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Triage

Howard B. Peterson
Utah State University

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53rd Faculty Honor Lecture
Utah State University
Logan, Utah
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FIFTY-THIRD HONOR LECTURE
DELIVERED AT THE UNIVERSITY

A basic objective of the Faculty Association of Utah State University, in the words of its constitution, is:

> to encourage intellectual growth and development of its members by sponsoring and arranging for the publication of two annual faculty research lectures in the fields of (1) the biological and exact sciences, including engineering, called the Annual Faculty Honor Lecture in the Natural Sciences; and (2) the humanities and social sciences, including education and business administration, called the Annual Faculty Honor Lecture in the Humanities.

The administration of the University is sympathetic with these aims and shares, through the Scholarly Publications Committee, the costs of publishing and distributing these lectures.

Lecturers are chosen by a standing committee of the Faculty Association. Among the factors considered by the committee in choosing lecturers are, in the words of the constitution:

> (1) creative activity in the field of the proposed lecture; (2) publication of research through recognized channels in the field of the proposed lecture; (3) outstanding teaching over an extended period of years; (4) personal influence in developing the character of the students.

Howard B. Peterson was selected by the committee to deliver the Annual Faculty Honor Lecture in the Natural Sciences. On behalf of the members of the Association we are happy to present Professor Peterson's paper:

TRIAGE

Committee on Faculty Honor Lecture

Triage

Throughout most of this century Utah State University has been developing its competence to a position of eminence in the science and art of irrigation and related fields of agriculture and engineering. It has accepted the responsibility to train local as well as international students and through a contract with USAID, conduct research in developing countries. Thus, we in irrigation find ourselves an integral part of the U.S. strategy to assist in closing the gap in development and hopefully winning the battle against world famine. To many this seems hopeless, and it may be, but I have a feeling that it is possible to assist and under certain conditions achieve. Before discussing some of the technical problems and telling something about our activities, I want to analyze the world food and population situation that we must contend with. I hope that I can show where and how there is a place for irrigation and that by our assistance we need not be a party to a program of selecting or sorting out who is to be given a chance to live--triage. All this is based on a premise that we adjust our numbers to the carrying capacity of the land.

In terms of man's history on earth population explosion is a recent phenomenon. But being concerned for the people suffering from hunger and disease is not new. Malthus pondered the situation and in essence said that *infinite hopes for human happiness will be in vain, for populations will always tend to outrun the growth of production. Populations will always exceed to the limit of subsistence and will be checked by famine, war and disease.* Even earlier Aristotle wrote that *from time to time it is necessary that pestilence, famine and war prune the luxuriant growth of the human race.* During the days of great crop surpluses in North America, many of us became much more optimistic than Aristotle, but now after several years of poor crop yields and declining reserves, pessimism seems to be back in vogue and we wonder how many in the world can be fed, who they are to be, and how we make that determination.

THE UNTHINKABLE

The President of the National Academy of Science recently stated (1) that the situation in South Asia may already be hopeless and the present policy of supporting the region through food aid may prove counter productive. He feels we are in danger of doing something which is soothing to our consciences but may lead in time to a debacle. He suggests it may be wiser to let nature take its course in some countries--cut Asia adrift--select who should die--a policy of triage. In another way Sylvan Whittwer (2), Chairman, Board on Agricultural and Renewable Resources of the National Academy of Science, recently stated "we could be living on borrowed time," as far as our ability to feed the expanding population.

In an assessment of the world food situation, scientists (3) told the House Subcommittee on Fisheries and Wildlife Conservation and the Environment that the recently concluded World Food Conference had failed to come to grips with underlying causes of the present crisis, and that the United States has begun a policy of selecting which people shall live and which shall starve on grounds of self interest.

University of Wisconsin Ecologist Grant Cottam (3), an official observer at the Rome conference, said delegates had failed to face the possibility that the world's carrying capacity may have already been exceeded and that any attempts to increase food production will only aggravate the decline of the quality of life. He feels the carrying capacity of the world is probably less than the number of people in existence.

Some of us feel the process of cutting off food has begun and whether or not we want to call it that, it is triage when we refuse grain to India and send it elsewhere. This is a sad situation, but what do we do? I hope that we participate in the development of a world strategy based on a logical balance between need and production capability.

BIOLOGICAL LAW

There must be a biological law that in essence reads that for every kind of organism something will limit its numbers. Otherwise stated, the population will eventually be controlled one way or another. For man the alternatives seem to be:

1. Food-Energy (famine)
2. Waste Products (pollution)
3. Space (competition)
4. Pests
    a. diseases
    b. wars
    c. violent acts of nature
5. Self Regulation

Man is a unique organism in that he has the potential to regulate all modes of population control. Except for control of reproduction, to eliminate one mode of control only enhances the others. Augmenting the food supply is not as easy as controlling disease nor is it as easy to double food production as it is to double the population. In both developed and developing countries there has been a successful push toward reducing diseases--thus producing a greater demand for food, which in turn raises the probability of deaths from famine, pollutants, war, or increases the need to implement logically and humanly a program of self regulation.

A STRATEGY

The United States announced a strategy to close the gap in development when Secretary Kissinger stated at the World Food Conference in Rome in November 1974 (4): "The profound promise of our era is that for the first time we may have the technical capacity to free mankind from the scourge of hunger. Therefore...we...proclaim a bold objective--that within a decade no child will go to bed hungry, that no family will fear for its next day's bread, and that no human being's future and capacities will be stunted by malnutrition."

That sounds noble, but is it? Yes, but not realistic. His declaration poses some problems in achieving the objectives. He never indicated how many people could be nourished nor for how long. I doubt that he realized that much of our technology does not readily transfer to geographic areas of greatest need and that the technology must be applied so as to manage all components that regulate population numbers and the quality of life. Too, some countries lack resources to be developed even though we make technology available.

