PN-AAY-923

ENVIRONMENTAL ASSESSMENT

OF

RWANDA FISH CULTURE PROJECT 696 0112

Prepared for

UNITED STATES OF AMERICA
AGENCY FOR INTERNATIONAL DEVELOPMENT

by

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Scope of the Environmental Assessment

Rwanda Fish Culture (696-0112)

Scoping Statement

The data for the proposed assessment will be collected from literature, by interviews with knowledgeable experts, field visits, and analysis of data collected during the field visits.

Great importance will be attached to the opinions of officials and experts working for the Government of Rwanda and medical institutions. Extensive visits will be made to the pond sites to collect data to be included in the assessment. Village chiefs, local people and officials will be consulted. Relevant data from ponds in operation will be used to help assess the environmental impacts of proposed project.

The EA will generally describe the present health conditions in operational ponds and will address and consider the following topics:

- any adverse environmental effects which cannot be avoided should the proposal be implemented.
- alternatives to the proposed action.
- the relationship between local short-term uses and the enhancement of long-term productivity.
- any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

Specifically, the EA will focus on the environmental impacts listed below, which were considered to be the most significant and recommend actions for mitigation of their adverse effects.

It will identify more environmentally acceptable alternatives. Discussion of these and other topics will also ensure that present environmental and cultural values will be given appropriate consideration in decision-making along with economic and technical considerations.

1. Collect and organize detailed data on water-borne disease vectors and habitats. Of special importance are schistosomiasis, malaria dengue/hemorrhagic fever and other communicable diseases.

2. Assess potential health hazards associated with occasional drainage of the ponds and the use of animal manure or plant materials as fish food.

3. Assess GOR institutional capabilities in public health and communicable disease control.

4. Assess potential preventative measures to prevent or mitigate disease problems associated with local fish ponds.

5. Make recommendations on how any deleterious environmental effects of the project can be eliminated or mitigated.

Five to six weeks will be required to complete the EA. A general schedule is proposed as follows:

WEEK 1 : Field trips to collect ecological data from existing ponds and site inspections

WEEK 2 : Gathering of environmental data and review of existing data

WEEK 3-4: Field trips to gather medical information from completed laboratory analyses

WEEK 5 : Rough draft based on local environmental and medical information

WEEK 6 : Complete EA

No significant environmental problems are anticipated that cannot be prevented or minimized to acceptable levels. Fish are currently being cultured in various ponds in the country. The specific issues listed above are considered to represent the primary environmental problems. They will be studied in detail and practical alternatives will be considered.

Approved: Gene Chiavaroli

Gene Chiavaroli, AID Affairs Officer

ENVIRONMENTAL ASSESSMENT OF RWANDA FISH CULTURE PROJECT 696-0112

SECTION I
Introduction and General Environmental Impacts

1.1 Introduction

The proposed action is a national fish culture program which has as its overall goal an increase in (a) the availability of nutritious food and (b) the income of farm families. It proposes to achieve this goal in a highly efficient way through the introduction and extension of small fishponds (approximately 20 m square and 1 m deep) which rural farm families can easily construct and manage in valleys throughout Rwanda. By the end of the project, (a) an estimated 1,200-1,600 fishponds will be producing approximately 36 metric tons of fish on 600 farms in Rwanda's ten prefectures, and (b) a national extension program will be established to support the development of on-farm fish production throughout Rwanda. The specific purpose of this project is to develop the capacity of Rwandan farmers to build and maintain productive on-farm fishponds. The project is more fully described in the Rwanda Fish Culture Project Implementation Document (PID).

The environment which this project will affect is bottomland with a year-round water supply, usually a small stream. This bottomland was traditionally preserved by pastoralists for grazing. Farmers often grow vegetables on this land by constructing long series of raised beds alternating with ditches, both to provide adequate drainage and to preserve moisture during the dry season. Much of it, however, consists of marsh or valley grasses.

The primary objective of this report is to evaluate the impact of the fish culture project on public health. The detailed impacts on human health are described in Section II which is entitled "Relationship of Fish Culture to Schistosomiasis and Malaria in Rwanda". The present section consists of an introduction and discussion of the general environmental impacts.

1.2 Impact on Plans for Land and Resource Use Policies and Controls

The proposed project should have no impact on plans for land and resource use policies and controls. This is because 2,000-3,000 small rural fishponds already exist in Rwanda but are not currently in production. Consequently, the project will involve construction of very few new ponds. Furthermore, land is owned by the government while individuals or families have the right to farm parcels of land. Farms have an average area of one hectare. Small fishponds easily fit within the farm. Additionally, land not farmed and which must be reclaimed from marsh or grassy bottomland, can be allocated to individuals or families by normal administrative processes.

1.3 Impact on Human Environment

The impact of the proposed project on the human environment is adequately discussed in the Initial Environmental Evaluation (IEE) of the PID with a few exceptions. We have based the following assessments on the discussions in the IEE, but have made additions in several areas. The single outstanding deficiency in the IEE concerns the Public Health aspect of the human environment, and we have discussed this aspect fully in Section II.

1.3.1 Land Use

As described in the introduction, the land this project will use is primarily bottomland with a year-round water supply. Pastoralists traditionally preserved it for grazing, and much of it still consists of sedge marshes or lowland grasses. Since 2-3000 small rural fishponds already exist throughout Rwanda, very few new ponds will be constructed under this project. In those few cases, small units (.100 ares) of the above-described land will be converted to ponds. Comparison of resulting fish production with traditional meat production from grazing of cattle, sheep, and goats is viewed as highly favorable for fish production (see study by U. W. Schmidt). Although the sedges from the marshes are used in basket-making, apparently a very small percentage of sedge marsh area is utilized for this activity, and the marsh area lost to fishponds will not affect basket-making. Conversion of marsh to properly managed fishponds may reduce mosquito habitat and hence the danger from malaria (see Section II).

