AGRICULTURE: ENVIRONMENTAL IMPACTS

Global Environmental Destruction:
Myth or Reality?

Blythe Brown
Vincent Brown
Kathy Jo Sullivan
Christina Triplett

Instructor: R. Cellarius

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INTRODUCTION

This paper was written for the group contract Global Environmental Destruction: Myth or Reality? It addresses the status of agriculture in the world today with special attention to the environmental impact felt from twentieth century farming practices.

We will be exploring this issue in the form of four separate articles, the first being a look at agricultural systems and food production, the second article will explore the depletion of agricultural lands due to soil loss and degradation, the third entitled Blue Revolution, looks at food resources from the sea, and the final article uses Japan as a case study to explore agricultural options for the world today.

This report is not meant to be exhaustive. It is a glimpse into problems and prospects for the future.

GLOBAL AGRICULTURE

Christina Triplett
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When considering interactions between the Earth and the human race, the Earth is rarely considered as an active participant. The realm of agriculture has exemplified this objectification since humans have begun to cultivate. Traditionally, when we needed to grow more food, we have simply increased the amount of land under cultivation. (USDA,19) Slash-and-burn methods of agriculture are the earliest examples of increasing cropland, and these methods were sustainable only because the low population density allowed the land to lie fallow after use. More recently, these conversions have been accomplished by logging forests and planting in pastureland. Current population increases, however, dictate a change in approach to the problem of feeding people. We must stop perceiving the problem as a crisis in the rate of production, and realize that it involves lack of access to the means of food production.

Considering that recent increases in food production have outstripped world population growth by 16% (Lappe', 9), and world-wide cereal production per capita has increased from 248 kg to 310 kg.(WCED, 9), you may wonder why people are still hungry. These figures, despite their optimistic tone, are very misleading. They hide wide variations in agricultural productivity, as well as distribution of food supplies.

Most food production systems can be categorized into three major groups: industrial agriculture, Green Revolution agriculture, and resource-poor agriculture, all of which have their endemic complexities in the areas of land, water, energy, and people.

INDUSTRIAL AGRICULTURE

Industrial agriculture is found in the developed areas of the world, and is characterized in words that could be used to describe most industrial pursuits: capital and input expensive and increasingly large scale. The climate tends to be temperate. Specifically, the countries include: North America, Europe, Australasia, East European non-market economies, and "their temperate enclaves in many developing countries".(WCED, 7)

A.LAND

Producers, seeking to increase yields, have turned to chemical inputs, such as fertilizers, pesticides, insecticides, herbicides, rodenticides, and fungicides. As yields increased, farmers and researchers thought that more was better. Recent trends indicate, however, that we have continued to increase the use of fertilizers without a corresponding upward shift in yields. Between the years 1960-1979, grain yields fell, while nitrogen fertilizer use quadrupled. (Todd, 143) The long term effect of intensive fertilizer use is, ironically, loss of soil productivity due to lost organic matter. Current U.S. soil losses are estimated at 25 percent more than during the Dust Bowl years of the 1930's.(Todd, 143)

Other chemical agents have their effect as well. The worst problem with pesticides is inaccuracy in application, resulting in accumulation in soil, water collection areas, wildlife, and eventually traveling up the food chain. These chemicals often harm non-target and beneficial species, which cause further complications later. For example, herbicides used to kill broad-leaved plants allow grasses to grow unchecked by any competition. The grasses themselves become the problem, and the farmer feels obligated to spray a new chemical to take care of this new weed.(Carson, 79) After years of applications, these chemicals build up to an enormous amount in the soil. In some cases, chemical residues turn up in the product itself, such as arsenic in tobacco, which has increased over 300% between the years of 1932 and 1952, and continues to show up in American cigarettes.(Carson, 59)

In addition to chemicals accumulating in the soil, a recurring problem with pesticides involves pests developing resistances. Insects provide an excellent example of Darwin's theory of "survival of the fittest". Due to their rapid rate of reproduction and the fact that only the hardiest insects breed, resistance can develop quickly. (Carson, 274) Farmers usually feel that they have no other option than to apply more chemicals. The number of pesticide resistant species world-wide jumped from 25 in 1974 to 432 in 1980.(WCED, 40) In addition, three-quarters of the insect pests in California are now insecticide resistant.(Todd, 143)

B. WATER

Besides land, water is the most important agricultural resource, and as the supply becomes more scarce and expensive, water rights will become a priority on the political agenda. The reduction of water resources in industrialized countries is mainly due to pollution, wastage in irrigation, and an increase in demand from the industrial and urban sectors. (IIASA, 37)

Agricultural water pollution is a result of fertilizers, biocides and manure leaching into the water, and collecting in drainage areas. One common effect of nitrogen and phosphate fertilizers collecting in run-off is eutrophication. By stimulating the growth of aquatic plants in the ponds, lakes, and reservoirs, the burden on an already limited amount of dissolved oxygen is increased. As blue-green algae spreads, it ruins fisheries, drinking water and recreational areas.(WCED, 39)

The spread of biocides, through the same channels, has caused an incredible number of poisonings and deaths among birds, fish, and other wildlife as they drink or bathe in drainage collection areas that have been polluted by agricultural chemicals. (Carson, 85-152)

Irrigation is both a blessing and a curse in the agricultural world. While it increases the productivity of land already under cultivation, irrigation systems, in general, tend toward inefficiency and waste, and can make the land useless for growing. World-wide, over 70% of fresh water withdrawn from the hydrological cycle for human use is for irrigation. There is no doubt that irrigation can increase yields, the question is sustainability.(WCED, 61)

C. ENERGY

The same questions that apply to water consumption, apply to agricultural energy consumption, as well. World agricultural energy consumption is 3.5% of commercial energy in developed countries, and 4.5% in third world countries.(WCED, 34) The energy resource that literally fuels the industrial agriculture of the world is petroleum, naturally. In fact, farming uses more petroleum, primarily in the form of fertilizers and biocides, than any other industry.(Todd, 143) Agricultural systems require fuel for machinery which pumps water, tills, and harvests; as well as the petroleum intensive process of creating fertilizers and biocides.(WCED, 34) Other energy needs involve post-harvest operations, such as drying grain or cooling it during storage.

"The increasing expense and uncertainty in energy supply will both increase the demand for land and make it harder to obtain higher yields through conventional techniques."(IIASA, 19) In other words, the price of land that is already under cultivation, and the price of chemical inputs could increase dramatically. Producers would then find it difficult to increase the intensity of their farming through conventional methods.

D. PEOPLE

In the developed nations, as more farmland is incorporated into agribusiness holdings, we witness the crumbling of the rural sector of society. Agribusiness attempts to produce food on a scale so large that the world's market can't absorb it. Agribusiness has undergone a process of "vertical integration", in which one corporation owns or effectively controls all phases of the food supply system, "from seed to supermarket" in the words of one expert.(Shea, 37) These "vertically integrated" companies contribute precious little to the local economies of rural communities. Most buy their machinery and supplies direct from a large producer or another branch of the owning company provides it. Often, companies will oppose local improvements, because they increase property taxes. (Merrill, 50)

In North America, the effects are felt from this farm crisis, as small farmers are forced out of competition by larger farms that have a larger margin for profit or error. Mechanization, in particular, poses a threat to rural labor, especially in light of advances in biotechnology, which tailor crops to the needs of the machines that handle them.

<u>GREEN REVOLUTION AGRICULTURE</u>

Green Revolution agriculture is most often found in flat, tropical, resource-rich land, and is often irrigated. This type of agriculture is more widespread in Asia, but includes the heartlands of Latin America and North Africa.(WCED, 7) Green Revolution techniques rely heavily on petrochemicals, electricity for some phases of production, and the internal combustion engine for tillage, harvesting, and transport. (Todd, 142)

The first experiments, on a high-yield variety of wheat in Northwest Mexico, were very encouraging to researchers in terms of higher yields, but long-term implications weren't considered. Even by 1974, these implications hadn't yet manifested themselves. "The Green Revolution, primarily a genetic innovation, does set in motion profound and far-reaching societal and economic changes. We know very little about the dynamics of this new system and presently have little control over its long-range outcome."(Hewes, 27) Consequently, Green Revolution technology hasn't lived up to its professed goal of feeding the hungry of the world, rather, it attempts to recreate the industrialized form of agriculture so common to First World countries.

A. LAND

Green Revolution techniques are based on breakthroughs in the development of high-yield varieties of certain crops, originally known as "miracle seeds".(Lappé, 47) These high-yield varieties, known as HYV's, have several inherent drawbacks: HYV's lack the disease-resistance found in traditional strains (Todd, 142), they have an incessant and ever-increasing requirement for fertilizer and pesticide applications (Lappé, 53), and vital, local strains are being replaced, leaving less genetic material for new seed stock.(Lappé, 61)

Another major problem related to land is lack of access to it.(Lappé, 49) In a similar pattern to the industrialized countries, the economic effects of Green Revolution techniques in the third world result in a greater concentration of land into corporate plantations growing export crops, or landlords who live off of small tenant farmers.(Merrill, 116) In this situation, small scale farmers get caught in the "cost-price squeeze", when the costs of fertilizers and pesticides increase more than gains in yield.(Lappé, 54) This problem parallels the difficulty facing farmers in industrialized nations, as well.

