AGRICULTURAL PRACTICES, PROBLEMS, & PROSPECTS FOR ANNUAL CROPS IN USE ON THE TRANSAMAZON HIGHWAY

Philip M. Fearnside
Department of Biology
University of Michigan
Ann Arbor, Michigan 48104

October 20, 1975

TABLE OF CONTENTS

I.) INTRODUCTION:

The present paper forms a part of a general overview of the agricultural system in the colonization area of the Transamazon Highway as a prelude to modeling the system for the calculation of its carrying capacity for human populations. This paper deals with the part of the agricultural production process related to annual crops. Other parts of the system such as perennial crops, domestic animals, and hunting and gathering will be treated separately. Yield relations with soils nutrients, planting density, interplanting, variety, and in some cases disease, have been treated separately for the six most widely-planted annual crops (Fearnside 1975). Also being treated in a separate paper are the parts of the agroecosyst which interface with the agricultural production subsystem, such as land clearing, land use allocation, and allocation of products to storage, sale and consumption, among others.

The present paper gives a discussion for each annual crop of the extent of the crop's occurence, agricultural practices such as planting, weeding, and harvesting as practiced in the colonization area, plus an evaluation of problems such as insects, weeds, vertebrate pests, and plant diseases. Apparent trends and future prospects are also discussed for each crop.

Particularly for the six major annual crops (rice, maize, Phaseolus beans, Vigna cow-peas, bitter manioc, and sweet manioc) the information related to frequency and size of plantings, labor requirements in different seasons, and contributions to yield variabilit from pests, weeds, diseases, etc., will be important for inclusion in the carrying capacity models.

II.) CROPS AND AGRICULTURAL PRACTICES:

A.) RICE:

1.) OCCURRENCE:

Virtually all colonists plant at least some upland rice. Plantings range from subsistence plots of a hectare or less to cash plantings of as much as 25 hectares. Financing policies in the past resulted in many colonists making financed plantings of about six hectares, but the areas vary widely. Rice is the most important cash crop in the area at present.

2.) PLANTING, INTERPLANTING, AND VARIETIES:

Upland rice is planted just after the beginning of the rainy season from the end of December through February, with most plantings being made in January. Planting is occasionally done with a machete, but usually is done with a hand planting machine. Densities vary widely: a median of 25 kg/ha of seeds were planted in 42 fields, with the range from 12 to 45 kg seeds/ha. The number of seeds per hill varys, but is usually around 20-30, and the spacement also varys widely with the median of 42 fields being 95,000 hills/ha and the range extending from 17,000 to more than 200,000 hills/ha. Both seeds per hill and planting density are somewhat different from the five seeds per hill and 111,111 hills per hectare recommended by IPEAN (Lopes et. al. 1973).

Rice must be planted in fairly clear ground, and so requires a more thorough coivara than does maize. For this reason rice is usually planted where the best burn has been obtained, and maize in the places that burned less thoroughly. Usually a weeding is required just before planting. Women and children over about ten years of age often help the men with planting.

Some colonists plant early (in December) with the intention either of re-using the same area for a subsequent crop of beans (which are planted in April and May) or of getting a small second harvest of rice from the resprouting stumps. Harvesting the resprouts can add about 60 kg/ha to the final yield. Planting early, however, carries the risk of having to harvest the rice before the rainy season has ended, which can cause losses. Toppling can be more of a problem with early-planted rice. There is no planting of more than one rice crop per year: there is no irrigation.

Late planting can also result in reduced yields due to weather factors. If maize has been interplanted with rice, late planting of rice can cause further reduction in yield due to the increased shading from the taller maize. Numbers of colonists planted somewhat later than they otherwise would have this year when INCRA seed being distributed in the area did not arrive until the end of January.

Colonists making large plantings of rice are wise to subdivide the area into several parcels planted a few weeks apart. This reduces the need to hire supplementary labor at harvest time. There may also be some added advantage in insuring that at least some of the planting will fall in the unpredictable best time from the point of view of weather. This last factor is not so important for rice as for some other crops, noteably beans, and it is usually the labor consideration that motivate split planting dates.

There are several rice varieties in use in the area. Most common is IAC-1246, which was distributed by INCRA in 1973/74 and 1974/75. Some colonists are also still using IAC-101, which was distributed by INCRA in 1971/72. Some also use the traditional variety Canela de Best yields are obtained with IAC-1246 and IAC-101. Canela de Ferro does have the advantage of being less prone to toppling, and I suspect there is more leeway for late harvesting before the seeds begin fallin out of the panicles. There are a very few colonists who have made small plantings of other varieties. The Barbaria variety that was distributed by INCRA in 1972/73 and proved succeptible to the fungal disease <u>Helminthosporium oryzae</u>, Van Breda de Haan, has disappered from the area. It is not uncommon for colonists to have different parcels planted with different varieties. The distribution of INCRA seeds in the area, along with the former requirement that they be used in financed plantings, has undoubtedly resulted in an abnormally low diversity of varieties being planted. This may change now that the INCRA seed distribution program has ended. With colonists planting several different varieties the chances should be reduced that an area-wide crop failure due to disease such as the one that occurred in 1973 wil re-occur.