No factors are involved in the project which will lead to any unusual increase in the population of people or animals in a particular area.

Pond sites are generally in bottomlands, often in narrow valleys between hills. In the construction of a few new fishponds, ground cover removed may consist of marsh or valley grasses or some cultivated land. Disturbance of the soil during construction might cause some loss of fertility, but, in turn, the accumulation of silt and residues from fish culture usually results in increased fertility. Feeding fish and fertilizing ponds will also increase soil fertility because many nutrients become bound up in the pond mud.

The training and technical services provided under the project will have no direct impacts on land use. Facilities for the ten fish production centers for the most part already exist. Any additional land required for renovation or construction will be designated by the GOR Ministry of Agriculture so as to avoid productive, inaccessible or unsuitable sites.

1.3.2 Water Quality

Impounding water and enriching it for fish production will probably result in reduced silt loads, but also in increased temperatures and nutrient levels. Downstream water flow patterns may also be altered slightly. Overall, the negative impact in terms of total runoff will be slight. Stream flows appear to be ample year-round; a reduced silt load will, if anything, improve the water quality. Unless excessive (an unlikely event), increased temperatures and plant nutrient load will generally enhance fish productivity in receiving waters. Furthermore, many areas where ponds will be built are currently farmed in such a way as to retain the water and impede runoff (see 1.1 Introduction) so that any temperature or stream flow impact will be indistinguishable from the results of farms, and any increase in plant nutrients should be beneficial.

There is some danger that dams will wash out during heavy runoff, but the capacity of any one pond is small enough so that the normal drainage system should handle it. Proper construction, using mainstream diversion, should make the danger very low. The potential sites for pond construction are dispersed enough in the countryside so that no significant impact on groundwater tables is foreseen as a result of seepage.

1.3.3 Atmospheric

During the construction activities there will be short-term environmental impacts from dust and noise. Such impacts are unavoidable. As most of the construction has already been completed and because any additional construction and renovation will be very small-scale and labor-intensive over a short time frame, these impacts will be marginal.

1.3.4 Natural Resources

Although the use of ponds will involve some diversion of water, the amount of water required is minimal because a "closed system" approach will be used. This means that, after initially filling a pond (which can be coordinated with water availability), water will be diverted to the pond only occasionally to replace water lost through evaporation and a small amount of seepage. This may not even be necessary during rainy periods.

Although presence of fishponds will not foreclose certain other agricultural uses, for example, it is a reversible process because pond areas can be returned to crop land.

Use of existing fishponds or construction of new ones may result in a change of wildlife habitat by clearing brush or slowing streamflow periodically, but generally the area of impact is so small that negligible losses or climatic alterations are involved. Since many ponds have been or will be constructed in cultivated land where wildlife habitat is changing, additional impact by ponds should be negligible. No rare species should be endangered as could happen with huge reservoir construction. Ponds do serve as new habitats for ducks and migratory water fowl and a variety of other small wildlife. The location of large game in Rwanda (elephants, lions, gorillas, buffalo) is restricted to the Kagera and Volcanos National Park.

Widespread development of fish farming will probably result in the moving of fish seed of different species around the country and the possible accidental seeding of natural waters. To the extent that the culture is with the native species, however, this should present little problem. In the case of fish culture in Rwanda, it is proposed to farm with indigenous "cichlids" or with species, such as Serotherodon nilotica, already widely introduced in Rwandan waters.

1.3.5 Cultural and Socio-economic

A complete socio-economic and cultural analysis of the impact of the fish culture project in Rwanda has been completed by U. W. Schmidt of the Aquaculture Development and Coordination Programme, Fisheries Department, FAO, Rome. This report entitled "The Economic and Social Feasibility of Small-Scale Rural Fish Culture Development in Rwanda" was published by FAO in Rome. A copy is available from AID in Kigali, Rwanda.

1.3.6 Health

Water-related diseases include schistosomiasis (bilharzia), malaria, Dengue/hemorrhagic fever, onchocerciasis, cholera, and typhoid. Control of cholera and typhoid is principally a question of sanitation and not particularly dependent on the presence or absence of ponds. Onchocerciasis is transmitted by simulid vectors whose larvae require rapidly flowing water. The disease is, therefore, not associated with fishponds. Dengue/hemorrhagic fever, fortunately, does not occur in Rwanda (personal communication from Dr. Molubu, Director of the Expanded Program for Vaccination, Ministry of Public Health, Rwanda). Furthermore, it is transmitted by culicid vectors which can be controlled in the same fashion as those of malaria.

Diseases which construction of fishponds may impact unfavorably are schistosomiasis and malaria. Section II, "Relationship of Fish Culture to Schistosomiasis and Malaria in Rwanda", discusses in detail the potential impacts and possible mitigation and alternative actions, and presents appropriate recommendations to decision-makers.

1.4. Alternatives to Proposed Action

Alternatives to the proposed action may be of two types. Alternative action in regard to fish culture, including the alternative of "no action", are adequately discussed in Section II. Alternative action to achieve the overall project goal, an increase in (a) the availability of nutritious food and (b) the incomes of farm families, could include such alternatives as poultry or rabbit production, introduction of improved crop varieties, or improvement of marketing procedures. However, consideration of such alternatives was taken up in earlier stages of project development and is not discussed here.

1.5. Unavoidable Adverse Environmental Impacts

The only significant adverse environmental impacts the proposed project presents are health-related and these impacts can be avoided. They are adequately discussed in Section II.