In this discussion I will deal mostly with problems related to food production because we are in that business. However, we must not forget pollution, war, etc. Shown in figure 1 (5) are the areas of plentiful food production. These are the same areas where the greatest technological competence exists. In figure 2 are shown the areas of critical need and a climate very different from the one in which our crops flourish. The location of production is becoming more and more imbalanced in relation to needs. The transfer of technology from the haves to the have-nots is not easy for all too often it is not adaptable and/or it must pass geographic, economic, social, illiteracy and language barriers.

Most of the efforts of my colleagues are directed toward closing the gap in development by transferring our technology for crop production rather than relying on direct food assistance. It seems to us that to "share the food" only developes welfare states, tending to move all the population eventually to a much lower standard or to selecting areas of attrition. What happens when the breadbasket countries no longer have what they need and enough for everyone they have been trying to help? If everyone in the world eats out of the same food basket we will all get hungry about the same time and then who will help in time of emergency?

To assist in analyzing the situation, I have constructed a generalized biological growth curve (figure 3) with its various phases. We are sure that populations will not follow such a pattern but it is reasonable for discussion. Unfortunately, we don't know where to write 1976 on the time scale nor the present 4 billion on the population scale. We recognize all segments of the world population are not at the same phase at the same time, but we ask ourselves, on a broad basis, where are we in general and what are we striving for? I hope we are striving for the optimized or stable phase or at worst an Aristotle phase of a gradual nature with only minor fluctuations. The catastrophic and death phases are the ones we want to avoid at all costs. I somehow have the feeling that we can arrive at a stable phase in which more people enjoy quality life if we arrive there on the incline rather than the decline. I hope that we can stabilize our number at a carrying capacity that will be much greater if it comes before the forests are denuded, crop lands eroded and the reservoirs all filled with sediment.