Interplanting of rice with maize or with manioc or with both maize and manioc is common, although not universal. Interplanting with maize alone is most common. Densities of the interplanted crop vary widely, but maize is usually planted in widely-spaced rows (carreirões) about 5-6 meters apart, with about two meters between plants. When manioc is added it usually is planted with one manioc plant between each maize plant in the same rows. Maize is planted before the rice. Manioc is usually planted after the rice, but sometimes it is planted before and the tops trimmed back. Whether or not the manioc is trimmed should have an effect on rice yield. The relative planting dates of the different crops planted together in an interplanted field affects the amount of competition between them and the resulting yields. The relation of interplanting to rice yields, as well as the relations of rice planting density, variety, and soils,are discussed elsewhere (Fearnside 1975).

3.) <u>WEEDS, PESTS, AND DISEASES:</u>

Rice requires that more labor be spent in weeding than in most other crops. Two or three weedings are required after planting, and reduced yields result if adequate weeding is not done. The timing of the weedings may also have an effect, but this is hard to quantify. The amount of weeding required depends on the burn quality and on the age of the field, older fields requiring more weeding. Weeding is usually done with a hoe (enxada) although sometimes weeds are pulled by hand. Women and children help in the weeding, and paid labor is seldom required.

Insect losses vary from year to year. Numbers of colonists complain of having lost rice to a leaf-eating lepidopteran larva in 1972, but damage has been slight since. When rice is kept in piles (pilhas) for long periods between harvesting and threshing, there may be severe losses to moths and beetles. Damage varies from colonist to colonist, between different piles and different parts of the pile.

There are several vertebrates that cause damage to rice. When rice seeds are first planted they are dug up by lizards and by rodents. Rodents also eat the young rice shoots. Rodent damage is greater near the edges of the forest. Rats also eat the heads of rice that touch the ground if the rice topples, eat the rice while it is drying before being piled, and eat it while it is stored in the piles awaiting threshing. There is also a bird (chico preto) which eats the ripe heads just before harvesting and eats the rice while it is drying before being piled. Vertebrate damage, especially from rodents, varies between colonists and between different parts of a field.

Disease, as already mentioned, caused tremendous losses in the 1973 Barbaria rice. Barbaria had been brought from Pernambuco without previous testing under Amazonian conditions. Many colonists got no harvest at all. Light attacks of the same Helminthosporium sometimes produce some symptoms on the more resistant varieties, as does the blast (brusone) Piricularia oryzae, Bri. & Cav., but only an occasional colonist complains of losses.

Chemical treatments can reduce some of the insect and rodent losses. Seeds supplied by INCRA are already poisoned with aldrin, and many but not all colonists use aldrin on seeds bought from other sources or produced on their own lotes. Aldrin is the most effective for preventing rodents from digging up the seeds. A few use Gesarol 33 (formula: 4.5% 1,1 bis-(p-chlorophenil-2,2,2-trichlorostan + 0.5% gamma 1,2,3,4,5,6-hexachlorocyclohene). This powder is only good for insects and does nothing for rodents. A few dip the rice seeds in kerosene before planting, but this technique often results in killing the rice seeds if they are left in the kerosene too long. Gesarol is sometimes sprinkled on the outside of the rice piles, which may help reduce moth damage somewhat.

A very few colonists have used some sort of spray or other treatment while the rice was in the field. Several tried this during the attack of Helminthosporium in 1973, but to no avail. The high price of chemicals plus the relative healthiness of rice in the field discourage this. No fertilizers or liming are used on rice, and the price would be prohibitive if these were used.

4.) HARVESTING:

Harvesting takes place from May through July. This is usually done only by the men, although occasionally women help some. Harvesting must be done quickly, otherwise there are losses as the grains loosen and fall from the panicles. If the rice begins to topple badly, immediate harvesting is also required. The need for large amounts of labor in a short period of time means that supplementary labor must be hired if large plantings are involved.