1.6. Trade-offs Between Short-term Environmental Gains and Long-term Losses

The proposed project presents no significant long-term environmental losses except those associated with the potential impact on health and such impacts can be prevented, as discussed in Section II.

1.7. Irreversible or Irretrievable Commitment of Natural or Cultural Resources

The proposed action involves no irreversible or irretrievable commitment of natural or cultural resources. The fishponds can at any time be drained and filled and the land returned to agricultural or other uses. The training and technical services provided under the project will have no direct impacts on land use (see Section 1.3.1) or cultural resources (see sections 1.3.1 and 1.3.5).

1.8. Amelioration of Adverse Environmental Effect by Other USAID or LCD Activity

Health care activities of the GOR will offset any adverse effect on human health due to the Rwanda Fish Culture project, as discussed in Section II. Other USAID or LCD activities are likely to influence or be influenced by the fish culture project, but there are no significant adverse environmental effects other than those related to public health.

1.9. Recommendations

Recommendations to decision-makers resulting from this environmental assessment are presented in Section II.

SECTION II

Relationship of Fish Culture to Schistosomiasis and Malaria in Rwanda

1. Introduction

The purpose of this report is to assess the impact of a national fish culture program on the public health environment in Rwanda. The overall goal of the fish culture project is an increase in (a) the availability of nutritious food and (b) the income of farm families. Its specific purpose is to develop the capacity of Rwandan farmers to build and maintain productive on-farm fishponds. The project is more fully described in the accompanying environmental assessment and in the PID.

Water-related diseases include schistosomiasis (bilharzia), malaria, Dengue/hemorrhagic fever, onchocerciasis, cholera and typhoid. In addition, a variety of parasites have eggs or cysts which readily survive aquatic conditions. Control of such parasites and also of cholera and typhoid is principally a question of sanitation and not particularly dependent on the presence or absence of ponds. Onchocerciasis is transmitted by simulid vectors whose larvae require rapidly flowing water. The disease is, therefore, not associated with fishponds. Dengue/hemorrhagic fever is transmitted by culicid vectors which can be controlled in the same fashion as those of malaria. Fortunately, Dengue/hemorrhagic fever does not occur in Rwanda (personal communication from Dr. Moluba, Director of the Expanded Program for Vaccination, Ministry of Public Health, Rwanda; 1979 Annual Report of the Ministry of Public Health, Republic of Rwanda). The remaining two diseases, schistosomiasis and malaria, may receive impact from implementation of the fish culture project.

This report includes, in Part 2, a brief description of the life cycles of schistosome and malaria organisms as they relate to humans. It presents an evaluation, in Part 3, of the influence of fish culture on incidence in human populations of these two diseases, and, in Part 4, an evaluation of Rwandan institutional capabilities to treat or prevent the same diseases. In Part 5, it discusses measures to prevent or ameliorate any fish culture influence on disease incidences presented in Part 3. Finally, in Part 5, it presents recommendations appropriate for decision makers regarding the influence of a national fish culture program on public health and includes consideration of the alternatives of (1) no changes in the fish culture project, (2) modifications in the project to prevent or reduce impacts, and (3) cancellation of the project.

2. Life Cycles

2.1. Schistosomiasis

Schistosomiasis is caused by a trematode parasite, a blood fluke, with a complex life cycle requiring both a definitive and an intermediate host. It matures in the definitive host, which may be man or a wide variety of other mammals, and eggs are passed in the feces or the urine. The eggs hatch in water as a free swimming cilliate larva called a miracidium. These miracidia must find an aquatic snail of appropriate species within about 32 hours, or they will die. Each penetrates its snail intermediate host and reproduces asexually to produce 100,000 to 200,000 cercariae, beginning in about 1 month and continuing for a period of several months. These cercariae escape their snail host as free swimming flagellate larvae. Cercariae approach suitable mammalian hosts in the water, attach by means of suckers and enter by dissolving a hole in host tissue with enzymes. They survive no more than 48 hours if they find no host. Each cercaria migrates through the blood system of its new host to the walls of the colon, of the urinary bladder or of the small intestine, depending on the schistosome species, where it matures and where it must pair with another of opposite sex to produce viable eggs.

Because of the variety of mammalian species besides man which can also serve as definitive hosts, it is not usually possible to reduce the danger of this disease in an area by treating infected humans or by improved sanitation. It is also not usually possible to eliminate other mammalian hosts since these usually include domestic livestock. It is furthermore very difficult to restrict such wild animals as small rodents from bodies of water even with such controlled access as man-made fishponds. The most effective means of controlling a reservoir of schistosomiasis has been to eliminate the snail intermediate hosts.

2.2. Malaria

Malaria is caused by a sporozoan parasite of the genus Plasmodium, including 7 different species and a variety of strains. In this case, man is the intermediate host, in which only asexual reproduction occurs, and female mosquitoes, of the genus Anopheles, are the definitive hosts where sexual reproduction takes place. When a female mosquito bites an infected human, micro- and macro-gametocytes invade the mosquito, combine to form a zygote, then reproduce, forming sporozoites, which migrate to various tissues of the mosquito, including the salivary glands. The mosquito is infective 10 to 20 days after it has ingested human blood. When an infective mosquito bites a human, sporozoites from its salivary glands enter the human blood stream, invade liver and other similar cells and reproduce asexually, after which the cells rupture, releasing 10-20 tiny merozoites. These merozoites invade either additional liver-like cells or red blood cells. There then follow series of asexual reproductions, cells bursting, and reinvasions, often periodically and corresponding to periodic appearances of malarial symptoms. The human is infective to mosquitoes in 10-30 days. Malaria can be controlled in an area by drug treatment of a large percentage of the human population or by a large-scale campaign to eliminate the mosquito vector, often by eliminating or altering its aquatic habitat. An integrated combination of both approaches is often most effective.

