginally in terms of use of family labor and capital than tenants and schisto prevalence may be higher. Thus, it is suggested that sharecroppers be included in the sample or be the subject of a separate parallel study.

It can also be argued that the survey should not exclude tenant farm families who rely primarily on hired labor. Schisto rates are probably lower, but morbidity is likely to have an impact on family income and productivity even though this may not directly affect agricultural productivity. In any event, exclusion of one category of farmers on the basis that schisto rates may be low clearly biases the sample.

In terms of analyzing the costs and benefits of schisto control, total benefits rather than simply reduction in possible losses in agricultural productivity should be considered (even if they cannot in many instances be easily quantified). Labor inputs and hence agricultural productivity is probably
at least likely to decrease. In terms of critical farm operations such as planting and harvesting, farm families are far less likely to allow productivity to drop dramatically as a result of family illness and will either reallocate the family work force (have children stay out of school, or have other members take excused or unexcused leave from jobs) or hire labor in order to complete the work. From an economic point of view the marginal returns to performing certain key farm operations in a timely fashion are very high, relative to almost any other farm family activity. All activities are being considered in the survey and thus the total impact of schisto upon family income and productivity will be measured, not just the impact on agricultural productivity.

The survey should run for at least 12 months to include a full agricultural cycle of activities aimed at quantifying (or at least identifying) the full range of impacts from schisto on family income and productivity; an additional two-four months would be desirable. The survey should begin no later than May, before the commencement of agricultural activities. Enumerators need to be selected, trained and in place sufficiently in advance of the commencement of the farming season so that at least some of the inevitable problems associated with getting the data collected and an analysis system functioning can be fine tuned while the work load/data load is still relatively light.

Given the number of tasks that must be completed well in advance of the formal commencement of data collection activities, it is unlikely that everything will be ready to commence the full study. Then, what can profitably be done during the upcoming season which will at least be complementary and preparatory to a survey focusing upon the 1984/85 cropping year? Consideration might be given to using a portion of the existing Sudan Gezira Board (SGB) sample and data on the basic farm management input and output. The SGB Economic and Statistics Unit is already associated with the proposed study for the purposes of general planning and analysis procedures. Some additional data will have to be collected, notably that relating to health status of respondents. This might be handled by recruiting and training a smaller group of enumerators who would specifically focus on health status, leaving the regular team of SGB enumerators to collect the core farm management information. Some modifications to SGB current procedures would be desirable, but these modifications will be minor and additive. The primary need is to refine the recording of information collected on labor inputs. At the present time, work performed by particular family members or laborers is not recorded unless it lasts more than two hours; then it is recorded as having consumed a complete day. BNHP requires more detail on labor inputs notably the approximate number of hours worked by a family member (or hired labor) on a particular task. Such information, together with assessments of quality of work performed, can provide a better basis for understanding productivity differences among farmers than is possible from the present data set/collection measures.

A more complicated issue is the need to have information on non-farm activities and family income from farm and non-farm sources. If it is not possible to add this component to the SGB sample, then it might be prudent to limit the sub-sample used to those family units who derive all or nearly all their income from farming.
1. Alternative Hypothesis

The hypothesis of this study might be restated that schisto has a major impact upon income and productivity in those families where one or more family members are temporarily or permanently disabled/incapacitated by the disease and that the percentage of families thus affected is likely to increase substantially without schisto control. Testing such a hypothesis might involve a comparison of "healthy" family units with affected units, possibly using a case study approach to determine the effects of the disease upon decision making and income/labor allocations within the family. It might be that families in which key decision makers and workers are affected by the disease would be disproportionately affected in terms of income and productivity, relative to families where only young children are affected. Yet, a seriously ill child consumes a large amount of adult time and family resources. Thus, studies of family units currently affected by the disease combined with projections of morbidity and mortality rates/incidence by age and sex might be used to roughly "quantify" the consequences of uncontrolled schisto and hence the benefits to its control. This suggests a stratified sample involving equivalent numbers of "healthy" and affected family units and the explicit inclusion of non-registered villagers, in addition to tenants. One major problem would be how to select an unbiased sample of families considering egg counts, chemotherapy and disability.