Harvesting is usually done with sickles, cutting the stalks off about 10 cms from the ground and placing the bunches of rice on convenient stumps and logs for drying. After drying the rice is usually not threshed immediately, but is stored in piles called "pilhas", which are long roof-shaped heaps of rice draped over logs in the field. The rice must be layered in the pilhas in a very precise way to prevent wetting and spoilage. Several inexperienced colonists lost rice in the early years due to improperly constructed pilhas. The length of time rice is left in the pilhas varys greatly, sometimes extending until October. This may be because of waiting to use an INCRA threshing machine, waiting for a better market price, or waiting for a travessão to be opened in the case of those in closed travessões. Since rat damage is usually less in the pilhas than in rice which has been threshed and sacked, it is best to leave threshing until just before selling time.

Threshing (bateção) is done both by hand and with threshing machines. The cost is about the same: INCRA provides the use of of the machines for a fee of Cr$ 3,00/saco (a saco is now 50 kgs, having been re-defined from the previous 60 kgs in 1974 by the Banco do Brasil), which is about the same as the cost of threshing using hired labor. The machine has the advantage in that no cash is needed as the cost is put on an INCRA account which is paid later through direct deduction from the value of rice sole to the Banco do Brasil. The machine is also quicker and easier and gives cleaner rice with less broken grains. INCRA maintains tractors in the roadside agrovilas which are used to tow the threshing machines to the colonists' lotes, as well as for hauling sacked rice out of the travessões by cart. The services of the tractor are also not paid in cash, but are put on the colonist's INCRA account. Three colonists in the intensive study area also have threshing machines of their own which were bought on credit. The colonists were convinced to buy them by a salesman that passed through the area in 1973, but the machines have proved easily breakable and parts for them are hard to find, with the result that only one is still functioning.

Hand threshing is done either on a threshing platform, which is a waist-high platform of sticks lashed together with a cloth curtain rigged as a backstop to catch flying rice grains, or it is done on a convenient log. A tarpaulin or sheet of plastic is spread on the ground to catch the threshed rice. Bunches of rice are picked up by the stalks and beaten on the log or platform. Debris is fanned from the fallen rice, and the rice is sacked for transport and storage. The amount of rice that can be threshed in a day varys, usually being at least 6-8 sacos of 60 kgs per man, being more when the rice is well dried. Hand threshing has the advantage over the machines of using family labor rather than money, but if paid labor is used this must be paid in cash. Threshing is strictly man's work.

The straw left after threshing is usually burned, it is not composted or allowed to rot in the field.

Milling (beneficiamento) is done only for rice to be consumed by the colonist's family. This has so far been largely done by hand by women using a traditional mortar and pestle (pilão). CIBRAZEM, which mills rice which has been sold to the bank, also mills rice for the colonists (for a fee) on one day per week. Because this involves a trip to Km 46 with no guarantee that the rice will be milled that week, few colonists from the intensive study area have taken advantage of this. A private milling machine has recently been installed by a newcomer colonist who bought the lote facing Agrovila Grande Esperança. This may replace the pilão in the area for those colonists that can afford it.

The chaff left after the milling process has not been used. Until this year CIBRAZEM at Km. 46 burned all of the chaff produced by their milling. They stopped this year, perhaps as a result of my having pointed out the tremendous waste this represents to some of of their staff. The chaff is now left in a huge pile outside the milling plant, and remains unused.

B.) MAIZE:

1.) OCCURENCE:

Most colonists plant at least some maize, but relatively few plant it as a cash crop. The great sensitivity of maize yields to poor soil conditions has caused a few colonists with poor soil to discontinue planting it. The relations of maize yield to soil quality, as well as the relations with planting density and interplanting, are discussed elsewhere (Fearnside 1975). The relatively low market value of maize, in addition to the variety of hostile conditions resulting in poor yields, has discouraged its use as a cash crop. Maize was financed as a cash crop in the early years, but maize financing has since been discontinued. Only a little maize is consumed directly, its primary use being feed for domestic animals.

2.) PLANTING, INTERPLANTING, AND VARIETIES:

Maize is normally planted in December, just after the beginning of the rainy season and before the beginning of rice planting. There is only one maize crop planted per year, although one colonist in the intensive study area has been pleased with the results of an experiment he did on a small plot of his land planting in October and harvesting in March and then planting the same area again in May and harvesting in October. Maize planted early seems to do fairly well, especially if it is a small plot intended to be eaten green rather than dried for animal feed. I suspect weevil attack in the dry ears may be worse for early-planted maize. Maize which is planted late, as in March, does very poorly due to weather factors.

Maize planting is usually done with a hand planting machine, and is usually done by men. Since plantings are almost all either small in area or are sparcely planted "carreirões" interplanted with rice, the labor demand for planting is not great. Patches of ground that have burned poorly or have unburned material not removed in the coivara are often planted with maize with the better-cleared portions reserved for rice. In Venezuela, Harris (1971, p. 492) had observed maize being planted on well-cleared ground as contrasted with manioc. On the Transamazônica manioc is usually planted after the ground has already undergone a coivara for a previous rice crop, and it is maize that is relegated to the tangle of branches when the burn is poor and there is little time for coivara.