2.3. Epidemiology

With any parasite which requires two alternate hosts, it is possible to eliminate the disease by reducing or dispersing the populations of one host. It is not necessary to totally eliminate a vector host. If the vector organism has either a very low population or is very dispersed, then the probability that a human (or other mammal in the case of schistosomiasis) will be exposed to an infected vector is very low. The probability is also very low that a vector organism will be exposed to an infected human. But to maintain the parasitic cycle, a human who has been exposed to an infected vector must be the same human to whom another vector organism is later exposed. If both probabilities are very low, their joint probability becomes negligible. The parasitic cycle becomes broken and the disease incidence actually decreases as infected humans are treated or as infected vectors die. Thus, a potential health danger in the case of such parasites does not lie with the presence of vector organisms, but with concentrations of such organisms. Any attempt to control snail or mosquito populations need not be 100% effective in order to prevent schistosomiasis or malaria.

3. <u>Influence of Fish Culture on Human Disease Incidence</u>

3.1. Incidence in Human Populations

Table 1 indicates the number of cases of schistosomiasis and of malaria, and their incidences per 1,000 population, per prefecture throughout Rwanda in 1979 (from 1979 Annual Report, Ministry of Public Health, Republic of Rwanda). The data in parentheses for schistosomiasis in Ruhengeri and Byumba prefectures, however, represent a new outbreak in 1980 (Mr. Jules Hanotiez, Head of Anti-bilharzia Mission of Rwanda, personal communication).

Table 1

Number of cases and incidence per 1,000 population per prefecture in Rwanda in 1979 (1980).

Prefecture	Schistosomiasis Cases	Schistosomiasis Incidence	Malaria Cases	Malaria Incidence
Kigali	0	0	14,805	20.6
Gitarama	0	0	19,997	32.3
Butare	0	0	31,092	50.3
Gikongoro	3	0.01	6,536	17.2
Cyangugu	165	0.48	15,040	44.2
Kibuye	0	0	11,167	32.2
Gisenyi	0	0	4,082	8.5
Ruhengeri	(300+)	(0.55+)	2,375	4.3
Byumba	(±100)	(±0.18)	7,198	13.2
Kibungo	0	0	24,755	66.7

3.1.1. Schistosomiasis

Although the incidence of schistosomiasis appears very low or zero throughout the nation, the number of cases in Ruhengeri prefecture increased from zero to over 300 during 1980 alone. Mr. Jules Hanotiez, a public health officer in Rwanda for 20 years, suggests (personal communication) that this sudden increase in schistosomiasis incidence in Ruhengeri is primarily due to two factors. The first factor is that farmers have begun draining and cultivating the papyrus swamps surrounding the two large lakes in Ruhengeri prefecture only recently, during the last two or three years. This activity may increase the farmers' exposure to the disease since a potential intermediate host, snails of the genus Biomphalaria, abound in the papyrus swamps.

The second factor is that public health clinicians in Ruhengeri prefecture apparently did not recognize schistosome eggs in routine fecal examinations before 1980. Rwandan and French medical doctors began to recognize symptoms of schistosomiasis in patients during early 1980, and subsequent careful fecal examinations, including supervision by Mr. Hanotiez, revealed the number of cases reported in Table 1. These facts suggest that the outbreak was not as sudden as the data in Table 1 indicate. The fact that symptoms were not recognized until early 1980, however, suggests that the outbreak is recent, probably corresponding with draining and cultivating of papyrus swamps. Hanotiez suggests that failure of clinicians to recognize schistosome eggs is not due to lack of training, but because such eggs so rarely occur in fecal examinations in Rwanda that they simply are not recognized. He also feels that clinician ability throughout the country to recognize schistosome eggs will be fully adequate within two years and probably within one year.

We may draw the following conclusions from the above discussion.

(1) The statistical evidence of schistosomiasis is slightly low except in the three foci reported in Table 1.

(2) The incidence of schistosomiasis throughout the country is likely to increase very slightly as clinician ability to detect schistosome eggs becomes fully adequate.

(3) The incidence of schistosomiasis is likely to increase markedly in additional foci around the country as farmers make more use of swampy areas, especially papyrus swamps, increasing their exposure.

3.1.2. Malaria

The incidence of malaria appears moderate but constant throughout the nation (see Table 1). It is highest in the prefectures containing lower elevations; Kibuye, Butare and Cyangugu, and lowest in prefectures with the highest elevations; Ruhengeri, Gisenyi and Byumba. Clinical diagnosis of malaria is an important part of clinician training in Rwanda (Dr. Moluba and

Dr. A. Mugobushaka, Director of Health Services, personal communications), and clinicians have frequent experience with it throughout the country. It is possible, however, that some rural people fail to recognize malarial symptoms and fail to report them. It is very probable that the malarial data reported in Table 1 closely parallel the true incidences in the Rwandan population, though they may slightly underestimate them. The incidence of malaria has increased steadily since 1974 (1979 Annual Report, Ministry of Public Health, Republic of Rwanda). This increase is apparently due, at least in part, to improved diagnosis and reporting of malaria during this period and also in part to increased awareness of the disease among rural people. It is probable that the incidences reported in Table 1 for malaria will continue to increase slightly in the near future.