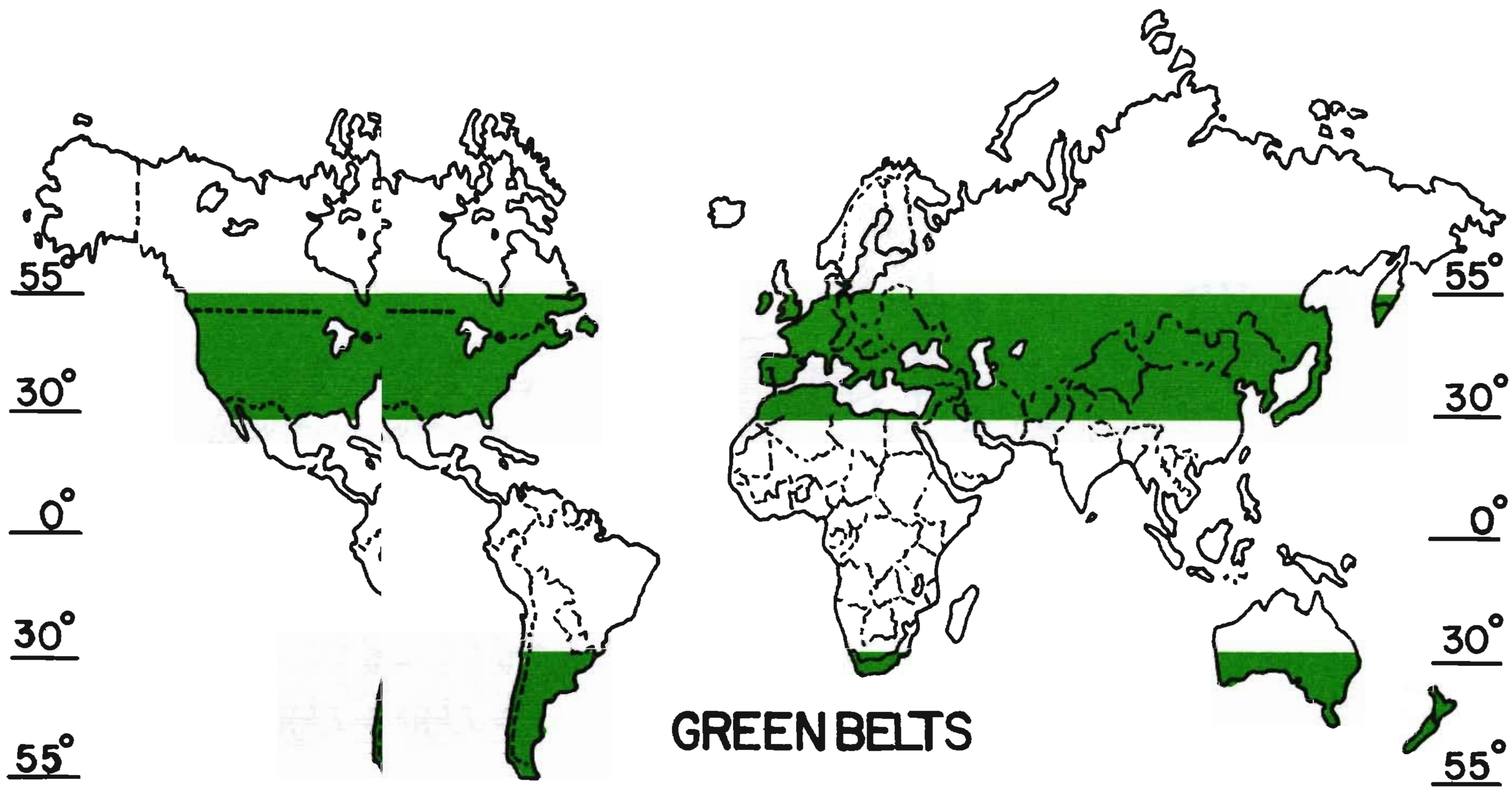


Figure 1

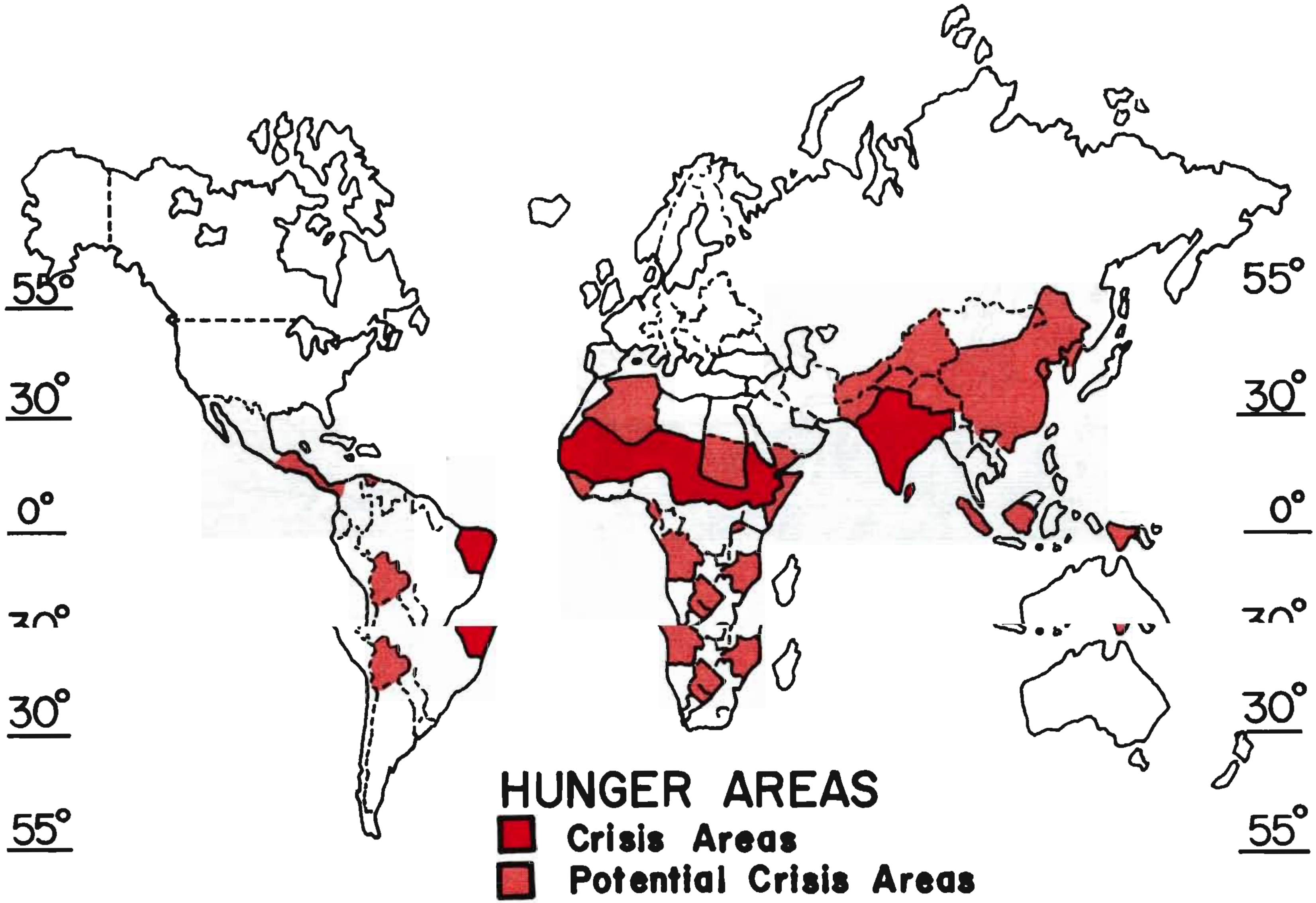

55°
30°
0°
30°
55°
55°
30°
0°
30°
55°
HUNGER AREAS
Crisis Areas
Potential Crisis Areas

Figure 2

Fellows (6) presents in figure 4 some projected trends with numbers indicating the world is in a geometric phase and on a collision course with the catastrophic phase. If we use this information to answer Cottam's question it would indicate that, yes, we have exceeded the carrying capacity for optimal life quality, but I feel only if we arrive there from a precipitous decline. If this is true, there is little an irrigation engineer or agronomist can do but salve his own conscience by doing his bit and hoping at least, over the short haul, that life can be better for some. For others, "nature may have to take its course."

BENEFITS FROM IRRIGATION

Famines are such horrible manifestations of food insufficiency that we are compelled to take an optimistic outlook and take advantage of the benefits irrigation has to offer. Some of these are:

1. Regulate the distribution of people and industry,
2. Provide a more stable or reliable crop production base for a region,
3. Recycle nutrients by using effluents,
4. Improve water quality by soil removal of pollutants such as pesticides, toxic elements, and to provide death time for pathogens,
5. Increase the quantity, quality and kinds of foods.

No attempt will be made to document all these contentions. Instead, I will try to demonstrate how irrigation can assist in increasing food production at levels that are reliable. One obvious way is to increase the area irrigated and another is by intensifying production.