B. WATER

Irrigation forms a large component of Green Revolution technology. Since the crops growing in Green Revolution areas tend to be imported from temperate zones rather than native, their water needs often exceed the area's capacity to provide an adequate supply. Water use projections for developing countries indicate a rise in demand, due to urbanization and a need for improved sanitation.(IIASA, 37) Nevertheless, the International Food Policy Research Institute has estimated that three-fifths of food increases projected for Third World countries in the next ten years will result from extending the land under irrigation.(WCED, 60) From one standpoint, irrigation is necessary to increase yields, and yet, present irrigation practices do not have the intended effect of feeding the region's inhabitants. Most often, irrigation projects are funded for export crops, in order to make debt payments, rather than improve the local food supply.

C.ENERGY

Currently, energy use in Green Revolution countries is concentrated in inputs for fertilizers and biocides, as the newly introduced crops require those supports. Contrary to widely-held opinion, the energy problem in third world countries is not a lack of oil: it would take only 5% of present world energy consumption to double production.(Lappé, 34) The real difficulties lie in reallocating petroleum products for agriculture and a lack of support for machinery, not to mention the ultimate unsustainability of relying on fossil fuels.

D. PEOPLE

It is often assumed that developed nations have more problems with agro-chemicals than developing nations, but as chemical inputs are introduced into areas not previously accustomed to their use, the hazards to human health have skyrocketed. People in LDC's use 10 - 25% of the world's pesticides, yet suffer 50% of the acute poisonings and 99% of deaths.(US AID, 1) These accidents are caused by a lack of training in use and handling, a lack of safety regulations, and a lack of capital for safer technology. (US AID, 20) In many cases, people are exposed to hazardous chemicals in their drinking water because it is a common source for all of the community's needs.(US AID, 15)

Another human aspect of Green Revolution agriculture is irrigation, and its attendant socio-economic disruption. Generally, irrigation is not available to the poor. The projects that are funded are usually large-scale export crops.(Lappé, 53) Farmers who lose cropland or livestock are rarely compensated, and a lot of hostility arises as traditional water-use patterns change. In addition, there have been marked increases in the incidence of disease from "water-borne, water-based, and water-related vectors", as new strains are introduced to the area.(WCED, 61)

RESOURCE-POOR AGRICULTURE

Resource-poor agriculture is most common in rain-fed areas that are ecologically diverse, complex, and highly vulnerable to exploitation. This includes most of Sub-Saharan Africa, and the marginal lands of Asia and Latin America. These areas have declining food production and are closest to losing access to food.(WCED, 7)

A. LAND

Resource poor agriculuture takes place on land not considered desirable by Green Revolution proponents. Which is not to say that land under this classification is not necessarily suitable for agriculture, it just refers to a general lack of input availability, such as fertilizers, seeds, irrigation, and credit. Instead, farmers must rely on the skill and knowledge that has been handed down for generations. Green Revolution practices are especially inappropriate here, as farmers can't afford the initial costs, nor can the land support such intensive cultivation.

B. WATER

As in areas under the influence of the Green Revolution, pressures on industrial and domestic water supplies will increase the demand for water. This will affect resource-poor farmers disproportionately, since they rely on unpredictable rainfalls, and often live in drylands. Irrigation seems like a logical alternative, but most small scale farmers can't afford it. While farmers growing food for local consumption are forced to watch their crops wither in times of drought, farmers who grow high priced export crops are able to irrigate. These exports are often luxury crops, grown for the first world. (Lappé, 58)

C. ENERGY

Third world nations have traditionally relied on human and animal labor to supply energy for food production. It is short-sighted of the industrialized world to believe that introducing machinery is the way to improve their situation. We are not doing the LDCs any favors by transferring our oil-hungry habits to their countries. In a World Bank publication, the authors studied the effect of introducing tractors to local farmers. Twenty of the 21 projects had failed, because the tractors weren't used enough to justify the expense, and because mechanics, parts and fuel were hard to come by. In this study, they found that animals were more cost-effective than tractors, and "that mechanization saves labor rather than raising yields."(African Farmer, 13)

Resource poor farmers have depended on wood and manure to cook and heat, and while manure is a renewable resource, wood is not. In order to counteract the deforestation, programs, such as Kenya's Rural Afforestation Project, are planting trees for the future energy needs of their children.

D. PEOPLE

Resource-poor agriculture refers to areas with a predominance of small-scale farmers and pastoralists working with minimal inputs and supports, and often on fragile lands. The tools that would be most useful to provide to the farmer are economic in scope. According to Mary Okelo, a director and senior advisor to the president of the African Development Bank, government food production policies are the critical issues to small scale farmers. "For example: policies that tend to overemphasize production of export commodities at the expense of food production; policies that ignore small-scale farmers - like subsidies, pricing and the protection of consumers, which in turn lead to low pricing of agricultural produce; inefficiency and mismanagement of institutions intended to support agriculture; lack of research; lack of access to land, credit, technical services and technology. I would also say lack of political will to redistribute land, heavy debt servicing and, of course, the exchange rate."

My point is this: current methods of increasing crop yields are unsustainable, ecologically and economically. We must devise new (and remember old) agricultural techniques that do not deplete the resource base that underlies our very subsistence and, to the maximum extent possible, restore and replenish the land that supports cultivation. If we are to prevent mass starvation in the areas of greatest population growth, then we must also change our habitual patterns of food distribution and availability.

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SOIL DEGRADATION AND CROPLAND LOSS
BLYTHE L. BROWN March 9, 1989

The crops and agricultural systems discussed in the last section of this group paper are all based on one thing: soil. The foundation upon which our survival depends is the soil beneath our feet, the land upon which we can graze animals and grow crops. This is also the land from which we harvest numerous natural resources. Lester Brown of The Worldwatch Institute once said "croplands are the foundations not only of agriculture but of civilization itself" (Brown, 1981, pg.13).

Yet each year about 11 million hectares of agricultural lands are lost through erosion, desertification, toxification, and conversion to non-agricultural uses. Another 7 million hectares of grasslands for grazing are lost each year due to desertification (Meyers, 1984). Even if the land is not outright lost often the productivity is degraded to a point beyond which it is cost effective to plant crops on it.

The total land area of this earth is about 13 billion hectares, of which only 11% (or 1.5 billion hectares) "presents no serious limitation to agriculture", another 28% is prone to drought, 23% is mineral stressed, 22% of the soils are too thin to support sustained agriculture, 10% is waterlogged, and 6% is permafrost (not including Antarctica or Greenland) (Meyers, 1984, pg.24). It is when these "marginal lands" are used beyond their capabilities that soil and cropland degradation is most likely to take place.

SOIL

The soil which actually supports life is a thin layer averaging only "six to eight inches thick ...over most of the earths surface" (Brown, 1984, pg.6). It is composed of mineral soil and organic matter. Under this topsoil is a layer of coloured mineral soil with no organic content, then below that is the parent rock material. This is a very simplified description but the important point to remember is that life is sustained in only the top layer. Fertility is lost as the coloured mineral soil is plowed in with the topsoil.

The natural soil formation rate from parent rock can be as slow as one centimeter in 100-1,000 years, or in a faster situation such as sediment build up: thirty centimeters in fifty years (Meyers, 1984). The rate of soil loss through various means depends on soil type, climate (weather), slope, etc. Exact rate of loss is hard to measure and widespread data is not available, but it is accepted by most people that soil is being lost world wide at a rate that is faster than sustainable.

EROSION

One of the ways in which we are losing soil is through erosion. One estimate is that 6-7 million hectares of agricultural land per year is rendered unproductive through erosion (Brewster, 1988).

Erosion is the actual removal of soils by wind and/or water. The land is first made vulnerable through removal of the vegetation cover. The existing vegetation inhibits erosion by holding the soil with its roots, by adding organic material to the soils, by shading and therefor preventing evaporation from the soils. and by acting as a wind break above the surface of the soils.

The vegetation and organic materials are lost through local wood gathering, deforestation, overgrazing, overcultivation and through the cutting of shelter belts to make room for larger fields and larger equipment such as tractors and combines. Sometimes the type of crop or method of planting contributes to erosion. An example of this would be a row crop such as corn with deep plowed furrows or lanes which the wind and water can flow along unimpeded.

Erosion by water is often the most visible and dramatic form of soil loss or degradation: gullies, mud slides, brown rivers and silt filled dams, but wind erosion is no less damaging. By measuring the dust brought by the winds "scientists at Mauna Loa can now tell when spring plowing starts in north China" (Brown, 1984, pg.16).

Combating the excessive erosion can often be a struggle of economics, intensification of agricultural practices often lead to short term gains. The long term detrimental effects to the land is accumulative, often not visible for many years. Similarly any expense used to combat what cannot be seen as an immediate threat to the farmers existence also is not viewed as cost effective.

The erosion of topsoil not only reduces land productivity, but also contributes to deterioration of irrigation systems, lost electrical generation capacity and reduced navigability of waterways. Siltation in the Yellow River of China is so great (averaging 1.6 billion tons of soil per year) that through the centuries the river bed "has risen between 15 and 40 feet above the surrounding plain", dikes have to be built higher each year to keep the river out of the surrounding farmland (Kohl, 1989, pg.287).

FERTILIZATION

Technology to increase the productivity of existing farmland is one strategy which can reduce the use of marginal lands but technology must still be used appropriately. Fertilization of farmland can produce increased yields. World per capita use of fertilizer "quintupled between 1950 and 1984, going from 5 kilograms to 26 kilograms" (Brown, 1988).

But chemical fertilizers are not an all encompassing magic answer. After a certain application tonnage the returns start diminishing for fertilizer use. Fertilizers must also be used in conjunction with irrigation to be most effective, and "chemical approaches to farming greatly reduce soil life and humus content, and thus fertility. Such losses in organic content also make soils more easily erodible" (Paddock, 1988, pg.8). Some of the detrimental side effects of chemical fertilizers can be decreased with the concurrent use of organic fertilizers.