Spacement of maize varys widely. For maize planted alone the median of 22 fields is about 7000 plants/hectare, but values range from 1500 to 17,000 plants/hectare. For maize interplanted with rice alone, the median maize planting density of 75 fields was 6000 maize plants/ha, but the range was from less than 1000 to 11,000 plants/hectare. These densities are of those plants that survived rodents, insects, and germination problems to become adult plants.

Most maize planted is interplanted, usually with rice but also with either manioc or both rice and manioc. When cow-peas (feijão da corda; *Vigna sinensis*) are planted, the already dry maize serves as a trellis. Occasionally other plants are interplanted, as in the early stages of plantations of permanent crops.

The variety which has been distributed by INCRA is Centralmex. There are both hybrid and traditional "comun" varieties available from private sources. An occasional colonist plants a few plants of popcorn as well. The hybrid and "comun" varieties do not show much difference in yield in the field, and IPEAN variety trials have also been unable to show any significant differences between varieties tested (Viégas & Kass 1974, p. 25). More colonists have used non-INCRA seeds for maize than for rice.

3.) WEEDS, PESTS, AND DISEASES:

The number of weedings required varys, and is usually either one or two, more often two. Maize requires less work in weeding than does rice. There is some variation in the weediness different colonists tolerate in their maize fields. Women and children sometimes help with weeding, as with other crops. Weeding is done by hoe, herbicides being quite expensive.

Insects are a major problem with maize. When the maize plants are young it is common to see five or six different species of insects feeding on different parts of the plant. Most serious are those that cut through the stem near the base felling the whole plant. It is not uncommon to see at least 10% of the plants seriously damaged while still young. Once the ears are formed and drying, weevil attack can be a very serious problem. Weevil losses vary from colonist to colonist and from year to year. Old farmers in the older settled area North of Altamira claim that every few years there is a great outbreak of weevils with heavy losses for everyone, and in other years there are very few. This is supported by the greater losses that occurred to weevils in 1974 as compared with 1972, 73, and 75 in both the older area and in the study area. In 1974 many colonists had maize that was so badly damaged that it was unsuitable for use as seed, and the few with good quality maize were able to sell it for a high price at planting time when the arrival of INCRA seeds was behind schedule.

Rodents are also a severe problem for maize. If the seeds are not treated with aldrin before planting, the losses of seeds to rats, agoutis, etc. before germination can sometimes be near total. Losses vary greatly, however, from colonist to colonist. They are greatest near the edges of the fields. Later when the maize ears are formed and after they have dried, the rats climb the maize stalks and eat great holes in the ears. This damage also varys from colonist to colonist, and in the most severe cases can affect almost all of the ears in a field. The extent of rat damage to the ears also depends on how long the dry maize is left in the field.

The use of aldrin on the seeds is the only chemical treatment used, although not all colonists treat their seeds. INCRA seeds are already treated before distribution. The high cost of pesticides mitigates against their use on a low-priced subsistence crop such as maize. Fertilizers, although IPEAN experiments have shown them to be effective in increasing yields (Cruz et. al. 1971), are prohibitively expensive in the area. Liming is also uneconomical and is not used.

4.) HARVESTING:

When the ears are formed but not yet dry the colonists harvest a little maize for eating green. In April and May when the maize planted in December is dry, colonists usually bend the stalks over about two-thirds of the way up the stalk and leave the maize in the field ("virar" or "dobrar milho"). The folded-over maize is left in the field until needed, usually being harvested a few ears every day for feeding to chickens. In spite of the damages from rats and weevils in the field, the damage to maize stored in the colonist's house is likely to be even greater. Any maize still remaining in the field by about October is then harvested for sale or storage. If the colonist intends to sell the maize he often harvests it earlier. Sometimes colonists do not fold the maize over, and harvest it directly, usually in July or August. Some colonists even leave piles of ears in the field for some time after harvesting them rather than bring them back to their house for storage. Usually the grains are stripped from the cobs fairly soon after picking the maize, but this varys. Usually the grains are stripped in the hand, but occasionally a colonist will flail at a pile of ears with a stick to break them off. Once the maize is doubled over the colonist often leaves it to children to bring the ears in from the field for feeding to animals.

C.) PHASEOLUS BEANS:

1.) OCCURENCE:

Phaseolus beans (feijão de arranca) are common as a subsistence crop and somewhat less common as a cash crop. They are preferred over Vigna cow-peas (feijão da corda) because of taste, price, availability of seeds from INCRA, and higher yields if undiseased. Bean plantings were financed regularly in the early years, but now bean financing is uncommon but not forbidden. Areas planted are usually small, the median field size of 34 fields being just over one hectare.