Unfortunately we do not have an inventory of the land and water available for expanding irrigation. If available it would be possible to project the potential production benefits from the expansion and determine what impact on the world food supply could be expected from irrigation developments. Such an assessment for each developing country should receive a high priority. We do know that in tropical and semi-tropical areas of Africa and South America, there is considerable land and water that can, when we know how, be developed. For example, in Northeast Brazil an enormous potential exists in an area of critical food need (figure 2). The Sao Francisco River is

Generalized growth curve with various phases

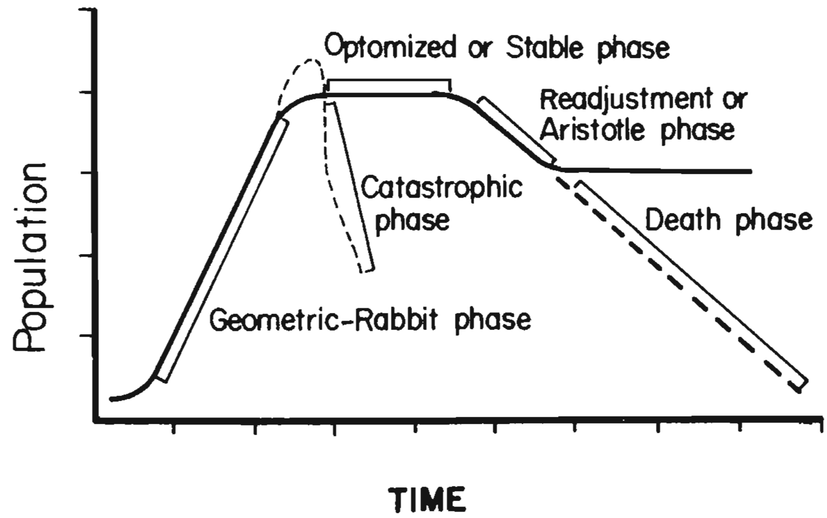


Figure 3

Predictions of World Population Trends

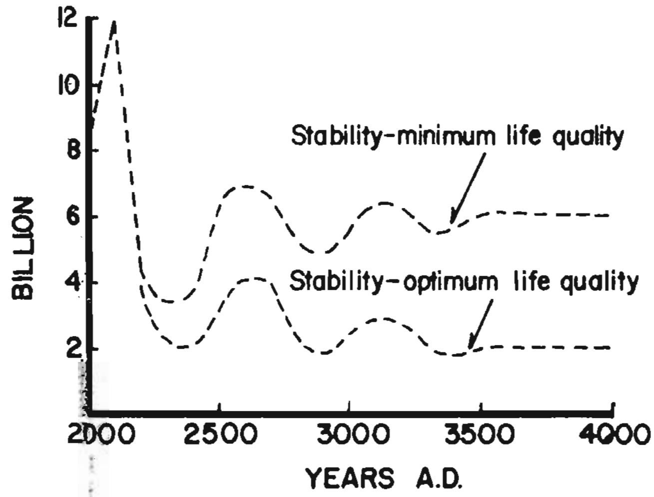


Figure 4

2700 km long and its basin has an area of 640,000 km^2. An estimated 3,000,000 ha are potentially suited for irrigation (7). The river flow is 3,150 m^3/sec or 100,000 million m^3 annually. There are wet and dry seasons with frequent draughts during the wet season and the dry season lasts for five or six months (figure 5). The precipitation in the wettest months has varied from 0 to 355 mm and the driest from 0 to 25 mm. With such a rainfall pattern, it is evident that irrigation can provide draught protection during the wet season and water for another crop or more during the dry season. From studies near Brazilia, it has been estimated that long-term rainy season yields of corn will only be about 54 percent of possible yields with supplementary irrigation during the wet season.

In cooperation with local scientists, my colleagues are solving some of the many soil and water management problems of the area to enable irrigation to flourish and the farmers to grow the needed crops on these new lands. Aluminum toxicity is one of these problems as is nitrogen, phosphorus and minor element deficiencies . Many of the tropical soils have high levels of soluble and exchangeable aluminum that restricts root penetration thus inhibiting the use of subsoil nutrients and moisture. These soils also have a low water holding capacity and hence water needs to be applied in small amounts rather frequently. In addition, the soils require larger amounts of phosphorus fertilizer to satisfy the fixing capacity of the soil and the nutrient needs for legume crops, but when the phosphate is supplied a zinc deficiency is made worse. Small amounts of lime are needed throughout the profile and at frequent intervals. Data in figure 6 from Brazil (8) indicate the value of lime and the benefit of depth of incorporation. I feel certain even deeper placement of some lime would be beneficial. Some unanswered questions are, where does the fertilizer and lime come from, who pays for it and how will the farmer apply the lime to get it distributed throughout the profile. Distributing lime throughout the profile makes more water available for the crop.

When we went to Pirapora, Brazil, in 1968, the land was in brush. With irrigation and the knowledge gained, it can grow a variety of crops such as corn, rice, mellons, bananas, vegetables, and grass throughout the year. Without irrigation even in the "wet" season, most crops would frequently fail, and it would not be possible for the people of the area to have fruit, vegetables, meat and dairy products.