Another approach might involve randomly selecting 100 farm families households in each of three villages in areas not yet subjected to mass chemotherapy or other major control efforts. Data on income and productivity of all 300 households could be collected for one year followed by testing all individuals in the sample for schisto. The 100 families with the highest combined egg count and the 100 with the lowest counts would be grouped. All positives would be administered chemotherapy. (Mass chemotherapy might be advisable to catch false negatives). The highest and lowest egg count groups would then be followed for a second year. The analysis of the two years of data should help answer the following questions:

i) Is there a relationship between infection levels as measured by egg counts and income/productivity?
ii) Is there a short-term effect from mass chemotherapy?

2. Case Studies

As a complement to the formal survey, it is suggested that a series of case studies of healthy and affected units might be initiated immediately. Respondents might include approximately 10 family units which would be selected on the basis of current health status as well as socio-economic status (tenants, sharecroppers, hired laborers). The results would not be significant in a statistical sense, but would be of great assistance in providing qualitative insights on how families deal with a serious disease, particularly schisto, which would aid in interpreting the results of the larger formal survey. Some of the 10 case studies might be drawn from the SGB sample. The case studies should consist of a series indepth questionnaires and open-ended interviews which would be administered by senior personnel.

3. Hired Labor

Exclusion of hired labor may negatively bias the results of the study in terms of the impact of schistosomiasis upon productivity. Schisto rates are probably higher among hired labor communities. Further, the effects of
disability from schisto upon family unit productivity and income is likely to be greater than for either tenant farm families or sharecroppers. However, the effect on agricultural productivity may be negligible since hired labor can be replaced. However, if labor has some positive value at the margin, then this should be taken into account in assessing the costs and benefits of schisto control.

A survey of hired labor might be undertaken during 1983/84 main harvest period as follows:

i) Select 200 hired laborers.
ii) Test half for schisto and administer chemotherapy to all positives.
iii) Record detailed labor input and income information for all 200 workers for the period November to February.
iv) Test all workers at the end of the period.
v) Analyze results with a view to identifying effects of schisto and chemotherapy.

(Note: There are some practical and theoretical problems associated with assigning values to labor days lost especially by times of the year and in economies where there is a surplus of labor. The wage rates utilized for purposes of calculating the economic rates for return for development projects by the Government of Sudan for planning purposes and donor agencies such as the World Bank might provide an approximation.)

4. Composition of Multidisciplinary Team

There is a strong study team composed of economists and medical researchers from BNHP, University of Gezira and SBG. However, the senior researchers will be able to devote only part-time to the project which may complicate the prospects of getting the project launched in time for the upcoming farming season.

The team might be expanded to include the full-time services of a medical anthropologist who would be a key element in the proposed case studies as well as assisting with the supervision of the general data collection effort. The part-time services of an agronomist extensionist with experience in Gezira are required to make assessments in the field of the quality of work performed by family units in the sample. This information is of critical importance in making sense out of large productivity differences that are likely to be observed and is discussed in more detail in Exhibit 2.

5. Utility of the Research to Others

Given the possible difficulties in measuring with any precision the impact of disease upon farm family productivity and income (to say nothing of trying to measure the impact of a specific disease), time and patience will be required to refine the methodology in the light of experiences gained. At the same time, the survey information, notably the core set of farm management information, should be of utility to other institutions concerned with the development/rehabilitation of the Gezira, notably the SBG and the ARC. SBG is already a participant in the Study. The data and insights gained from the proposed study could provide ARC with valuable information on understanding productivity differentials among farmers. ARC might be interested in formally collaborating in the future to initiate farming systems research activities similar to those being implemented elsewhere in Sudan. In the longer run, the core set of data collection activities associated with measuring the impact of disease upon
productivity, might be more effectively managed by the agencies who stand to benefit most from the results, namely the ARC and the SGB. BNHP inputs might focus upon the health component of such studies/surveys.

C. Recommendations

1. The definitive study of the impact of schisto on productivity should be delayed one year to allow adequate time for preparation and refinement of the methodology and expanded collaboration with other agencies. This current year could be used to test many of the study elements.

2. The proposed sample for the impact study should be reviewed carefully with consideration given to including:
   i) equal numbers of affected and unaffected family units;
   ii) sharecroppers and residents of unregistered villages.

3. As soon as possible, the impact study team should review and improve the SGB data collection in with a view to possibly using SGB sample and data to study health impacts beginning with the 1983-84 season.

4. A limited number of case studies of affected and healthy families should be initiated in 1983 to facilitate further refinement of the impact study proposal.

5. A special study should be initiated to measure the impact of schisto on hired laborers during the 1983/84 farm season.