2.) PLANTING, INTERPLANTING, AND VARIETIES:

Phaseolus is usually planted in April and May. There is a fair amount of variation in planting dates; some have planted as late as July, but they have regretted it. Some have experimented with planting different parcels at different dates. If beans are planted too early colonists say they are attacked more heavily by the web blight ("mela") fungus Rhizoctonia microsclerotia Matz (Thanatophorus cucumeris Frank). This agrees with IPEAN's conclusion that humid conditions favor the disease (Albuquerque & Oliveira 1973). If planting is done too late there is an increased chance that there will be inadequate rain at the time of flowering (about 28 days after planting) and the plants will die.

Spacement of beans varys widely, and its effect on yields is discussed separately (Fearnside 1975). IPEAN has suggested that wider spacing results in less Rhizoctonia (Gonçalves 1969). Although an IPEAN experiment implanted at Km. 68 in 1974 attempted to show this without success (unpublished), casual observations in the field tend to support the spacement effect somewhat.

The Phaseolus varieties distributed by INCRA have been Canario, Jalo, Rim do Porco, and Costa Rica ("preto"). There also have been a number of Phaseolus varieties from private sources in use. A number of colonists have planted more than one Phaseolus variety in the same year, and some of them link this to a conscious effort to escape Rhizoctonia with at least one variety. I suspect that there may be a slight trend to more diverse bean plantings.

A few colonists have complained of germination problems where a large percentage of the beans planted simply rot in the ground. Sometimes a second planting is made if the first one has poor germination

3.) WEEDS, PESTS, AND DISEASES:

Usually beans are weeded twice, although occasionally only one weeding is given. If the beans are badly attacked by Rhizoctonia then the weedings are curtailed.

Rats and agoutis pose no significant problem for bean seeds, and seeds are often not treated with poisons before planting. After the beans have sprouted, rabbits can be a problem eating the young plants. Rabbit damage varys from colonist to colonist, and occasionally it reaches severe proportions. Vertebrate damage to the bean fruits is not a problem.

There are a variety of insects which feed on the vegetative parts of the plant, especially caterpillers and beetles. In spite of evident leaf damage from insects, outbreaks completely devastating beans have not ocurred, and colonists rarely complain of insect losses.

The fungus Rhizoctonia is far the most severe limitation on Phaseolus production in the area, and has been discussed separately (Fearnside 1975).

A very few colonists have applied insecticides to beans, chiefly Folidol or B.H.C. A few colonists have back-carried sprayers which were supplied by INCRA (charged to the colonists' INCRA accounts) in the early years. Treatment with insecticides is very rare, and treatment with fungicides is even less common. IPEAN experiments have shown several fungicides to have some effect against Rhizoctonia (Prabhu et.al. 1975). Although they could not eliminate Rhizoctonia completely, the use of fungicides gave an approximate 50% increase in production in the experimental plots. There is a problem with the fungicide washing off the leaves when applied in rainy weather, which is when the fungus is most active. Some colonists have asked IPEAN têcnicos for advice on the fungus and been told to use the fungicide Benlate; I know of no colonists who have followed the advice. Planting the more resistant Vigna instead of Phaseolus is probably the surest defense against Rhizoctonia.

Often when the beans are picked through to remove spoiled beans just before cooking there can be large numbers of bad beans thrown out, occasionally approaching half the beans. Although some of this spoilage may occur in storage, much of the spoilage occurs before harvest.

4.) HARVESTING:

Harvesting is done in July and August, about 70 days after planting. The entire bean plant is pulled up by the roots (which gives Phaseolus its name "feijão de arranca") and dried. A tarpaulin is then spread on the ground and the dried plants placed on the tarpaulin and beaten with a quarterstave. This is strictly man's work. After the beating has broken the beans out of their pods they may or may not require additional drying before being sacked for storage or sale.

D.) VIGNA COW-PEAS:

1.) OCCURENCE:

Vigna sinensis has so far been planted only about a quarter as often as Phaseolus vulgaris, although this may change gradually as Rhizoctonia fungus makes Phaseolus cultivation inviable for many colonists. Vigna has a less preferred taste, lower price, and lower yields both per hectare and per kg of seeds planted than undiseased Phaseolus. The greater resistance to Rhizoctonia compensates well for all of these disadvantages. Vigna seeds have not been distributed by INCRA, nor has Vigna been financed.

Vigna is almost entirely a subsistence crop, and plantings are therefore smaller on average than for Phaseolus.

2.) PLANTING, INTERPLANTING, AND VARIETIES:

Vigna is usually planted in April, a couple of weeks earlier than Phaseolus. In the area of the Transamazônica it is invariably planted with dry maize plants in the field to serve as supports. This is in contrast to practice elsewhere in Pará, as in the Zona Bragantina where Vigna is planted without maize.