3.2. Examination of Existing Fishponds

We examined existing fishponds in 8 of Rwanda's 10 prefectures. We captured snails and examined them for schistosome infections, and we searched for the presence of mosquito larvae. We recorded snail species and density, fish species and density when known, vegetation conditions and the results of snail examinations and mosquito searches. The results are summarized in Table 2.

Table 2

Results of examination of 8 sets of prefectural fishponds for snails (schistosoma) and mosquito larvae in Rwanda, 1980

Ponds Sampled Location	S	T	Vegetation Marginal	Conditions Aquatic	Fish Species	D	Snails Species	D	S	P/S	Schist.type	P/P	Mosquito larv
Kigali	1		excessive	2		low	Biomphalaria	low	10	0/10	-	0/10	none obeserv.
							Bulinus 1	mod	6	0/6	-	1/6	
							Bulinus 2	high	9	0/9	-	2/9	
Gitarama	4	16	excessive	moderate 3 (algae water lilies)	T.macrochir T.zillii	mod	Biomphalaria	mod	10	2/10	reptilian	8/10	none observed
							Lymnaea	low	8	0/8	-	8/8	
							Bulinus 1	mod	10	6/10	reptilian	10/10	
Gikongoro	4		excessive	2		mod	Biomphalaria	high	11	0/11	-	0/11	none observed
							Lymnaea	high	9	0/9	-	3/9	
Kigenbe (Butare)	4		excessive	1 none	T.nilotica T.zillii	high	Biomphalaria	mod	15	4/15	avian	14/15	none observed
							Lymnaea	mod	12	0/12	-	9/12	
Ruhengeri	3		very little	0 little algae	Tilapia	low	Lymnaea	v.low	3	0/3	-	1/3	none observed
Gisenyi	3	3	excessive	2 mod.algae	Tilapia mix	mod	Biomphalaria	low	17	0/17	-	0/17	none observed
							Lymnaea	mod	20	0/20	-	20/20	
							Bulinus 1	low	10	1/12	avian	8/10	
Gatsibo (Byumba)	4	8	excessive	moderate (emergent. carex) 3	none	-	Biophalaria	low	10	0/10	-	5/10	very abundant
							Lymnaea	high	5	0/5	-	1/5	
							Bulinus 1	low	5	0/5	-	0/5	
Rusumo (Kibungo)	5	15	excessive	excessive algae, some emergent	mixed Tilapia of Lac Nasho	low	Lymnaea	low	10	0/10	-	10/10	none observed
							Bulinus	low	10	0/10	-	10/10	

S = number sampled
T = total number
D = density

P/S = proportion of snails with schistosomes
P/P = proportion of snails with parasites

We point out the following observations from Table 2:

(1) Although we frequently found snails of the genrea Biomphalaria and Bulinus, both potential intermediate hosts for schistosome, and although we found some cases of reptilian and avian schistosomes, we found no schistosomes capable of infecting man.

(2) In the single set of ponds in which vegetation was kept carefully trimmed around pond peripheries and was carefully removed from the water itself, in the presence of fish, we found virtually no snails (only 1 found in 3 ponds of about 10 ares each).

(3) Snail density does not appear to be related in any way to fish density.

(4) In all ponds with fish, we observed no mosquito larvae, while in the single set of ponds without fish, mosquito larvae were very abundant.

An additional observation not reported in Table 2 is that in new ponds the proportion of snails with schistosomes and with parasites of any kind is very low or zero compared with ponds which have held water for one year. or more.

We conclude, with respect to the specific ponds examined, that (1) eliminating marginal and aquatic vegetation is effective in controlling snails, and that (2) presence of fish, irrespective of species or density, is effective in controlling mosquito larvae.

3.3. Expected Impact Effect of Fish Culture on Snail and Mosquito Populations

In the absence of fish and without removal of marginal and aquatic vegetation, fishponds should provide ideal habitat for high population levels of both snails and mosquito larvae, and, therefore, excellent foci for both schistosomiasis and malaria in areas where these diseases already occur.

Addition of fish of almost any species can be expected to reduce mosquito larval populations greatly. We can expect addition of fish, combined with the removal of marginal and aquatic vegetation, to lower snail populations greatly and reduce mosquito larval populations to near zero. However, we must emphasize that during examination of sets of fishponds in 8 of Rwanda's 10 prefectures, in only one set of ponds was the vegetation along the pond margins carefully trimmed away.

Addition of compost and animal manures to increase the food supply for the fish should increase the biological productivity of a pond and, therefore, increase the growth rates of both snails and mosquitoes. With such increased growth rates, control of these disease vectors by adding fish and removing vegetation must be less effective. Although some such control of snails and mosquito larvae must remain, this degree of control may be offset by increased exposure of the farmers who manage the ponds to the two diseases. Furthermore, since domestic mammals can serve as determinant schistosome hosts, addition of animal manures to fishponds can result in the addition of schistosome eggs and miracidia, an increased infection rate of snail intermediate hosts, and an increased danger of schistosome infection to humans.

We draw the following conclusions regarding the impact of fish culture on human incidence of schistosomiasis and malaria in Rwanda.

(1) Although fishponds appear largely or entirely free of mammalian schistosomes at present, the recent outbreak in Ruhengeri prefecture suggests that similar outbreaks may occur in other parts of the country and fishponds can become infested with schistosomes in the future through exposure to infected humans.

(2) Since malaria is widespread and moderately common among humans in Rwanda, fishponds have the potential at any time of parti-

cipating in the malarial parasite cycle.

(3) The presence of fish in ponds and the removal of marginal and aquatic vegetation should provide sufficient protection against both schistosomiasis and malaria and may even decrease the danger from these diseases from existing ponds neglected many years.