WATERLOGGING AND TOXIFICATION

Irrigation is another widespread technology with the potential to greatly increase productivity in many areas. Unfortunately irrigation can also contribute to the degradation and eventual loss of large expanses of farmland due to waterlogging and toxification.

Excess water either on the soil surface or surrounding the roots of a crop can be detrimental to the crops growth or even its survival. The excess water prevents the exchange of oxygen causing suffocation. This waterlogging can occur due to poor drainage of fields or a rise of the watertable. Natural watertable levels can be greatly influenced by human activities, cutting trees and excessive irrigation can both help raise the water level dangerously near valuable crops.

Often accompanying waterlogging is a condition called salinization. Salinization is a toxification of soils due to the collection of neutral sodium salts. These salts are left when ground water rises up through the soil and evaporates on the surface, they are also deposited by irrigation water on soil ridges and high spots of poorly levelled fields (United Nations, 1977). Some irrigation water has a naturally high salt content, water can also pick up extra salts in unlined canals or irrigation ditches.

The chances of cropland loss or degradation through waterlogging or salinization can be greatly reduced by planning and using efficient irrigation systems.

Another form of salts which detrimentally affect cropland are "sodium salts that are capable of alkaline hydrolysis" (Brewster, 1988, pg.226). These salts accumulate on clay particles, then the resulting reaction creates an almost impenetrable soil surface, this whole process is called alkalinization (or sodication).

DESERTIFICATION

Desertification is the degradation of drylands or the conversion of land to desert-like conditions. About 35 percent of total land area is arid or semi-arid and therefore threatened by desertification. These drylands support about 850 million people, and production of their meat, cereals, fibres and hides (UNEP, 1988).

Desertification is not spreading deserts, instead, as the land is destroyed it meets the natural desert resulting in a larger desert area. This distinction is important when combating desertification, rather than attacking the "front" of an approaching desert you must send your forces into the vulnerable areas to prevent a conversion.

The causes of desertification are complex. Often salinization, alkalinization and erosion are major contributing factors. A simplified flow chart to explain desertification was presented by the United Nations

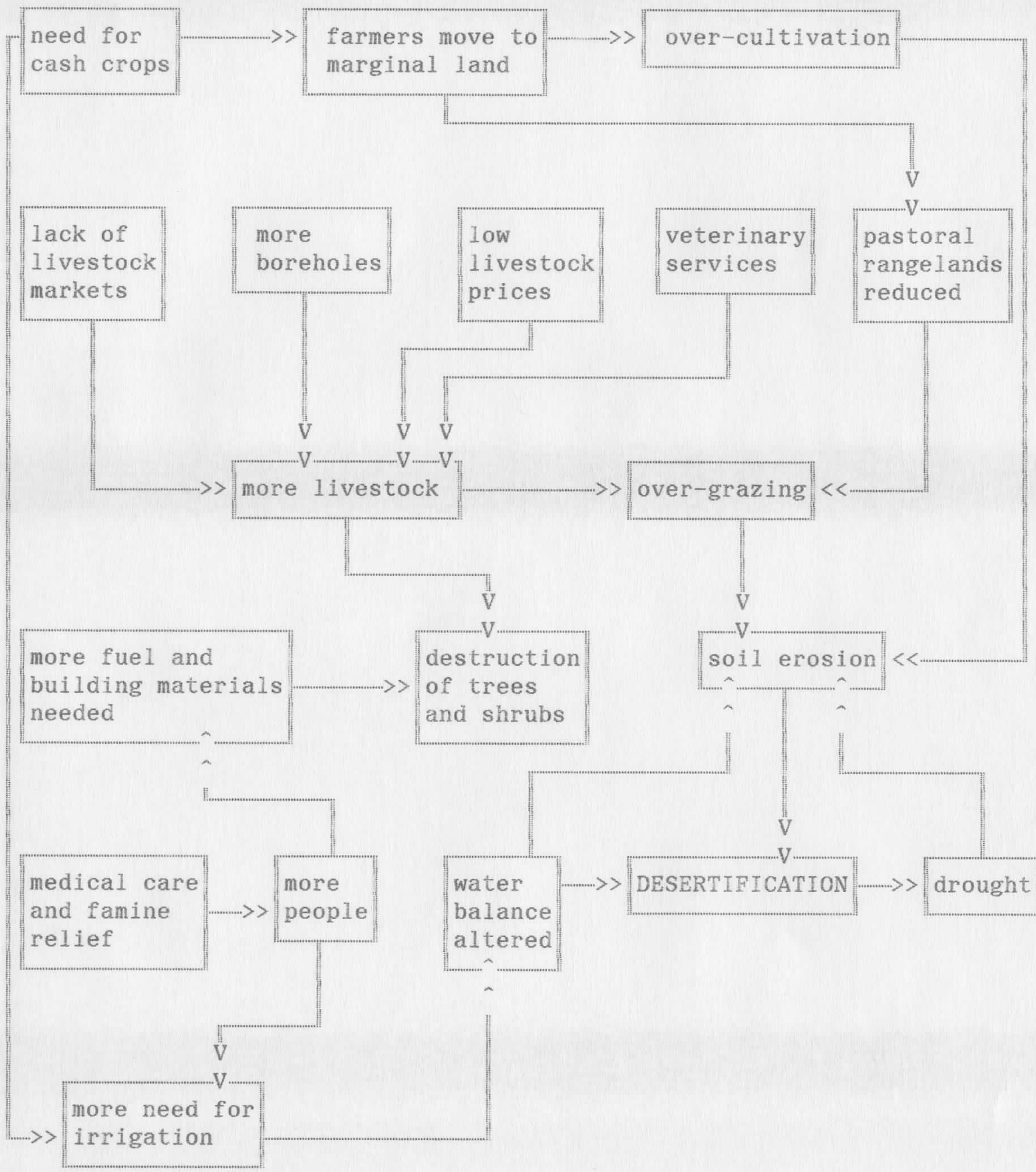

figure 1 - Desertification: The Causes Are Complex

United Nations Environment Programme 1988 Sands of Change

Environment Programme (Figure 1). It is not just a chain reaction with one cause and one result. The actions and effects start ricocheting off of each other in all directions and soon you have a tangled pile of disaster: famine, revolts, fallen governments, foreign debts, etc.

Cattle play a major role in the degradation of drylands. Domestic cattle do not have a niche in the natural ecosystem, their selective, then indiscriminate grazing patterns are exacerbated by overly large herds. Unlike native ungulates in Africa, domestic cattle must stay near water sources, their physical use of the water is poorly adapted to dry conditions. During the 25 years before the 1968 drought the western Sahel had a five-fold increase in cattle (Berry, 1984). The environmental damage to the vegetation and land which the cattle can cause make recovery from natural phenomena such as a drought extremely difficult.

DROUGHT

A drought is an extended period of little or no rain, or the reduction in "normal" rainfall patterns to the extent that the reduced water availability affects local life cycles.

Droughts are actually a normal occurrence in world weather patterns but they happen seldom enough that people become accustomed to their absence and mold their lives around a moister "normal" environment. There is "a world wide correlation... the smaller the annual rainfall, the greater the year to year variation in the amount that occurs" (MacMahon, 1985). Unfortunately the increasing human population is putting additional pressures on the worlds drylands, the very lands that can least tolerate the intensive use.

Although droughts are a natural phenomena they can also be intensified and maybe even caused by human activity. It is thought that people accidentally altered the climate of the Indus valley and caused the decline of their own civilization 4,000 years ago (Bryson, 1977).

By changing the vegetation cover of the land the cooling and heating circulation of air can be altered, combined with excessive dust in the air, the whole moisture balance of an area can be upset. Today the Indus valley in eastern Pakistan and western India is called the Rajputana desert. Again, this is a very simplified example, groundwater changes and a myriad of other unknown factors could also have influenced the loss of the agricultural society in the Indus valley. There are other examples of similar human/environment trends.

CONVERSION TO NON-AGRICULTURAL USES

Another contributor to the loss of modern agricultural land is the conversion to non-agricultural uses such as: urban growth, housing, roads, warehouses; oil drilling; mining; dams and reservoirs. In the United States one to three million acres per year is converted to non-agricultural uses (Simon, 1984).

Some arguments are made that this form of land loss is not as dramatic as it seems, but that it is more visible than other soil degradations because the conversion is most likely to take place near population centers. A counter argument can be made that urban centers have historically begun around lush farmlands. Therefore the converted land was often highly productive and its loss proportionately even greater than the mere acreage. "In the U.S., as much land is lost to development as to erosion" (Paddock, 1988, pg.8), I do not have statistics for the rest of the world.

POLITICS AND POLICIES

I have written about many differing forms of land degradation and loss, all of which are influenced by human use of that land. What are some of the politics and policies which promote or cause some of the aforementioned phenomena?

The colonial history of many countries changed land use patterns drastically. Indigenous cultures which had evolved with the local ecosystems were disrupted and forced to adopt agriculture which was not native to their environment. In parts of Africa French colonialists demanded taxes to be paid in cash which forced a move towards a market economy, cotton was "originally introduced into some areas of Chad at the point of a gun" (Glanz, 1977, pg.180).