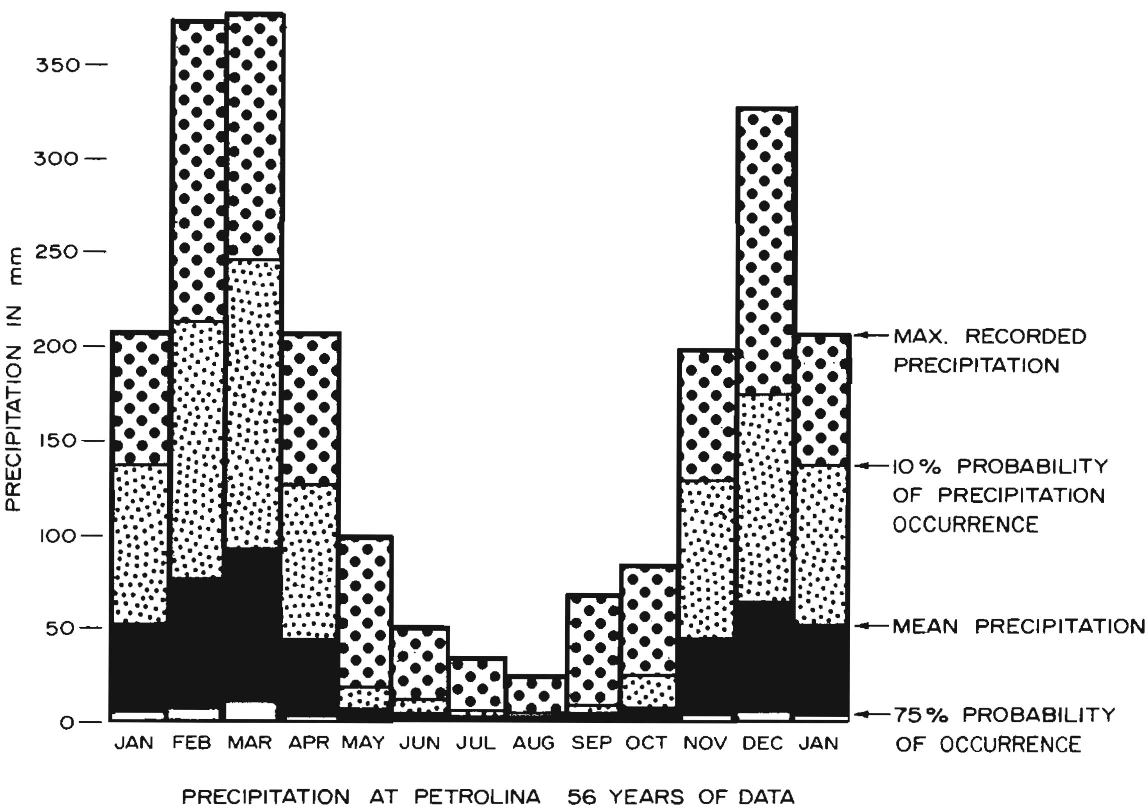

350
300
250
200
150
100
50
0
PRECIPITATION IN mm
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN
MAX. RECORDED PRECIPITATION
10% PROBABILITY OF PRECIPITATION OCCURRENCE
MEAN PRECIPITATION
75% PROBABILITY OF OCCURRENCE
PRECIPITATION AT PETROLINA 56 YEARS OF DATA

Figure 5

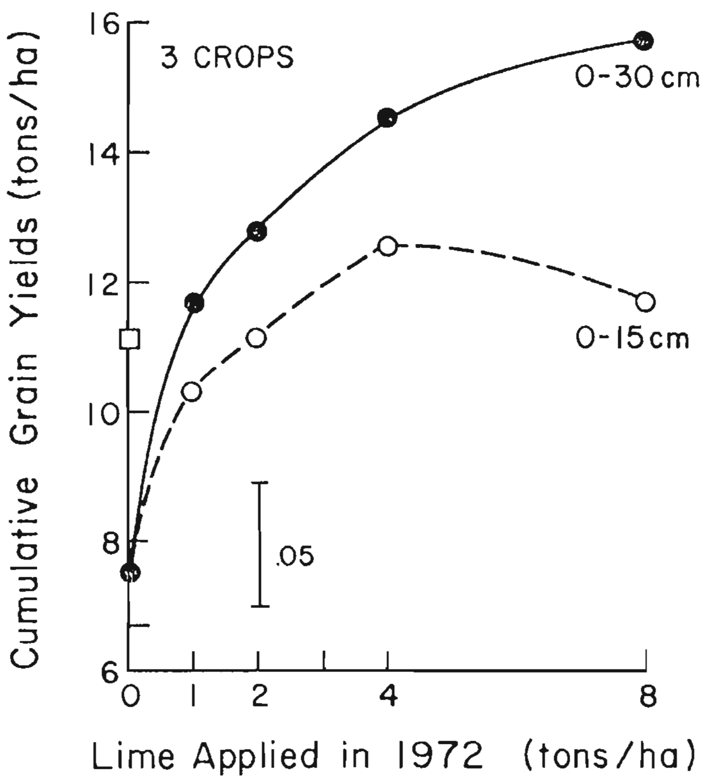

3 CROPS
0-30 cm
0-15 cm
.05
Cumulative Grain Yields (tons/ha)
16
14
12
10
8
6
0
1
2
4
8
Lime Applied in 1972 (tons/ha)

Figure 6

Provost R. Gaurth Hansen summarized some data for us that indicates the nutritional needs of the people in Petrolina.

Table 1. Average Food Index for Petrolina, Brazil.

Nutrients	Food Index*
Energy	48
Protein	59
Vitamin A	04
Vitamin C	12
Niacin	65
Riboflavin	28
Thiamin	48
Calcium	39
Iron	63

*Percentage of basic needs based on 2300 K cal standard.

These data emphasize the nutritional inadequacy of the diet. I see no way those people can grow crops to improve the diet, and particularly the vitamin A and C intake, without irrigation for these crops. The land has not been developed as yet but they are nearer to the realization.

Much of our effort is directed toward increasing production from presently irrigated land. We have a fair estimate (table 2) of current hectarage.