(4) Farmers may or may not keep marginal vegetation adequately trimmed.

(5) Addition of compost and manures to fishponds to provide increased fish production may also produce a danger of infection to humans, especially of schistosomiasis, because of increased populations of snails and mosquito larvae.

4. Rwandan Institutional Capabilities to Treat or Prevent Diseases

4.1. Treatment

In terms of statistical reporting, the Rwandan Ministry of Public Health is organized in a hierarchial fashion (Dr. Moluba, personal communication). Local dispensaries and health centers each send reports of every public health action to the hospital in its particular region and to the Ministry headquarters office in Kigali. Each hospital also sends reports of all public health actions to Kigali. There are one to several hospitals in each prefecture and several health centers and several to many dispensaries in the region of each hospital. Health centers are essentially miniature hospitals with clinical diagnosis capability and maternity wards. There is usually a doctor or paramedic in residence, or one may visit regularly from a nearby hospital. A dispensary contains drugs for outpatient treatment and first aid and has capability of referral to a health center or hospital. In

Table 3, we summarize, per prefecture, the number of hospitals and beds, the number of health centers and beds, and the number of dispensaries and beds. In addition, we indicate the mean human population served per bed of all types combined (from 1979 Annual Report, Ministry of Public Health, Republic of Rwanda). The national average population served per bed of all types is 615 persons.

In Table 4, we indicate, per prefecture, the number of medical doctors, the number of paramedics, the number of nurses of all types, and the number of other medical personnel. Finally, we indicate the mean population served by each medically trained person, including doctors, paramedics and nurses, but excluding "other personnel" (from 1979 Annual Report). The national average population served, per medically trained person, is 5,401 persons per person.

Personnel of dispensaries and health centers are given training in recognizing symptoms of schistosomiasis and malaria, and personnel of health centers are given training in the clinical diagnosis of these two diseases. (Dr. Mugubushaka, personal communication). Please refer to section 3.1.1. and 3.1.2. for discussions of present and future clinician ability to detect these two diseases.

Every health center and every dispensary in the nation, as well as every hospital, has a supply of the medicines used in the drug treatment of both schistosomiasis and malaria (Dr. Mugubushaka, personal communication). These medicines are apparently kept up-to-date and the supply replenished when necessary.

We conclude that Rwandan institutional capability to treat schistosomiasis is, at least potentially, fully adequate for the incidences of the disease we discuss in section 3.1.1. Capability to treat malaria also

Table 3

Prefecture	Population	Hospitals (beds) public	private	Centres de Sante (beds) public	private	Dispensaries (beds) public	private	Average population served per bed (all types)
Kigali	717,500	1 (445)	1 (105)	8 (202)	7 (91)	21 (329)	13 (149)	543
Gitarama	619,500	0	2 (465)	10 (212)	3 (15)	17 (391)	9 (69)	538
Butare	617,900	2 (586)	0	5 (92)	10 (267)	17 (149)	15 (382)	419
Gikongoro	380,200	0	1 (156)	2 (16)	6 (209)	5 (49)	7 (237)	570
Cyangugu	340,600	1 (139)	2 (414)	1 (11)	4 (14)	11 (33)	6 (14)	545
Kibuye	347,100	1 (131)	2 (236)	0	6 (165)	3 (40)	11 (106)	512
Gisenyi	481,900	2 (250)	1 (101)	5 (118)	4 (183)	11 (143)	8 (232)	469
Ruhengeri	543,400	1 (322)	1 (96)	0	6 (26)	11 (126)	8 (125)	782
Byumba	544,700	1 (89)	1 (48)	2 (47)	1 (34)	18 (178)	6 (43)	1,241
Kibungo	371,000	2 (306)	2 (161)	2 (28)	2 (34)	12 (134)	4 (40)	528

Table 4

Prefecture	Population	Doctors	Paramedics	Nurses (all types)	Other Personnel	Average population served per med.personnel
Kigali	717,500	42	52	241	161	2,142
Gitarama	619,500	8	19	69	69	6,453
Butare	617,900	37	44	142	117	2,771
Gikongoro	380,200	3	7	26	29	10,561
Cyangugu	340,600	9	13	42	46	5,322
Kibuye	347,100	9	10	67	58	4,036
Gisenyi	481,900	9	31	50	31	5,354
Ruhengeri	543,400	11	27	53	45	5,971
Byumba	544,700	10	25	43	23	6,983
Kibungo	371,000	11	26	47	47	4,417

appears adequate, yet incidence of malaria in Rwanda does not decrease. Apparently, awareness of the disease and the habit of reporting its symptoms to medical personnel lag several years behind the clinical capability to detect and treat it. Implementation of a fish culture program should not adversely affect Rwandan capabilities to detect and treat these two diseases.

4.2. Prevention

Prevention of schistosomiasis is best achieved by elimination of its snail intermediate host, while prevention of malaria is best accomplished by a combination of control of the mosquito vector and drug treatment of a large proportion of the exposed human population. At present, in Rwanda, there are no programs for either snail or mosquito control. Furthermore, administration of anti-malarial drugs is at the level of treatment of those cases detected and not at the epidemiological level needed to interrupt the vector/human transmission cycle.

It is very probable that programs for large-scale prevention of these diseases, especially malaria, will be initiated by the Rwandan Ministry of Public Health in the future. It is imperative that a national fish culture project be implemented in such a fashion that it will not interfere with any such prevention programs. Such precaution is best achieved by assuring that snail and mosquito populations are adequately controlled in the fishponds.