The arrogant human attitude of "us over nature" and "us over them" contributed to many of the abuses. Today some foreign investors in third world countries act as absent landlords, it is not their own backyard they are destroying with their beef cattle. Industrial countries' agricultural systems are often introduced over local historically successful systems. Government debts force cash cropping which then push subsistence farmers onto marginal lands. Politics have forced the settlement of nomadic peoples onto land which is best suited to a nomadic subsistence system. Boundary lines have been drawn through wars and politics, rather than with local sustainability in mind.

The Green Revolution which was supposed to grow food for the world was affected by politics also. It concentrated on large industrial systems, promoted irrigation, fertilizers, exports and cash crops. There was no research for local foods or dryland farming, therefore the benefits of the

Green Revolution were limited to many of the areas which were not most in need of help (Wolf, 1986).

Human caused degradation of the land has been going on for hundreds even thousands of years, but except for local populations and limited civilizations it has not been anything to be concerned about.

Until recently (the last hundred years or so) when population pressures became too great people were able to pick up and move: shifting agricultural societies in tropical forests, nomads in arid lands and European "refugees" to North America. Today, even without political pressures, the sheer number of people limit many of the options of yesterday.

Some people believe the problems we see are the result of these "sheer numbers of people". Our population is simply growing too large for a limited earth to support and feed (Ehrlich, 1978). Others believe that with technology to overcome some of the limitations, 24% of the total ice free land surface of the earth could be used for crops (Simon, 1984). With that increased acreage and with increased yields from already existing cropland we should be able to abandon (and restore) some of the marginal land currently in use and still feed the people.

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THE BLUE REVOLUTION

Harvesting food from the sea

-Kathy Jo Sullivan-

Throughout time, humans have looked out over the vast oceans and beheld an expanse that held immense wonder and unheard of secrets, a sea that must surely hold the future of our species in its depths. The oceans, which cover two-thirds of our world, are still frontier territory, holding riches of which human beings are only recently becoming aware. The supposition that the sea is rich seems to be confirmed by the immense swarms of fish and other life that can sometimes be seen in the ocean. Great schools of herring in the North Atlantic, seemingly endless numbers of tunas rolling in the Central Pacific, hoards of salmon surging up the spawning streams of Alaska all seem to indicate the expanse of the life of the sea.

Despite the differences between the land and ocean environments, food production follows the same basic principles in the sea as on land: All food is derived from living material, plant or animal, and all living matter originates as plant substance. All plant substance gets its energy to grow from the sun. Since the ocean covers 72% of the globe it seems only reasonable to say that the ocean absorbs the majority of the energy that makes it to the planet, and conversely, the majority of the earth's plant life can be found in the ocean.

It has been estimated that the ocean contains 250,000 million tons of nitrate nitrogen, 75,000 million tons of phosphate phosphorus, and similarly large quantities of potassium salts. The ocean has by far the greatest part of the earth's carbon dioxide - fifteen to thirty times as much as the atmosphere - and of the soluble carbonates. All the trace elements, some of which are essential to the production of protoplasm, are present in the sea in substantial quantities. Like so many of the land's riches, the plant nutrients of the sea are very unevenly distributed. Consequently the productivity of the ocean varies enormously from place to place.

Coastal areas generally are about as productive as some forests, moist grasslands, and lands under ordinary cultivation, but some parts of the ocean support no more plants and animals than deserts on land. Shallow regions at the edge of the ocean are often six to nine times richer than the poorer parts of the open sea, and coral reefs forty times as productive. Some estuaries are similar in productivity to evergreen forests and lands under intensive cultivation: they are fifty times as productive as some barren regions of the open sea.

In Herman Melville's introduction in Moby Dick, he describes an episode from Nantucket Island, once the center of a flourishing whaling industry. In 1690 people were standing on a high hill looking out over the ocean where numerous tumbling whales spouted their water cascades into the air. One pointed toward the sea: "There is the green pasture where our children's grandchildren will go for bread" (Melville,1932). Despite the indisputably large numbers of whales that once inhabited the seas, unrestrained whaling has led to extinction and near extinction for many species of cetaceans. This will be the same fate for many more marine species if unrestrained fishing continues.

Whale meat as food was a standard article in the diet of the meat hungry Europe of the mid 1900's. But the wasteful exploitation which has characterized most of our use of the sea and its products led to the untimely depopulation of many species of whales. Gradually, under the pressure of shortages in the supply of certain species, the attitude of conservation began to emerge. This "conservation" basically consisted of learning new ways of utilizing the entire carcass (Brittain,1952). This led to many new products and did actually decrease the numbers of whales killed for human consumption.

In response to the many years of over-exploitation, the International Whaling Commission has taken a series of conservation measures since the early 1970's and now all stocks that are below a certain level have been classified as protected from commercial whaling. At first the IWC was dominated by whaling nations. After 1979, non-whaling nations became increasingly significant as a majority of the membership. The change was reflected in the IWC's decisions, which increasingly opted in cases of scientific doubt for a cautious approach and the reduction of catch levels or the termination of whaling altogether for the species in question.

This trend led to the moratorium decision of 1982. Members have the right to object and continue commercial whaling or to catch whales for scientific purposes. There is a strongly held view in conservation circles that the "scientific purposes" clause might be used as a loophole by whaling nations (World Comm.,1987). Allowances for such hunting should be stringently monitored by the IWC.

An important political factor in recent developments has been the ability of the US Government to invoke legislation that enables contracts for fishing in US waters to be withheld from nations that undermine marine conservation agreements. Another important factor has been the strength of the non-government organizations in organizing support for anti-whaling actions, lobbying governments and organizing boycotts of fish and other products from whaling nations.

By 1987, whaling had been restricted to scientific research catches for Iceland and The Republic of Korea, and to a small catch for Norway. Norway continued to object to the moratorium, but it planned to halt its commercial whaling following the 1987 season. There were also continued catches by Japan and the Soviet Union, but both indicated they would join the moratorium after the 1988 and 1987 seasons respectively. According to Hiroyuki Ariyushi, the Japanese consul in Seattle, Japan has continued whaling under the "scientific purposes" section of the moratorium (Ariyushi,1989). Native peoples of the Soviet Union and Alaska continue to whale on a very small basis (World Comm.1988).

If the moratorium is respected, commercial whaling will no longer pose a threat to the remaining stocks of whales. The annual rate of increase for these whales will not exceed a few per cent. So the idea of sustainable whale populations will not be witnessed until the second half of the twenty first century.

Who? We must see now that the sea is not an infinite resource of food that can be plundered year after year, but rather a delicate balance of nature that with our help and care can and will offer to us immense supplies of nourishment that are so desperately needed.

Humankind has already surpassed the population numbers that we can support considering the actual distribution and amounts of food now available. The surge in human population is not the result of a general increase in birth rate, but rather a very significant drop in death rate. This reduction can be attributed to increased knowledge of nutrition and sanitation, and to the discoveries of methods for controlling disease. The most urgent problem arising from the increase in human population is the inadequate supply of consumables - food, fresh water, minerals, energy. Food is the most critical of these.

A fundamental truth is that regardless of the miracles of science and technology, everything required for human comfort and existence must come from the earth. A great many of the necessities exist in fixed amounts, and once consumed are gone forever; other resources are renewable, and, if skillfully managed may produce considerable quantities of material as long as the energy of the sun is supplied.

The problem is clear: The number of people on earth is already so large that 3 billion of them are hungry, and the numbers are increasing at such fast rates that humankind is faced with a truly disastrous situation, with starvation, misery, and wars as possible consequences. The ultimate answer can only be a marked reduction in the rate of increase in population to the point of zero population growth. No one would seriously advocate stemming the downward trend in death rates, so the remaining alternative is a reduction in birth rates. This is inevitable if humankind is to survive. Even with wholehearted widespread agreement and active implementation of effective birth-control measures it would be decades or generations before any large impact would be made on the population curve.

In the mean time we must turn our efforts energetically to the problems of producing more food for the swarming numbers of additional people who will inhabit our planet in the next few years.

The sea **might** hold the key to human survival. At the present time more than 96% of human food comes from the land, and it is certain that a high proportion will continue to come from that source in the future. While the sea provides a very small proportion of the total food consumed by humans, it has shown a rapid increase in the production of vital and scarce animal protein and offers many delicious and hardy foods that grow quickly and in great abundance.

More than half of the human population depends on fish for a great part of their animal protein. For example, in Portugal 36% of the animal protein consumed by its people comes from the sea(Idyll,1970). In other countries - Japan, Norway, Chile, Peru, and India for example - fish proteins are also of major significance.

The hungry of the world cannot wait for that recovery of the fish population, but there will be no choice if continued over-exploitation of the fish population is allowed to persist. At the present time the world catch is slowly gaining ground after having stabilized at around 70 million metric tons per year. There are those that say we are at our sustainable fish catch (Culliney,1976) and those that think we can increase fish yields up to 30 mmt more than that same 70 mmt levels and still maintain a sustainable resource (Royce,1987).

Despite the unresolved argument about the possible levels of global fish assets, the solution is not in pushing the resources to their limits but in supplementing the current levels through fish and plant cultures. There are many societies and countries that have practiced aquaculture for centuries.

The Resources Council, Science and Technology Agency, provided a rather conclusive definition of aquaculture:

> ...aquaculture is an industrial process of raising aquatic organisms up to the final commercial product within properly partitioned aquatic areas, controlling the envi-

> ronmental factors and administering the life history of the organisms positively, and it has to be considered as an independent industry from the fisheries hitherto.(FAO,1976)

JAPAN

Japan is one such country with an aquaculture industry. Japan has the longest history of aquaculture in the world and historically has been the largest supplier except during the period of the second world war and the years immediately following. "The production from aquaculture in Japan, a country with a long tradition of cultivating aquatic organisms, is steadily increasing" (FAO,1976).