Table 2. Assessments of the World's Irrigated Area (9)

Author (Country)	World's irrigated total (million ha)	Year
D. Thorne & H. Peterson (USA)	106.3	1949
N. D. Gulhati (India)	121.0	1955
R. M. Highsmith (USA)	172.6	1965
V. M. Borovsky (USSR)	203.2	1969
S. A. Girshkan (USSR)	225.3	1969
My current guess	250.0	1976

It may well be possible to grow "two blades where one now grows" on these 250 million hectares. In Chile we found that by changing the method of irrigation from flooding to furrow and by having the proper balance of plant population, fertility and water, the yields of corn were doubled. In El Salvador, a potential crisis area (figure 2), our team is finding out how best to fertilize and water corn and other crops in sequence and to have almost continuous crop growth. In figure 7 (10), they have given us an example of the interactions of crop response to water and nitrogen fertilizer amounts. For a given amount of water, the "best" amount of fertilizer can be determined and vice versa.

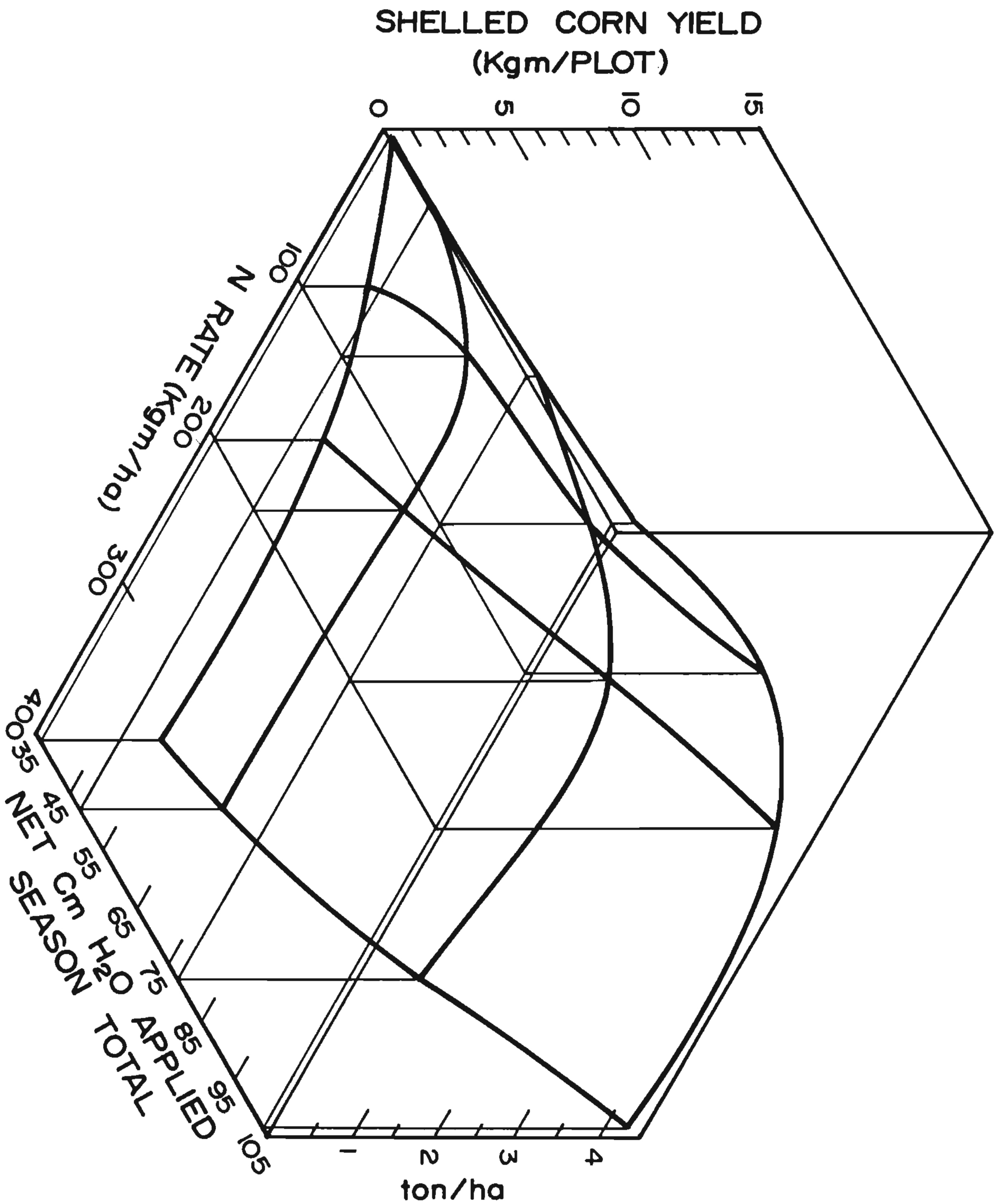
The Rockefeller Foundation, USAID and others are making a big push in the humid areas to multiple or intercropping where two or more crops are growing at the same time. This is the best use of time, space, water and fertilizers in an intensive cropping system. It makes possible the greatest production from a limited area. It is particularly attractive for soils having a high fixing capacity for such nutrients as phosphorus. By this method it is possible to recover the maximum proportion of applied fertilizer and lime.

A comparison was made of production from monoculture and intercropping of corn, soybeans, cassava and cowpeas grown on equal areas with the same fertilizers. In the Yurimaqus region of the Amazon (8), production was compared when corn, soybeans, cassava, and cowpeas were intercropped (63,160 soles) and grown alone (45,300 soles.) In these soils they found there was aluminum toxicity and nitrogen, phosphorus, potassium, boron, copper, sulfur and molybdenum deficiencies. In my experiences, molybdenum deficiencies are rare.

A disadvantage of intercropping is that when a draught occurs in humid areas, or when the practice is pushed to the drier irrigated regions, there is potentially greater damage to the crop. High fertility with dense plant populations and adequate water are conducive to high productions. These conditions with water shortage results in maximum crop loss. Under irrigation it is essential that the water requirements be determined and that the acreage planted does not exceed the probable water supply.