5. Mitigation Measures of Fish Culture Impact on Disease

Potential adverse health impacts of the fish culture project are participation of fishponds in human/vector parasite cycles of schistosomiasis and malaria. Large and concentrated populations of snail vectors of schistosomiasis and of mosquito vectors of malaria can result from allowing vegetation to grow untrimmed around and within ponds and addition of compost and manures. The problems to be solved become twofold: (1) removal of vegetation, and (2) removal of snails. If vegetation is removed, mosquito larvae will be removed adequately by the fish.

5.1. Removal of Vegetation

Removal of unwanted vegetation can be chemical, mechanical or biological. The objective is that no vasculor plants grow in or extend into the water. A variety of herbicides are available commercially for control of vegetation. Chemical control has two disadvantages in fish culture ponds, however. One is that toxic chemicals may transfer to either the fish in culture or the farmers or other humans who eat the fish, and may cause physiological harm. The second is that use of such chemicals may also destroy phytoplankton or other plants which the fish must use for food. We do not recommend the use of chemical control of vegetation in fish culture ponds.

Mechanical control of vegetation, in terms of small rural fishponds, means cutting it with a machete or other hand tool, or pulling it by hand. According to our observations of 8 sets of prefectural fishponds in Rwanda (refer to section 3.2.), this form of mechanical control can be fully adequate. The same observations also suggest that such control is rarely carried out in practice.

Biological control of the vegetation may involve herbivorous animals which eat the vegetation, diseases or parasites which weaken or destroy specific vegetational species, or other plant species which eliminate undesireable vegetation through some means of competition. The competition alternative would not eliminate all vascular plants, since the winning species would remain. The method is, therefore, not adequate for fish culture ponds.

The disease or parasite alternative would be very complex, may require a different control organism for each species of plant, and would almost certainly require extensive preliminary research. An example of the herbivorous animal alternative which has proven effective in fish culture is the inclusion in the pond of macrophytophagous fish which eat the vegetation and are cultured in the pond for human consumption as well. Table 5 is a list of macrophytophagous fish species which have been cultivated in ponds for human consumption.

Table 5

Some Macrophytophagous Fish Species Used in Fish Culture

Species	Endemic System	In Rwanda	Authority
Tilapia marial	Niger delta	no	Ruwet, et.al. 1976
Tilapia rendalli	Katanga-Zambia	no	"
Tilapia zillii	W.,N.,Cen.Africa	yes	"
Tilapia tholloni	Zaire	no	"
Tilapia guineensis	Ivory Coast	no	"
Ctenopharyngodon idellus	China	no	Bardach,et.al. 1972
Puntius javanicus	Indonesia	no	Coche, 1967

The productivity of most of the species listed in Table 5 is lower than that of some other fish species, notably those that feed on phytoplankton or tiny planktonic plants, the microphytophagous fish. However, many of them have been grown together with another or other species of fish in a polyculture. The result of such polyculture has been both control of vegetation and increased total fish production. In situations where fish farmers do not in practice adequately control the vegetation mechanically, or where they do not wish to do so, then use of macrophytophagous fish species is an obvious advantage and is an adequate method to control the vegetation. A disadvantage of their use is that polyculture fish culture requires availability of fingerlings of all species included and hence more elaborate support facilities than for monoculture. If this disadvantage is unacceptable, then mechanical control of vegetation can be officially monitored in some fashion to assure its adequacy.

5.2. Removal of Snails

Removal of snails can also be chemical, mechanical or biological. The objective is to reduce snail numbers to such a low concentration that the parasite cycle is broken. At least a dozen different chemical products can be obtained commercially to control snails. Such chemical control has the disadvantage, with fish culture, that toxic chemicals may be transferred to either the fish in the culture or the farmers or other humans who eat the fish, and may cause physiological harm.

Mechanical removal of snails, in small rural fishponds, would entail collecting the snails by hand and disposing of them. The labor required for such collecting would be very time consuming, and the farmers simply might not spend time at such an activity. Furthermore, the snails involved would be very small, often less than one centimeter diameter, and a large percentage may escape detection. It is doubtful that snail numbers could be reduced by this method to concentration low enough to break the parasite cycle.

Biological control of snails may involve animals which eat the snails, diseases or parasites which reduce snail populations, other snail species or other animals which eliminate the snails through some means of competition, or species of plant which produce a substance toxic or repellant to the snails. The toxic or repellant plant alternative has been suggested in northeastern Africa. The competition alternative has proven effective in Puerto Rico, and the disease or parasite alternative could be very specific to particular snail species without a broad ecological impact. All three alternatives appear promising and potentially effective, but they would all be very complicated for application in widely dispersed rural fishponds and would all require preliminary research. An example of the alternative of animals which eat the snails, that has been discussed by many authors and which has been applied successfully in some cases and not in others, is the inclusion in fishponds of fish species which eat the snails and that can also be consumed by humans. Characteristics which such fish must have include the following:

1. Snails must make up a significant proportion of its diet;
2. It must not exclusively eat snails, for it would starve once the snails in a delimited pond were decimated;
3. It must be cultivable in fishponds;
4. It must be acceptable for human consumption;
5. It must complement, or at least not compete with, other fish species if used in a polyculture;
6. It should be indigenous to or already occur in the watersheds of the region where it is to be cultured.

Table 6 is a list of fish species which may possess these characteristics. A few of these species have been successfully cultured in ponds, including H. mellandi and the three species of Clarias. The other species have not been tested. As with the macrophytophagous fish, these snail-eating fish contribute best in polyculture with at least one other more rapidly growing species. A disadvantage of their use is that polyculture fish culture requires availability of fingerlings of all species cultured, and hence more elaborate support facilities than for mococulture. However, their use should eliminate any increase in snail populations due to addition of compost and manures to increase fish food supply. The increased fish production resulting from addition of compost and manures to ponds is so great that it probably justifies the use of snail-eating fish in polyculture.