This increase can be attributed primarily to the culture of four organisms: a red algae called "nori", a fish called "yellowtail", a shellfish or oyster "kaki", and another algae called "wakame". The first two are the major contributors, and are relied upon heavily in the Japanese diet. The higher the demand goes, the more aquaculture is relied upon to help supplement the natural resources and make available these highly valued sea foods.

In addition to the strong support the seafood resources receive from aquaculture activities, Japan was for many years the nation with the largest catch.1 Its fishery products are characteristically of excellent quality. But the Japanese government found it necessary to reshuffle their fishing fleets when the Law of the Sea Treaty jurisdictions increased resource

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1 See figure #1, "Fish catches by Japan 1948-1983"

FIGURE #1

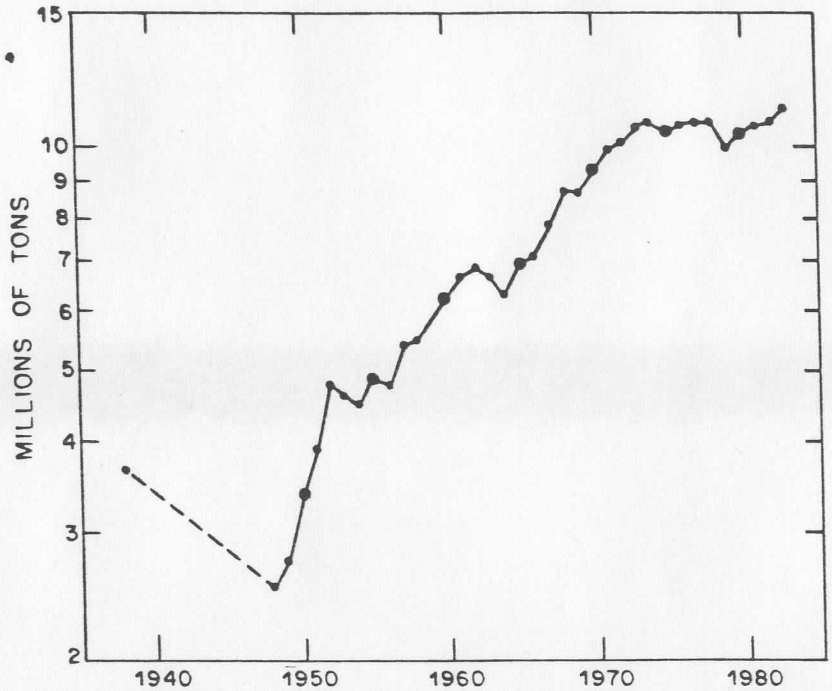

Fig. 6.4. Fish catches by Japan. Source: FAO "Yearbooks of Fishery Statistics, Catches and Landings," 1948-1983.(7)

rights, known as Exclusive Economic Zone or EEZ, to 200 miles off the coasts of all coastal nations. In fact a great many catches were slashed to half and less of most of their previous catches. This and the increase in oil prices during the early 1970's, and similar raises in the cost of ropes and other fishing gear, had a great economic impact on the Japanese fishing industry (Royce,1987).

The Japanese government undertook many steps to assist the fisheries. It encouraged the transaction from fishing to fish farming. It promoted consumption of species that were most abundant, and adopted a stricter quality control in all fishery products. It extended cooperation to foreign nations as part of fishing agreements; including grants in aid research, training vessels, shore facilities, technical advice, and education of trainees. It encouraged a private organization, The Overseas Fishery Cooperation Foundation, to support foreign assistance as a part of its strategy to increase or maintain access to EEZs. It provided about $650 million (U.S. dollars) to fishers who lost jobs in its vessel reduction program. Those who remained employed paid a higher license fee in order to assist those who had lost their jobs. It reduced fuel consumption by implementing mandatory reductions in engine speeds and by incentives to construct more efficient vessels (Moriya,1983).

Although Japan's fishery difficulties in the past have been effectively dealt with, they are not over. They are in need of more resources. They can still increase their resources gradually through their programs of environmental improvement. Catches off the coasts of other countries can be continued only through bargaining with each country, and all countries see the fish of their EEZs as resources to be used in their domestic interest. The only significant possibilities for increased fish supply are through fish farming or increased importing. Fish farming is far more to the benefit of the country than importing; Japan is already heavily involved in fish farming but can well afford to increase it substantially.

In addition to the aquaculture industry and the fishery industry, Japan has had a long tradition of harvesting the many species of seaweed that grow in great abundance off their coast lines. This harvesting is done in many ways, mostly by hand. One type is harvested traditionally by women year round. They dive to 10 meters and pick plant foliage by hand. Experienced divers can harvest 120 to 250 kgs. a day (Naylor,1976). This method allows for the most control on the harvests impact on the remaining plants, thus higher amounts of healthy plants remain to continue growing and reproducing for future stocks. This long standing tradition recognizes the need for sustainability and respects the natural growth of this so highly relied upon food source. Not only do the Japanese harvest as much seaweed as possible, but for centuries they have grown algae in aquatic farms. Over one third of the total production of the country comes from culture (Naylor,1976).

UNITED STATES

In contrast to the ancient ways of harvesting seaweed, the U.S. has one of the few seaweed resources that can safely and efficiently be harvested by mechanized techniques. The giant kelp (Macrocystis) forests off the southern California coast have been harvested effectively and at sustainable levels for years by a hay reaper type device attached to the stern of a flat bottomed barge. It cuts the weed down to the legal four feet below the surface, and the fronds are taken aboard the open barge by conveyor. Due to the rapid growth of the plant, any given area of the standing stock can be harvested three or four times a year (Idyll,1970). This species of seaweed and method of harvesting allow for extensive amounts to be harvested each year but the U.S. is not by any means a large supplier of edible seaweed to the world. In fact the U.S. is harvesting only 7,000 wet tons of sea weed from the Pacific when it has the potential for 3,550,000 wet tons of sustainable yield (Michanek,1975).

The United States has traditionally advanced in the area of the fishery industry.2 In fact the statistics on the U.S. catch is lower than actual catches because much of what is caught is not reported. This is because the U.S. is filled with "anglers" (300 for every one commercial fisher), and these fishers are not required to report all their catches. In fact, so much fish is contributed by the anglers of America that their catch brings the edible fish per capita up 2kg. Even with this contribution,

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2 See figure #2, "Fish catches, landings and imports by the U.S. 1948-1983.

FIGURE #2

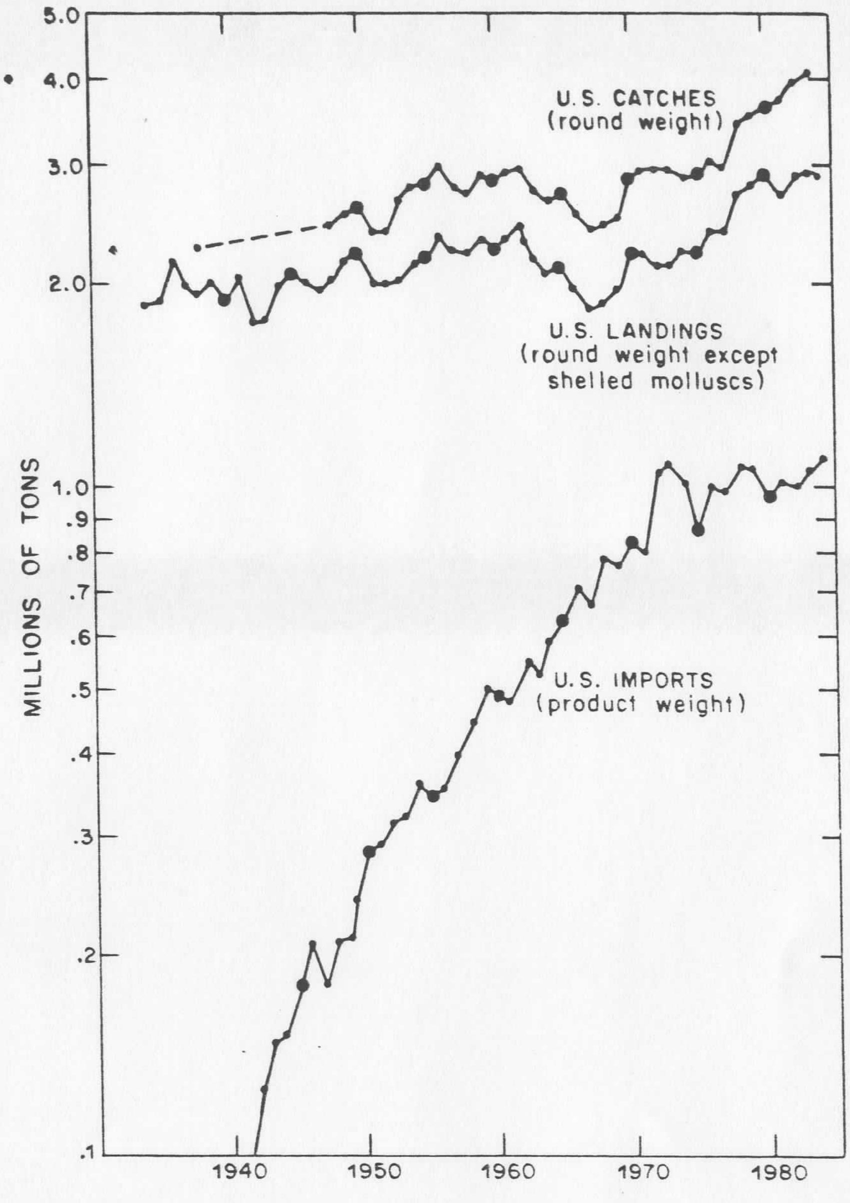

Fig. 6.5. Fish catches, landings, and imports by the United States. Sources: FAO, "Yearbooks of Fishery Statistics, Catches and Landings," 1948-1983,(7) and U.S. Annual Reports, "Fishery Statistics of the United States."(56)

bringing the total per capita up to 8kg, the American people still eat one-fourth the amount of fish the Japanese eat (Royce,1987). But this figure is steadily rising as the health benefits of eating less red meat become widely realized.