UNDESIRABLE EFFECTS

All that comes with irrigation in developing countries is not good and in fact some things are



SHELLED CORN YIELD
(Kgm/PLOT)
0
5
10
15
N RATE (Kgm/ha)
100
200
300
400
35
45
55
65
75
85
95
105
NET Cm H_2O APPLIED
SEASON TOTAL
1
2
3
4
ton/ha

Figure 7

rather discouraging. Some tropical soils commonly called laterites, that have iron accumulations in the subsoil, harden like stone when erosion removes the topsoil. Such soils can no longer be cultivated. In temperate zones freezing induces dormancy of many pests so that they do not continue to thrive throughout the year. In the wet-dry regions of the tropics, the dry season has some of the same effects. With irrigation the soils may be moist most all the time and the pests are unrestricted.

When irrigation is developed where nomads live, it takes away some of their land but, more seriously, the canals restrict the movement of the herds and often serve as death traps for the animals.

Irrigation projects can also contribute to resurgence of malaria and induce other diseases. New irrigation developments in the Sao Francisco Valley of Brazil, in Egypt, in Africa, and elsewhere, have increased the incidence of schistosomiasis.

SCHISTOSOMIASIS

Some experts think this is the greatest unconquered parasite disease affecting human beings and animals in the tropics and subtropics. It is a water-related disease that infects more people today than ever before in history. Its increasing incidence and widespread prevalence are largely due to tropical irrigation schemes. The importance of irrigation in the spread of the disease is illustrated with data from four areas in Egypt showing increases within a three-year period after the introduction of irrigation.

Table 3. Relation of Schistosomiasis to Irrigation (11)

Area	% of Population Infested	
	Before	After
Sabaoa	10	44
Kilh	7	50
Mansouria	11	64
Binban	2	75

Before Egypt's Aswan High Dam was begun, some warned that this would lead to serious health problems such as a rapid increase in schistosomiasis. This has apparently happened (12). Stable water conditions and increased aquatic plant growth have provided ideal conditions for the snails. Below the dam, where year-around irrigation has replaced annual flooding, incidence of schistosomiasis has risen from roughly 5 to 35 percent of the population. Above the dam prevalence of the disease is close to 76 percent. The extra food being produced in the irrigated areas cannot keep up with Egypt's 600,000 persons-per-year population growth. We wonder if increased incidence of schistosomiasis will serve as an unfortunate means of population control in Egypt.

Schistosomiasis can only occur with the appropriate interaction of water, snails, and man. When *S. mansoni* eggs, which are carried in human feces or urine, enter fresh water, they hatch into ciliated miracidia within minutes, then find and penetrate the proper snail species. There each miracidium produces more than 100,000 cercariae (larvae). After about 4 to 6 weeks the cercariae begin to leave the snail. Upon contact with a person in water, a cercaria bores into the body in three minutes and metamorphoses into a schistosomule (young worm). The young worms then migrate via the circulatory system to the lungs, where they undergo some development, then pass to the liver, where they mature and mate--the female entering the cleft in the male's body and remaining there for life. The couple then migrate to the intestines or walls of the bladder where they produce hundreds of eggs per day during their lifespan, which may last up to thirty years. Many of the eggs remain in the intestines and the liver, but the rest are expelled, renewing the cycle. Other species follow similar routes through the body affecting different vital organs.

It would seem reasonable that a disease affecting 300 million people, a disease whose etiology has been demonstrated, would have been the object of intense scientific study. But world interest has remained relatively insignificant. The probable reason is simple: schistosomiasis is a disease of the poor, and particularly the children in tropical or subtropical countries, who work irrigated land or bathe in the streams. The rural poor are of marginal interest to politicians and many scientists. Schistosomiasis is not a dramatic disease. Its degenerative effects often become apparent only after years of infection and reinfection. The fact that we struggle to help develop irrigation and it results in the suffering of the population we want to help is most discouraging.