Table 6

Some snail-eating Fish Species

Species	Endemic System	in Rwanda	Authority	
Haplochromis mellandi	Bangwelo-Luapulo	maybe	Coche, 1961	
H. sauvagei	Lake Victoria	no	Greenwood, 1957	
H. prodromus	"	no	"	
H. xenognathus	"	no	"	
Astatoreochromis alluaudi	"	no	"	1959
Macropleurodus bicolor	"	no	"	1956
Hoplotilapia retrodens	"	no	"	
Clarias senegalensis	Senegal-Gambia	maybe	Micha & Frank,1976	
C. massambicus	L.Victoria & Kivu	yes	Hulot, 1950	
C. lazera	West Africa	no	Grover,et.al.1979	

6. Recommendations

We recommend that the national fish culture project of Rwanda include provision for eliminating marginal and aquatic vegetation that would otherwise extend into the water. We recommend this control be achieved either by mechanical removal of vegetation by the farmers themselves or by inclusion of a macrophytophagous fish species in polyculture with two other species, one exhibiting high productivity and one which eats snails.

We also recommend that a snail-eating fish species be included with at least one other species. This species should possess the characteristics described in Section 5.2. and may be one of the species listed in Table 6.

We further recommend on-going monitoring of farm ponds throughout the nation to assure that snail and mosquito larvae populations remain low and that schistosomiasis is not detectable in snails. This monitoring activity should be carried out by person or persons with ability to assess snail and mosquito populations and to recognize and identify schistosome cercarviae from snails. This monitoring activity should be fully effective if it occurs twice a year.

Finally, if mechanical control of vegetation is chosen over biological control, we recommend on-going monitoring of the effectiveness of vegetation control in farm ponds throughout the nation. This monitoring activity could be carried out by such government operatives as extension agents. Such activity should occur at least approximately twice yearly.

These recommendations would require certain modifications in the project as described in the PID. These modifications are described in the following list.

(1) The use of polyculture instead of monoculture of fish. Plans have called for the culture only of Sarotherodon nilotica. We recommend inclusion of a snail-eating species and possibly a macrophytophagous species as well. This modification is not great because the Kigembe fish culture center and other fish culture centers are capable of rearing several species of fingerlings.

(2) The monitoring of snail and mosquito populations and schistosomiasis. This modification will require employment of an additional specialist not more than two months per year and will include the cost of travel,round trip to Rwanda, if the specialist comes from outside the country, and in-country travel and per diem.

(3) The monitoring of vegetation control, if macrophytophagous fish species are not included in a polyculture. This modification will require employment, possibly by the GOR, of appropriate technicians, and in-country travel and per diem.

We feel that the potential adverse impacts of the fish culture project on public health can be eliminated, and we do not recommend cancellation of the project.

Suggested References

Ruwet, J. Cl., J. Voss, L. Hanon and J. Cl. Micha (1976): Biologie et Elevage des Tilapia. Symposium on Aquaculture in Africa, CIFA Technical Paper No. 4, Supplement 1. FAO, Rome.

Micha, J. Cl. & V. Frank (1976): Biologie des Principales Espèces Utilisées en Pisciculture Africaine. Symposium on aquaculture in Africa, CIFA Technical Paper No. 4, Supplement 1. FAO, Rome.

Bard, J., P. de Kimpe and P. Lessent (1976): Nouveaux Poissons et Nouvelles Méthodes d'Elevage en Afrique. Symposium in Aquaculture in Africa, CIFA Technical Paper No. 4, Supplement 1. FAO, Rome.

Coche, A. (1976): La Pisciculture en Rizière: Possibilités au Congo, dans le Haut-Katanga Méridional. Bulletin Agricole du Congo, 51 (5): I-

De Bout, A.F. (1956): Lutte Contre les Mollusques dans les Eaux Africaines. Bulletin Agricole du Congo Belge, 47 (2): I-

Coche, A.G. (1967): Fish Culture in Rice Fields: A World Wide Synthesis Hydrobiologia, 30 (1):1-44

Brown, E.E. (1977): World Fish Farming Cultivation & Economics, AVI Publishing Co., Westport CT USA 397 p.

Edwards, P. (1977): Design of an Experimental Stabilization and Fish Pond Aquaculture System. Technical Report. Joint SCSP/SEAFDEC Workshop on Aquaculture Engineering, Tigbanan Lloilo, Philippines. Nov. 27— Dec. 3, 1977. FAO-FI-SCS:GEN/77/15, pp. 307-323, FAO access. No. 40368.

Menon, A.G. (1977): Fish and Malaria Control/Sci. Cult. 43 (3): 110-114.

Yancey, D.R. (1976): Manual of Warmwater Fish Culture, Mennonite Central Committee, Akron, PA, USA.

Dunseth and Bayne (1978): Recruitment Control and Production of Tilapia Area with the Predator Cichlasoma Managuese. Aquaculture 14(4):383-390.

Whitfield, A.K. & S.J. Blaker (1978): Resource Segregation Among Eliophagous Fish in Lake St. Lusia, Aululand. Environ. Biol. Fishes 3 (3): 293-296.

Serfling, S. & Mendola, D. (1978): Aquaculture Using Controlled Environment Ecosystems. Commer. Fish Farmer Aquaculture. News 4 (6):15-18.

Bard, J.P., de Kimpe, J. Lazard & Lessent, P. (1976): Handbook of Tropical Fish Culture. Centre Technique Forestier Tropical, Nogent sur Marne, France, 165 p.