6. The impact study team should be expanded to include the full-time services of a medical anthropologist/sociologist and the part-time services of an agronomist.

7. Expanded collaboration with SGB and possibly ARC should be sought in the collection and analysis of farm management information.
Exhibit 2
COMMENTS ON THE RESEARCH PROPOSALS
"IMPACT OF SCHISTOSOMIASIS AND MALARIA ON AGRICULTURAL PRODUCTIVITY"

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It is not intended here to discuss in detail the BNHP/SGB/University of Gezira proposal entitled "Impact of Schistosomiasis and Malaria on Agricultural Productivity". The Emphasis here is on the prospect for the proposed activity reach its goals through the suggested approaches. Moreover, additional considerations are suggested in assessing the benefits of control of schistosomiasis, other than its possible final effects on crop productivity. These measures may be more sensitive and suitable for measurement than final crop yield in estimation of the effects of this disease.

The "Impact" project proposes to collect information regarding yields of various crops and relate this information to family health status. Thereafter, these data are to be used to compare productivity of these units and hence to determine the impact of the disease on agricultural productivity. Considering the following points this approach might yield little, if any, significant results.

a. Growth of plants is affected by many physical biological factors, and the final yield is the result of the interactions of all these factors. Some of the factors affecting the yield are controllable such as cultural practices (planting, variety, weeding, harvesting ...etc.). Other factors are uncontrollable such as climate, even in irrigation schemes such as Gezira. Therefore, crop yields often vary greatly from one block to another and even within the same field, from one site to another.

b. In the Gezira, most of the major cultural operations such as planting, weeding and harvesting are carried out by hired laborers or SGB supplied mechanized services. Therefore, illness of one member of the family would not influence the quantity or quality of much of the work per se, to the extent of having a significant effect on crop productivity.

c. Reported crop yields may be affected by the production relationships as many tenants have share croppers who carry out field operations.

d. Although there are standard cultural practices recommended by ARC for the various crops, many farmers fail to follow these practices in a timely fashion for reasons beyond their control. This will eventually lead to great reductions in productivity.

For such reasons yields vary greatly. Therefore, taking this parameter to measure impact of schistosomiasis on productivity may not be appropriate. Despite these many factors influencing agricultural productivity, following the optimum cultural practices is likely to produce high yields. The major field operations that are under the control of the farmers are stand establishment, weeding, watering and harvesting. Since these operations require high man hours of work, the impact of schistosomiasis on crop productivity may be best detected at peak times of these critical field operations. In other words, comparison might be made between healthy and unhealthy families on the quantity and quality of work done for these critical operation. If additional laborers
are to be hired, this should be indicated in the survey to determine the cost of the disease.

Moreover, cultural practices for any crop are not limited to fixed days, but can be carried out during a period of time, often extending for 2-3 weeks, without adverse effect on yields. Therefore, a farmer suffering from schistosomiasis may take a longer time to complete a field operation, but do so within the period allowed, and hence the impact of the disease on crop productivity not show up. Information regarding time spent for completion of a field operation will be included in the survey which should facilitate assessment of this factor.

Because of the great variation in yields of the various crops in the Gezira, it is highly advisable that the fields selected for the study be of similar history and yielding potential so as to minimize inherent variation in yields. In addition, fields of similar productivity are likely to demand similar levels of management.

From the above discussion, it is suggested that an agronomist work closely with the team of this project. The agronomist should be able to provide useful information to answer and explain significant differences in productivity among farms under study. The followings are some of the tasks of agronomist:

1. Selection of farms for study to be representative of the area. Fields should also be comparable in soil fertility, proximity to irrigation and in their productive potential (based on their past history).

2. Monitoring the various cultural practices at farm level, registering date and durations (including planting, weeding, irrigation, harvesting.)

3. Observing plant growth and stresses, (drought, weeds, pest.. etc.) Degree of severity may be measured by different methods but scoring the fields in range 1-5 in each instance should provide useful indicators to explain variation in yields.

4. At times of major field operations (stand establishment sowing, thinning, weeding, and harvesting) the agronomist should also collect data to permit rating of the quality of word and the duration of completion.

5. Determining final yield and quality.

The above suggestions should assist the research team in its efforts to measure the impact of disease on agricultural productivity by more systematically sorting out the factors contributing to yields. The complexity of this task should not be underestimated and adequate provision should be made for technical backstopping from ARC and SGB. In turn, these organizations can benefit from the results.