The planting density is usally fairly sparse, and kgs of seeds per hectare is almost always less than for Phaseolus. The effects of planting density are discussed separately (Fearnside 1975). Sometimes manioc has been interplanted in Vigna fields.

The most common varieties are Roxinha and "Branco".

3.) WEEDS, PESTS, AND DISEASES:

Weeds are cleaned off the area just before Vigna is planted (the "limpa") and then usually one additional weeding ("carpa") is applied later as the crop grows. As with all crops, this is in addition to casual pulling up of weeds noticed whenever the farmer walks through the field.

There are many insects that attack *Vigna*, and complaints of losses are a bit more frequent than with *Phaseolus*. No chemical treatments are applied. Rabbits can also be a problem, as with *Phaseolus*.

Rhizoctonia occasionally appears on *Vigna*, but is much less common and does less damage than on *Phaseolus*. *Rhizoctonia* effects are discussed separately, as are the effects of soil nutrients (Fearnside 1975).

4.) HARVESTING:

Vigna is harvested in July and August. Occasionally the pods are beaten with a quarterstave to release the seeds in the same way as *Phaseolus*, but more often the pods are picked by hand, dried, and then broken open by hand. The beans are always eaten without the pods.

E.) BITTER MANIOC:

1.) OCCURENCE:

Bitter manioc (mandioca brava) is common both as a subsistence and as a cash crop. The frequency and extent of plantings appear to be increasing. Although the lack of financing for manioc has made other crops such as rice more attractive for cash plantings in the past, manioc has distinct advantages from the relatively secure yield with low risk of losses from diseases and pests, plus the lower need to rely on hired labor allowed by a crop which can be harvested year-round rather than all at once.

One drawback is the requirement of the equipment for a "casa da farinha" to process the manioc tubers into farinha. To make the process practical for producing farinha in quantity as a cash crop, a small motor is needed to run the grinder. Motors and farinha-making equipment have not been financed, although two colonists in the intensive study area have gotten around this by using motors from financed rice threshing machines. In the intensive study area there are six casas da farinha with motors and seven that make farinha as a cash crop without motors. This represents about one casa da farinha for every 13 occupied lotes. There are numbers of other colonists who have smaller versions of the equipment not really qualifying as a "casa da farinha" for making farinha for their own use. Most of the operations without motors in the intensive study area do the grating of the farinha by hand by rubbing the tubers on a grater made from an old kerosene tin, five of them that have the grinder driven by a hand-operated flywheel that is characteristic of casas da farinha in traditional areas of Pará. Sometimes the smaller operations make a few sacks of farinha for sale. The owners of the mechanized operations also rent out the use of their equipment for a percentage (20%) of the farinha produced. Both white farinha "seca" and yellow farinha "dágua" are made.

A modern farinha-making factory was built by INCRA in the "industrial sector" of Agrópolis Brasil Novo at Km. 46. Unfortunately the Agrópolis has a severe problem with its water supply, which is pumped from wells by an ever-failing pump. Since the Agrópolis has a chronic lack of water both for drinking purposes and for running the steam-operated generators it has in its sawmill, the increased demand from the farinha factory could not be met. The factory's shining new machinery has never been used. Were farinha to be industrialized in the area the amount of manioc planted could be expected to increase dramatically.

The creation of an industry to extract alcohol from manioc for use as a gasoline additive is another possibility that could result in dramatic alterations of the present pattern of manioc occurence. The Brazilian government has announced the intention to do just this to reduce reliance on Arab oil. There has been a redent flurry of interest in the press on this possibility (cf. Abelson 1975). The calculations appearing in the press have arrived at various conclusions. Some have suggested that the alcohol produced by present methodology would be too expensive to be economical as an additive (A Provincia do Parȧ, 7 Oct. 1975); however, this may be due to confusion as to whether it is gasoline or drude oil that is to be replaced with alcohol. The most universal error in the calculations that I have seen is the use of figures for per-hectare yields of manioc referring to the amount that is obtained per hectare when a field is harvested, rather than a sustained yield figure that includes the fallow period. This can make an order of magnitude difference in the results obtained for area requirements. Repeated manioc crops could be expected to result in reduced yields through depletion of soil nutrients, as is mentioned in the separate discussion of soils effects on manioc yields (Fearnside 1975). In any case, if the government does follow through on the plan to replace 15-20% of the volume of gasoline burned in the country with manioc alcohol, then manioc may well become a principal crop in the area.