PERU

With the ability to surpass the U.S. and Japan in catches, Peru was once known to have the most fertile fishing grounds in the world.3 This impressive fertility is due to the westerly winds blowing off the west coast of South America. This wind takes the top layer of water and carries it out to sea leaving behind a vacuum that is filled by cold nutrient rich water slowly making its way up from the deep ocean floor. This cold water brings with it nutrients that have taken centuries to filter down from the lively surface of the Pacific to finally rest on the sea floor, until they are once again raised to the surface to serve as food for plankton and algae.

This abundance of the basis of the food chain, in turn offered life to the billions of tons of fish that have been pulled from the cold Peruvian waters to serve as a much needed food source for the people of South America. This source of human nourishment is all but demolished, even though the cold water nourishment still exists. Overfishing has brought the once active waters of Peru to a virtual stand still. Most of the overfishing is the result of too many other nations pulling as

3 See figure #3, "Fish catches by Peru 1948-1983"

FIGURE #3

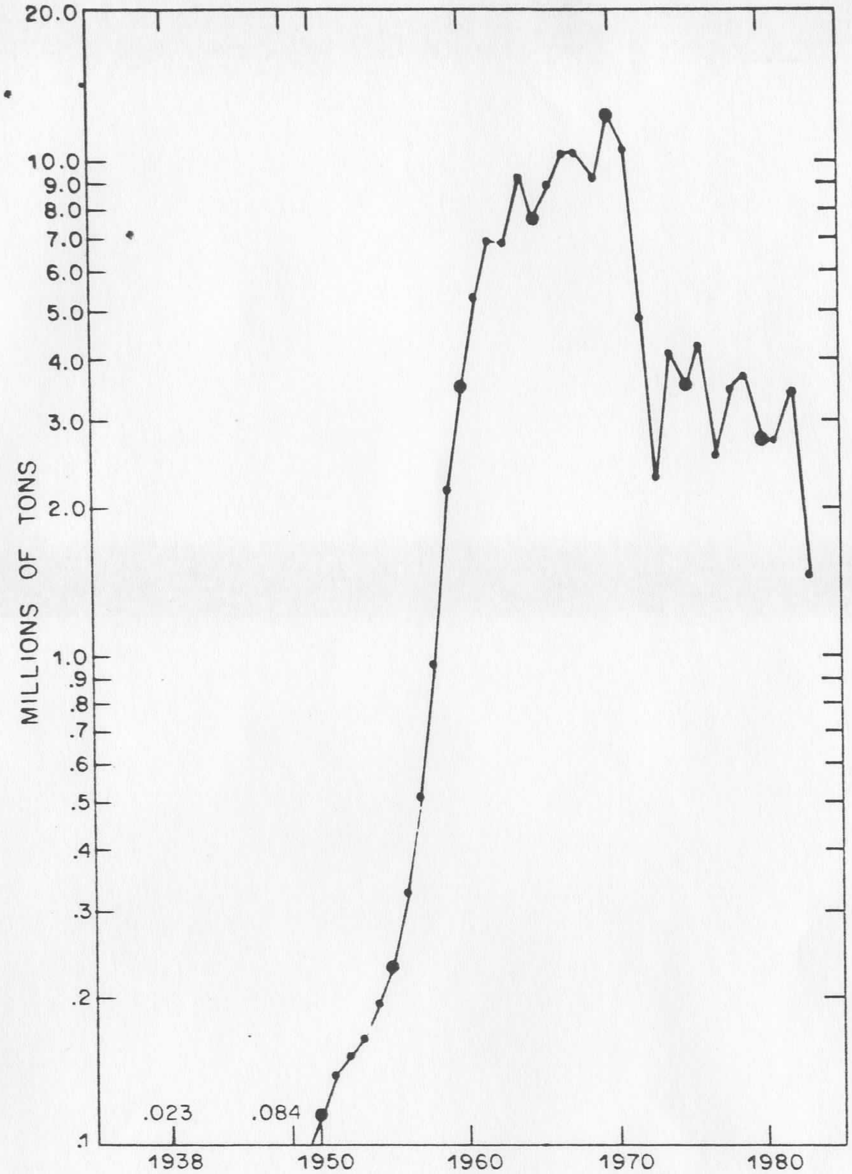

Fig. 6.2. Fish catches by Peru. Source: FAO "Yearbooks of fishery statistics, Catches and Landings," 1948-1983. (7)

much from the stocks as they possibly could. The race for the last fish is almost over.

Now, the native people that once depended on fishing for their living find it hard to get by, much less feed their children and themselves. To solve this problem for many out of work native fishers, Smithsonian researcher Walter Abey has stumbled upon a new line of work for these people who have always depended on the ocean for their lives.

It all started very far away from any fishing village in the world, in the living coral reef at the Smithsonian's Museum of Natural History (Miller,1985). In an attempt to avoid chemical imbalances in the coral reef, an adjoining tank was fitted with plastic screens that would grow a lawn of filamentous algae called "scrubbers". These algal scrubbers would clean the water in the main tank at night when the photosynthesis of the reef plants shut down but the reef organisms continued to breath and excrete wastes. The researchers were amazed at how fast the screens filled with algae. They found themselves scrapping the screens every few days, and soon realized they were getting more than 5 grams dry weight of algae per square meter of screen per day. This is about par to the productivity of the best terrestrial agriculture.

When the screens were tested in the ocean, suspended one foot below the surface near reefs in the Bahamas, some produced 20 to 30 grams dry weight of algae per square meter per day. The physical energy supplied by the strong ocean waves is suggested, by Abey, to be the key to the amazing productivity. However great the production of this scrubber algae, few people crave a diet of it. Abey concedes "Why fight food preferences and force algae into the mouths of even hungry people?" (Miller,1985,p.222)

The researchers turned to a creature that had become a nuisance in the Smithsonian reef, the tropical spider crab. "It turned out to be the perfect sea cow to eat our algae." Abey says. This grazer is easy to sustain through its short simple childhood of a few days. Then it settles down to a sedentary adult life of eating algae. When raised in a floating cage stocked with the fast growing scrubber algae, the crab grows to market size within a year and can be sold at $4 a pound at dock.

Abey believes that a mariculture industry for export and tourism would be a boon for the impoverished fishers who are currently without work due to the depletion of fish and shellfish in their natural workplace. The possible introduction of such a mariculture industry to native island peoples could earn them about $15,000 a year on a $5,000 investment. The scientists' research grants would supply the first few fishers with the necessary kit to get started. Then loans are expected to become available later so large numbers of fishers can buy the required equipment to go into business for themselves. This proposed program requires much labor, but most out of work people would rather work hard than not at all.

This method of creating supply of seafood where one was not available before is just one way of increasing the world's food supply. For years the practice of fish farming has been a great benefit to the coastal fishers of many countries. This procedure supplements the catch of an established fishing community by putting more stocks into the area. The stocks are raised in a controlled environment until they are large enough to have a higher than normal survival rate.

A prime example of effective fish farming is the hatching of salmon eggs,by the thousands, in captivity. The fingerlings are then taken to a pre-chosen release spot, submerged in the river, but confined in a pen for three days, then released. The bonding period of three days is enough to imprint the necessary factors so the fish can return to that exact spot when it comes time to spawn (Culliney,1976).

Some enterprises have been so bold as to have the returning salmon jump right into the cages they were raised in, to spawn. From there they are easily harvested. Since most species of salmon die after spawning, this way of fishing has very little impact on the survival of the species as a whole, as long as the responsibility of returning young fish to their natural enironment is continued with as much intensity as the removal of the adult fish.

Despite the obvious positive aspects of these and other techniques for increasing the sustainable yield from the sea, there are draw backs. As aquaculture evolves from small scale fish farming to the level of large scale agribusinesses, its problems increase with its size. It is expected by the FAO, that world aquaculture production will reach 140 million metric tons by the end of the century, nearly double the world fish catch. This increase will come only through the growth of large scale vertically integrated aquaculture enterprises. That is,centrally managed systems in which all components of the system, from original provision of energy to the final marketing of the product, are coordinated. The problems that will face such aquaculture enterprises could be (but not limited to) species limitations, site selection, feed, labor needs and legal institutional and financial requirements (FAO,1976). The UN FAO has outlined recommended courses of action to circumvent these possible problems to the quickly growing industry of aquaculture and mariculture (FAO,1976,pp.31-34).

Optimists in the area of food from the sea often think that plankton and krill should offer an abundance of nutritious food. This myth can quickly be dispelled.

The Soviets have, for many years, been trying to come up with a krill based food product that is both nutritious and appealing. Krill is a small shrimp like creature that grows in incredibly large numbers in the cold arctic waters. The crews of stranded vessels have been known to survive for months on this tiny crustacean. But it offers little attraction for anyone with anything else to eat. Although it is high in many vitamins and proteins, it is difficult to process into an inviting dish. The Soviets find it difficult to get their citizens to eat the product they have come up with, the translation for the name of this interesting food is "ocean paste", not a very appealing title (Borgstrom,1972).