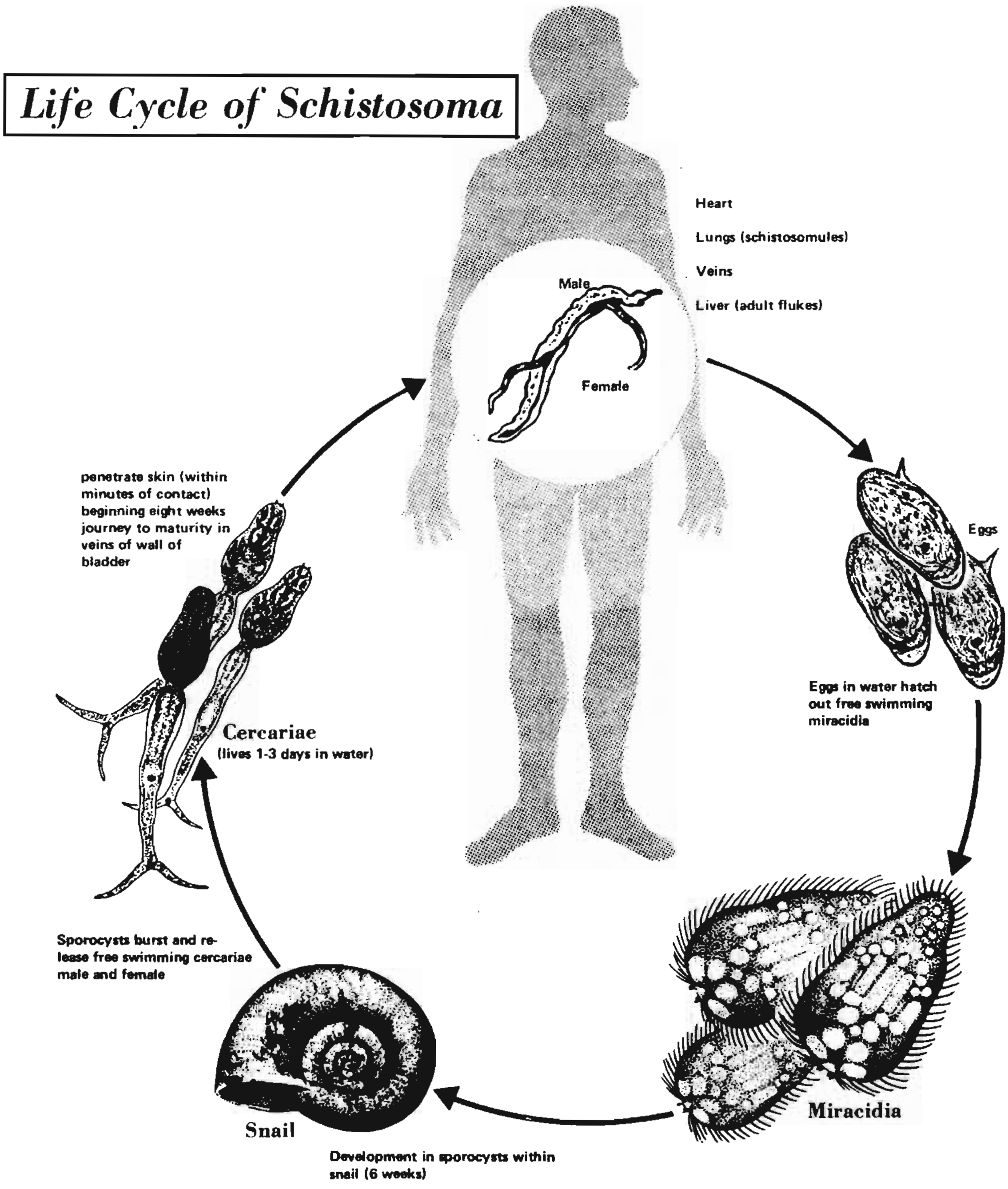

Life Cycle of Schistosoma
Heart
Lungs (schistosomules)
Veins
Liver (adult flukes)
Male
Female
Eggs
Eggs in water hatch out free swimming miracidia
Miracidia
Development in sporocysts within snail (6 weeks)
Snail
Sporocysts burst and release free swimming cercariae male and female
Cercariae
(lives 1-3 days in water)
penetrate skin (within minutes of contact) beginning eight weeks journey to maturity in veins of wall of bladder

Figure 8

EXTENDING OUR INFLUENCE

Most of my colleagues are spending much of their time traveling at considerable risk and inconvenience in an attempt to make their knowledge available to people in developing countries. The need for our technology is great, the time is short, and there are too few helpers to go around. In order to increase our effectiveness and extend our influence, we are developing a better strategy to transfer the information we have now and that which we develop. We have an exciting program to generate information that is not time and site specific but broadly transferable. An effort is also being made to get our knowledge in a form that is transferable and that is located where it is readily available. Much of our present information gets buried in some technical publications not available to the technicians in developing countries or is in a form unusable by them.

All this effort is an integral part of our strategy to close the gap in development as fast as possible. I wish we had time to go into detail for there are many exciting aspects.

CONCLUSION

Decline in food reserves, the loss of momentum in the green revolution, poor world crop yields, and failure of promised innovations to contribute to our food supply have rekindled our anxieties about the world situation.

The major portion of the food to meet the demands of a growing world for more food comes from farmlands, much of it from the green belt, and will likely do so in the future. Better protein in grain, feed from algae and protein synthesis are largely as of now only promises.

We can do some worthwhile things with irrigation but is is not a panacea. There is an abundance of land and water in the food shortage areas of the tropics, but the problems of development are many. Very likely the production from the current hectarage can be doubled and maybe the hectarage can also be doubled but there is a real need to determine these potentials. There is also a need to determine all resource potentials of each country and to determine the carrying capacity at an optimum quality of life.

Our sharing of technology does not endanger our own food supply but a permanent commitment to provide food for less developed countries does jeopardize our supply. Those without resources to develop by technology should not expand their number in a welfare state. By exporting our technology to help close the production gap, we enable the recipients to expand to the limit of other resources and arrive at their maximum carrying capacities. So called "surplus" food produced should be a market commodity and for emergency relief rather than for permanent welfare.

My hope of course is that the numbers to feed will be in harmony with the production increases, that our irrigation technology will materially increase production and no political triage will determine who is to die.

REFERENCES

1. Science News. November 2, 1974. Vol. 106.

2. Science News. January 18, 1975. Vol. 107.

3. Science News. November 30, 1974. Vol. 106.

4. Agency for International Development 1975. Aid in an Interdependent World - Food and Nutrition. Office of Public Affairs, AID, Washington, D. C.

5. Hewitt, William A. 1975. Famine. Conference sponsored by Dartmouth College, February 18, 1975.

6. Fellows, Irving F. 1975. Population Trends and Food Production Potential. NACTA Journal. 19:68-72. pp. 68-72.

7. USDI Bureau of Reclamation. 1967. Reconnaissance Appraisal Rio Sao Francisco Basin, Brazil. Vol. 2, Appendix 1.

8. North Carolina State University. 1974. Agronomics - Economic Research on Tropical Soils. Annual Report. Raleigh, North Carolina.

9. Zonn, I. July 1974. Irrigation in the World. International Commission on Irrigation and Drainage. pp. 26-33.

10. Utah State University Annual Report. December 1975. Water Management Research in Arid and Sub-Humid Lands of Less Developed Countries.

11. McJunkin, F. E. 1970. Engineering Measures for Control of Schistosomiasis. Report to AID, Washington, D. C.

12. Science News. December 14, 1974. Vol. 106.