2.) PLANTING, INTERPLANTING, AND VARIETIES:

Manioc is usually planted during the rainy season, although there is wide variation in planting dates. IPEAN experiments with planting dates have shown it possible to plant all year round, but best results are obtained if the dry season and the first few weeks of the rainy season are avoided (Albuquerque et. al. 1974). If manioc is interplanted with rice or with rice and maize it is usually planted in January or February. Cuttings of the stems about 15 cms in length are planted horizontally in a shallow pit scraped with a hoe and just barely covered with earth. All plantings I have seen have been made with the horizontal planting method, but a few Northeasterners are said to have used the vertical planting method at first which is adapted to the dry, rock-hard soil of Northeastern Brazil.

Planting densities vary among colonists. IPEAN spacement experiments done at Km. 23 do not show significant differences between treatments in yield in kgs tubers/hectare. However, when the data presented in the report (Viégas & Kass 1974, p. 24) is plotted with the conversion made to yield in kgs/1000 plants, a clear negative relationship between density and yield emerges. This agrees with a similar decline in yield in kgs farinha/1000 plants/ 12 months growth found in the data from the intensive study area.

Interplanting is done with rice, maize, rice and maize, beans, and sometimes other crops such as bananas. Manioc is also used regularly as a shade plant for young cacao seedlings.

Not all colonists distinguish between varieties of bitter manioc, although some distinguish between "yellow" and "red" manioc. The varieties used are of the branching, as opposed to the erect, type. The manioc varieties tested in IPEAN variety trials have not been disseminated in the area. There is one case in the intensive study area of a colonist experimenting with a manioc variety taken from an Indian camp which was abandoned at the beginning of the colonization (the camp is outside of the intensive study area in Travessão 18/20).

3.) <u>WEEDS, PESTS, AND DISEASES</u>:

Manioc usually requires two, and sometimes three, weedings before it is large enough to shade the ground and prevent further weed growth. If it is interplanted with other crops, the first one or sometimes two weedings take place while the interplanted crop is still in the field. If it is rice that is interplanted, usually two additional weedings are required after the rice has been harvested. Because the manioc shades the ground for much of its vegetative cycle, the weeding requirement is considered light. If the growth of the tubers is slow due to poor soil conditions, the amount of additional labor required from a longer growth period is not great.

Damage to bitter manioc from vertebrates insects and disease is not a great problem. Caterpiller damage and a bacterial disease attacking the aerial portions of the plant have been occasional problems in other parts of Brazil (Almeida & Canéchio Filho 1972 pp. 153-155), but have not been problems here. In ten bitter manioc fields, 20% of the colonists complained of losses to rodents. Losses were slight, however. One common problem is a root rot that occurs where the soil is waterlogged during part of the year, especially if the soil is clayey (which contributes to the poor drainage). This has caused severe losses in several cases, although in others the others the yields, even though less than they might be, are still sufficient to make manioc an attractive crop. Of ten fields of bitter manioc, 80% had some loss from root rot. It is possible that some of the rot may be the attack of a fungus such as Phytophthora drechsleri which has attacked manioc in other parts of Pará (Figueirēdo & Albuquerque 1970), but rotting from waterlogging independent of fungal attack undoubtedly explains much of the root rot.

4. 4.) HARVESTING:

Some harvesting takes place all year round, although harvesting is easier and losses from tubers breaking off in the ground in the hard soil are less if it is not done at the height of the dry season. The problem of breaking tubers is worse in clayey soils than in sandy soils.

Harvesting usually takes place beginning after about the twelfth month and continues until after the eighteenth month. Occasionally a colonist that is short on farinha may harvest after as little as six months, and if he has more manioc than he can process he may leave it for as long as 30 months. If manioc is harvested too young the tubers are small and much more labor is required to peel them for conversion to farinha, in addition to the disadvantage of lowered growth rate of the tubers in the later months, and the problem of the tubers becoming woody producing farinha of lower quality. The relation of growth period to yield is discussed separately (Fearnside 1975).

Harvesting involves first cutting the tops of the manioc off by machete and then pulling the tubers out of the ground by the stem. The stems are then cut off and the tubers separated and piled to await transport. Transportation can be a major problem if the colonist does not have a casa da farinha in his own or in a nearby lote. Transportation of the tubers is done by either carrying them directly, by burro, or by wheelbarrow; hiring a pickup truck has been considered by some and rejected as uneconomical. Transporting a pickup truck-load of manioc 10 kms costs Cr$100, and is good for making about 15 sacks of 60 kgs each of farinha. Occasionally colonists will sell manioc still in the field to another colonist who will harvest it and convert it to farinha.