Plankton on the other hand has had even less success than the krill. The harvesting of plankton can be done with fine nets, but extremely large amounts would have to be seined out of the ocean to offer any amount of food. That would be the smallest problem. The outer shell of this tiny organism is indigestible and very hard to remove (if not impossible). This "shell" is what filters to the bottom of the ocean and creates the super nutrient rich waters there. It can withstand many journeys through the digestive tracks of marine creatures that swallow it. "Plankton does not offer humankind a suitable and, and far less, cheap food" (Borgstrom,1972).

In addition to the problems the krill offer in marketing, and plankton offer in edibility, there is another consideration. The removal of krill and plankton will seriously effect the ecosystem of the antarctic. Krill and plankton are the main food source for baleen of whales, and many seals and seabirds. Penguins exist entirely on krill. If the harvesting of krill and plankton reaches the levels necessary to make it a profitable market, impacts on the whale populations could have dire consequences. This food source is not worth the competition it would put on the whales feeding grounds.

The prospects lie elsewhere in the search for sea born food stuffs. Fishing must be regulated to maintain sustainable natural fish supplies, and supplemented with ecologically sound fish farming. New sources of already accepted foods must be discovered and wide implementation of cultivation enacted. The use of seaweeds should spread and flourish with old and new harvesting techniques used where applicable. In short, the ocean offers many exciting ways of supplying food to the world's people, but imagination and prudence must be used to do this fully and in the proper perspective of maintaining the ocean for years to come.

JAPAN AS AN AGRICULTURAL MODEL FOR DEVELOPING WORLD AGRICULTURE

- Vincent Brown -

Japan has passed from what Marx called the Asiatic mode of production, into a satellite state of the global industrial complex, to its present position as the dominant economic power in the world, all in the space of 120 years. During this time it has maintained an agricultural system that favored an "economical and technical balance in favor of a small holding that could be worked efficiently, mainly or entirely with family labor, to yield a modest surplus."(Nair, 1969, 130)

This is remarkable when compared to a developed world that exports an agricultural model to developing nations favoring large land holdings, low labor inputs and technologically intensive farming practices, as a pre-requisite to economic development.

The four basic reasons given for expanding agricultural output are regarded as:

(i)supplying food and raw materials for urban/industrial sectors;

(ii)earning foreign exchange through exports or saving foreign exchange through import substitution;

(iii)selling for cash a "marketable surplus" to increase demand and provide a market for products in the industrial sector in the rural areas;

(iv)providing capital, and "investable surplus" to subsidize, even underwrite, the needed investment in urban/industrial sectors of the economy to facilitate or induce structural transformation of the economy considered necessary for modernization and development. (Meir 563-564)

In other words agricultural development has been used as the seed stock to provide capital for the development of the industrial sector. Yet millions are starving in the rural areas of the developing world and this insistence on development serving the needs of those in the urban sectors and providing exports, or capital, for future investments, denies the rural poor the opportunity to build a sustainable, agriculturally based lifestyle.

Japan's history directly speaks to the existence of an alternative model. By exploring the development of agriculture in Japan some of the underlying assumptions and attitudes that inspired the Green revolution come into question and perhaps we can begin to explore alternatives.

When measured from the sea floor to the peaks, Japan is perched atop some of the highest mountains in the world. The mountainous terrain has made cultivation in Japan difficult. Rice is the primary crop grown, 2.5 million hectares, or 40% of all arable land devoted to its production, (Noh 105) and rice paddies must be flat. The Japanese have responded by terracing hillsides, but even after two thousand years of slow expansion onto marginal lands, only 16 % of the total land mass is arable. Compare this against 24% arable land in the United States, 29% in the United Kingdom, 39% in France and 52% in Italy (Geography of Japan 191) and it underscores the fact that land shortage is the number one trait describing Japanese agriculture.

The Akaishi mountains are active volcanoes, having deposited enough volcanic ash to make the soil too acidic for most crops, including rice. Inversions are common, both to the east and west of the mountains, causing abundant rainfall throughout the year. While this solves some irrigation problems, it has led to leaching of the already bereft soil. (Noh 11)

The Japanese farmer has had to respond to the poor soil conditions with massive infusions of fertilizer and careful land husbandry. Throughout the Tokugawa period, (1603 to 1867) the soil was fertilized extensively using household nightsoil, grass and leaves. One tan.(2.55 acres) required a minimum of 70 to 80 cartloads in cut grass alone. (Nair, 1983, 15)

As cultivation crept up the mountainsides, by terracing grades in excess of 10%, farmers increasingly turned to commercial, organic, fertilizers. These included; dried fish, urban night soil, Manchurian soy bean cake, and phosphates.

These were used in addition to the already heavy use of farm and village produced fertilizers. The purchase of organic fertilizers frequently proved to be the largest single item in a farmers budget, often amounting to 50% or more of his/her total expenditure. (Nair,1983,10-11)

Heavy fertilization required careful soil management. Even today with a heavy dependency on chemical fertilizers, (second only in volume to the Netherlands) the Japanese farmer uses more organic fertilizer per acre than any other farmer in the world. (Nair,1983,11-13) In 1970 the per acre consumption of nitrogen in Japan was 111 pounds per acre compared to 13 pounds in the U.S. (Noh 106) Over time, soil conditions in Japan have steadily improved.

Japan has experienced a relatively stable state agricultural system for the past two thousand years. The present administrative districts were established in the 6th century A.D. In 1603 Tokugawa Shoguns unified the territory of Japan and institutionalized the Asiatic mode of production into a national system of taxation based on rice production. (Noh 124) The already hard pressed farmers had little recourse, in view of the limited land available, but to increase yields. The resulting agricultural system was highly efficient in terms of resource utilization. Production per acre becoming the most important determinate of success.

But increasing yields was not enough. Even when the farmer was able to produce a surplus, he/she faced a wildly fluctuating market. In 1715 rice sold for 230 momme per unit. Three years later it was selling for 33 momme. Yet the taxation rate, with few exceptions, remained constant. Often a farmer would be taxed for his/her entire crop of rice and had to rely on subsidiary crops for survival. A few cash crops were developed in the 18th century to market in order to buy back enough rice to meet the families needs (Noh 124- 128) - a situation not unlike that in much of the developing world today.

The Japanese industrial revolution began in 1867. At first the only change felt by the farmer was a loss of labor to the industrial centers, but soon farmers began losing their land as well. The Asian mode of production had guaranteed each member of an agricultural community the rights to a certain amount of private and communal land. The social restructuring that came with industrialization meant that now property could be bought and sold, and therefore, concentrated in the hands of a few. The size of the farms remained the same, but many farmers found themselves working for absentee landlords.

Japan's population had previously remained stable at about 30 million,(Noh 13) but along with industrialization came an increase in population. The loss of labor coupled with increased demand placed the farmers under even more pressure to produce ever higher yields. By 1935 the population had increased to 68.66 million, (Dulfer 149) but the area under cultivation had only grown by 20%. Yield, however, rose by 75%. (Noh 155) The average production of rice per acre from 1883 to 1887 was 2047 lbs. For the years 1903 to 1907 it had risen to 2,985, and by 1933 to 1937 the average was 3,657 - resulting in a yearly rise in resource utilization of 0.5%. (Nair,1983,11)

The farmers increased their yields using such techniques as; more careful seed collection, testing seeds in a saline solution for germination and soaking seeds till they sprout in order to lengthen the growing season. Maximizing the number of plants, shifting from dry cultivation to wet, irrigation expansion, improved water management, and using oil as an insecticide, also played important roles. In 1880 when no "scientific " methods were in use the output per acre was 3 times higher than in the U.S. in 1970. Yet in three hundred years the Japanese had not known what would be considered a revolutionary change in technology, or organization of their agriculture. (Nair,1969,176) They had simply taken the existing peasant level technology and applied it more diligently.

After the war Japan received massive infusions of foreign aid to help rebuild their war torn economy. They redistributed the land and instituted massive reforms aimed at creating "a unimodal system of small owner-cultivated family farms of near equal size." (Nair,1983,13) This was primarily a protectionist act to guard against the farmers previous exploitation at the hands of absentee landlords, and to limit the maximum size of each holding.(Smith 35)

By 1951 agricultural production had returned to pre-war levels, (Noh 11) and industry was booming. In the early stages of the post-war period priority was given to industrial growth. Japan was successful in this regard but at a high cost - pollution - and the resulting environmental degradation. However, very little of this was the result of agricultural practices. The Japanese farmers penchant for careful land husbandry had led to farms in the twentieth century that have maintained their fertility and yield, and have a low environmental impact.

117 million people live in Japan today - 655 per square mile - giving it the highest national population density figure in the world. (Geography of Japan 380) There is only .06 hectares of agricultural land per capita, with 10 % of the population engaged in agriculture as a livelihood, compared to 50% prior to the war. (Durrell 171)

In the face of Japan's spectacular success in the industrial sector, agriculture has come to occupy less of an important position in Japan's marketplace. between 1960 and 1975 the proportion of agriculture in the net national product fell from 10.2% to 5%.(Geography of Japan 199)

The Japanese farmer produces 13,000 potential food calories per day, feeding 3.7 persons per acre and continues to be the number one producer of rice in the world. (Noh 113) Between 1878 and 1962 agricultural production in Japan tripled, but the farm labor force remained constant. Japan obtains 1,100 kilograms more rice per acre than the United States, furthermore, total farm production, yield per acre, and yield per capita, have been consistently higher than the United States, the United Kingdom, France, or West Germany, from 1880 through 1970.(Binswanger 83-87) This in spite of the fact that, "5% of the rice land in Japan is not irrigated, a good deal is double cropped, and all of it has been sowed to rice at least once a year for hundreds of centuries before the American soil was first plowed. "(Noh 109)

The only way in which Japanese agriculture has fallen behind is in its labor to yield ratio. In 1960 the average Japanese farmer spent 49 hours producing 100 kilograms of rice, his/her counterpart in the United States spent 1.3. For other commodities the disparity is as great or higher. (Noh 106) By adopting practices of direct seeding as opposed to traditional transplanting methods, the Japanese farmer could cut her/his time in the field from 1819 hours to 465 hours. But the Japanese farmer has resisted such labor saving methods largely because it might mean a drop in total yield. (Noh 118) As one farmer stated,

> "land productivity is still the important consideration to me and to other farmers. That is why the practice of direct seeding is not spreading." (Noh 120)

The devotion to yield, with it's resulting labor intensive, care laden techniques, is precisely why the Japanese have maintained such fertile soil and are not experiencing the environmental problems inherent in more heavily industrialized agricultural practices.

Since the war, the Japanese government has continued its protectionist attitude towards agriculture, stiffening land tenure laws and restricting agricultural imports in order to maintain domestic markets. One effect of this policy, when combined with labor intensive agriculture, is high prices. In 1988, 50 pounds of rice cost the Japanese consumer nine times what her/his counterpart in the United States would pay.(Yuize 91) Recently the Nakasone administration has been under extreme pressure, both domestically by disgruntled consumers and developers, and internationally from foreign competitors who want open access to the Japanese market, to deregulate agriculture. It is not clear how the administration will respond. If they give in to the pressures for deregulation, the fragile soil, so carefully built over centuries of farming, will most likely deteriorate in the face of large scale, American style, farming practices. We can only hope that Japan's lengthy history will contribute to its ability to see a future and husband the land in such a way as to provide for it. Japanese farming techniques may not be profitable in a highly industrialized, capitalist, world market, but what is profitable, is not always best for the land, or its people.

Japan has shown that it is possible to modernize a peasant agriculture without creating an indigent class of landless workers or an unwanted surplus of farming households. Moreover they have steadily increased yields for over two thousand years, while at the same time, improving soil fertility. While its true a unique constellation of historical and geographic factors were responsible for Japan's success and those factors cannot be replicated, we are able to use this as a case study to better understand what kinds of farming techniques would be most successful in the developing world, and how best to motivate developing farmers to accept them as viable alternatives to already entrenched farming practices.

"Output per unit of land is the key problem in many underdeveloped countries." (Nair 110) Given that this is true, Japan's high yield, low technology, farming practices are an invaluable model to developing countries. Fertilizer use, as has been shown, when combined with careful land husbandry, can increase yields without degrading the soil or the environment. Such techniques as increased weeding, careful planting, transplanting in straight lines, selection of better seed using salt water, etc., can all contribute to higher yields as well. However, all of these techniques require a high commitment of labor. While there is no shortage of labor in the developing world, there are a multitude of attitudes, beliefs and circumstances, both from outside the cultures in the form of Green Revolution extension services and technology, to inter-cultural pressures, that have led to the present agricultural dilemma.

It is clear from Japan's example that in order to change the agricultural practices of a people you must first address the traditions and ideas that surround agriculture in that society. This will be more effective than any number of technological improvements. Differences in the level and efficiency of using chemical fertilizers today reflect exactly the same regional patterns as in the previous use of organic inputs, (Nair 10) and this pattern of use has no correlation with exogenous factors. In other words, those that practiced intensive farming in the past continue to do so with new inputs - those cultures which historically have not fertilized, as in India, continue to lag behind. (Ishikawa 29)

In 1969, William S. Gaud, then director of AID, described the Green revolution as important because it "added an element of drama, an element of excitement- some sex appeal if you will - to agricultural production." He went on to say that it made,

> "...the normally complicated business of the development process - how to get a country to develop, how to get people to change their attitudes - suddenly come down to a very simple proposition: one man seeing his neighbor doing better then he was doing." (Green Revolution 28)

But as was shown with the Japanese, profit is not always the motivating factor in making agricultural decisions. Throughout history farmers in Japan have "nurtured the land with a care and concern more akin to that of a mother for a newborn rather than of calculating economic agents." (Nair,1969,10)

The notion of "doing better" can exhibit itself in many ways. For the Japanese farmer we know it's total yield per acre that describes success. For a male in Zimbabwe it's the amount of goat meat he consumes and due to the intricate social system that describes his world, a higher rate of agricultural production may not guarantee him access to increased goat consumption. (Anthony 116 -138) In Bengal, during the great famine of 1943, not even survival could motivate people to ignore their societal aversion to wheat. The United States and Europe shipped tons of wheat to the stricken population as aid, but many preferred death to changing cultural patterns of consumption.(Brown 11)

This adherence to tradition to the detriment of economic profit can also explain why,

> "In a modern, democratic, and prosperous Japan, the majority of farm families continue to supply labor for the repair and maintenance of their village roads and for desilting and weeding farm ditches just as they did in feudal times. Despite the sharp decline in the relative importance of agriculture in the total economy and an acute shortage of labor on the farms, only 0.3% or less of the customary community operations of agricultural Shuraku (hamlet) in the country was performed by hired workers." (Nair,1983,114-115)

Development agencies often assume that if an individual has access to land, labor and inputs, and if the economic incentives are "right", she/he will respond in a "rational" way. The above examples reveal this to be an erroneous assumption.

This calls for a careful assessment of the traditions and ideas that surround agriculture before development agencies attempt to provide increased resources, technology and assistance. It is not enough to presume that a farmer will want to increase production, even if he/she is presently producing below subsistence level. Any assistance must be tailored to meet the diverse needs of the subject.

As the earlier quoted directives for agricultural development indicate, however, much of the purpose of agricultural development is not to meet the needs of a developing rural culture, but to transform that culture into one that more directly serves the urban/industrial market. Using Japan as a model suggests that aside from the issue of exploitation, this policy promises little in the way of sustainable agriculture. The affects of industrial agriculture worldwide are startling - from pollution, to desertification, deforestation, and species loss - we feel its affects every day as the available cropland shrinks from abuse, and poor management. Japan, however, has shown that even while the increase in production has outstripped population growth, the integrity of the environment can be maintained.

The issues facing agriculture in the developing world are of global concern. Problems of overgrazing, erosion, and deforestation, to name just a few, are problems that threaten the survival of people everywhere, not just those on marginal lands. In looking for solutions we must recognize that they will not be found in new technologies. The problems are those of distribution, industrialization, and new methods of social organization that are not consonant with existing cultures, or sustainable development. If industrialization requires mass migration to the cities and sustainable agriculture needs labor intensive methods than these two goals are clearly at odds.

Agricultural development is not a lost cause, just a difficult one. If our intent is to push the developing world as quickly as possible towards industrialization at the expense of the lives of the rural poor, then the present environmental degradation, and world wide famine are probably a necessary step. If, however, we want to help the millions in the world, who are presently barely surviving, achieve self sufficiency, we must drastically alter our programs.

Why import alternative agricultural methods to the third world if yields can already be increased using existing peasant level technology? Instead of waiting for scientists to invent "modern" packages of technology and inputs for the developing world, it is time to trust the local farming communities, they alone know the needs of their local environment. Rather than investing in largely unproductive national institutes and research systems, it is time to invest directly in the peasants who produce the crops.

In order to make a difference in the lives of the rural poor we need to learn to listen to their concerns, and respect their ways. In the words of Shithembiso Nyoni, executive officer of ORAP, (Organization for Rural Association for Progress), Zimbabwe,

> " If I were one of my countries rulers, I would go back to the people; now it is no longer a question of keeping up with the Joneses - it is a question of survival for the village women of Africa. Survival is a creation of the peasant who is involved in the struggle, who is taking control, who is trying to live under very difficult conditions.
>
> If I do not control food, there is nothing else in the world I can control."

CONCLUSION

What is Agriculture? The common assumption is that it is a way to feed ourselves. But for much of the world agri*culture* has become agri*business.* In the course of our research we have come to question whether agricultural practices oriented towards developing a strong industrial sector are consonant with the goals of sustainability.

The twentieth century fishing industry has exhausted the supply of fish in many previously fertile fishing grounds, and threatened the survival of the species as well as those dependent on fishing. Mismanagement on the part of the agricultural industry has led to massive erosion and desertification. Inappropriate technologies have been introduced when peasant level techniques would be more efficient and productive. In all of these cases the appropriate level of use has been ignored in favor of agricultural practices that promise high, short term, profits.

We are not suggesting that there are no technological solutions. Some may exist. But the introduction of new resources and new technologies must be appropriate. In the fishing industry, technology can supply new methods of supplying not only food sources but jobs for many out of work fishers. The introduction of fertilizers can increase yields while maintaining soil fertility. Irrigation, if done properly to guard against erosion and leaching of nutrients, can lead to increased production on existing cropland. But in all cases the level of investment should be local, targeting the local community.

The agricultural industry must stop managing for quick profits and cash crops and start managing for sustainable yields to feed the people.

Agriculture is not just how we feed ourselves but is political in nature. Much of the developing world is caught in a struggle for self determination, and agriculture is fundamental to that struggle. Until the people of the world are allowed to feed themselves and control their own food sources we cannot realize a world wide level of sustainable agriculture.

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