The amount of labor required to convert the tubers into farinha is considerable, varying with the size of the tubers and the water content, as well as with the equipment used. The farinha must be processed within a day or so after the tubers are harvested. There are two processes, one for the yellow "farinha puba"(farinha dágua) which has a higher market value and is preferred by people from Pará, and the white "farinha seca" (farinha branca) which is preferred by Northeasterners. Making farinha dágua involves soaking the tubers in water for a while while the skins partially rot off. Making farinha seca requires more work: the skins are peeled off the tubers by women and children which is often a limiting point in the production operation. The peeled tubers are then ground and the ground manioc left in its own juice for a while in a trough. The mash is then put in a wooden press, often overnight but for shorter periods if farinha is being produced in quantity. After removal from the press the mash is passed through a sieve and then roasted in the shallow metal bin of a wood-burning "forno". The mash is stirred on the forno with a wooden paddle; this is a man's job as the fumes from the roasting manioc can cause dizziness and vomiting. The dried farinha is then cooled in another trough and sacked for storage or sale.

Use of other parts of the manioc plant is limited, with the exception of the stems which are saved for planting. The leaves are sometimes fed to pigs, but are generally not eaten by people in the area. A few colonists save some of the starch (fecula). The tucupi (manioc juice which is used in several dishes eaten by Paraenses) is not usually saved by non-Paraenses. An alcoholic beverage made from manioc also appears occasionally, but is a rarity. The larger chunks of the manioc mash that do not pass through the sieve are often roasted and fed to pigs. On the whole, farinha is the only manioc product produced regularly and in quantity.

F.) SWEET MANIOC:

1.) OCCURENCE:

Sweet manioc (macaxeira) is planted in small quantities by almost all colonists as a subsistence crop. There are a few larger plantings for cash purposes, but these are rare since the higher yields of bitter manioc make it more attractive for producing farinha for sale. Some farinha is made from sweet manioc, however. The lack of toxins in the tubers allows sweet manioc to be eaten boiled or fryed or in a variety of less common preparations. It is also used as feed for pigs. Under the organization of the INCRA administrator in Agrovila Grande Esperança, a communal plot of sweet manioc has been planted in the senter of the Agrovila for the use of those colonists that contribute labor to its maintenance.

2.) PLANTING, INTERPLANTING, AND VARIETIES:

Sweet manioc is planted and interplanted in the same way as bitter manioc. Most colonists do not distinguish between different varieties of sweet manioc.

Planting density shows the same relationship with yield as with bitter manioc.

3.) WEEDS, PESTS, AND DISEASES:

Weeding requirements are the same for sweet as for bitter manioc.

Insect damage to sweet manioc is small, as with bitter manioc. Vertebrate pests can be more of a problem with sweet manioc, mainly rodents eating the tubers. Rodent damage was complained of in 80% of five fields of sweet manioc, four times as often as for bitter manioc. The damage was greater in magnitude, in addition to the much greater frequency, than in bitter manioc fields.

Root rot also causes losses in sweet manioc, 29% of seven sweet manioc fields having been affected.

4.) HARVESTING:

Sweet manioc is harvested year round, with a few plants being pulled every day or so for table purposes and for feeding pigs. Yield relations are discussed separately (Fearnside 1975). When farinha is made, it follows the same pattern as for bitter manioc.

G.) SWEET POTATO:

Sweet potatoes (batata doçe ; Ipomea batatas Lamm.) are strictly a subsistence crop planted in small patches in many lotes. Planting is done from cuttings, usually in the rainy season, and harvesting is year-round. The variety used is one with white flesh in the tuber. The tubers are either boiled and eaten directly or fed to pigs.

Virtually no effort is expended in weeding sweet potatoes, as the vines quickly cover the ground themselves. Several colonists complain of insect damage to the tubers, and of root rot in poorly-drained soil. Sweet potatoes are also succeptible to a long list of diseases (Albuquerque & Pinheiro 1970), but these have not been a problem yet.

H.) YAMS:

Yams ("inhame" or "carå" ; Dioscorea spp.) is common in small subsistence plantings. Although there is a long list of pests and diseases that can potentially attack it (Albuquerque & Pinheiro 1970,p.56), it, like sweet potato and sweet manioc, does well enough to amply satisfy subsistence needs for starchy tubers. The vines quickly spread out to cover the ground and need a minimum of maintenance. It is eaten boiled or fryed or fed to pigs. There is no market demand for yams.

I.) VEGETABLES:

Colonists pay very little attention to raising vegetables, certainly much less than would be warranted by their nutritional importance. Many, but by no means all, colonists have a small vegetable garden or "horta", usually a window-box-like arrangement on stilts. These are the responsibility of the women. A survey done by ACAR-PARA in 1974 outside of the intensive study area found only seven of 31 families (23%) had hortas (Brasil 1974). Although the same study found over half of the colonists "always" eating vegetables, these responses are best explained as the result of the colonists' desire to please the organizers of the survey. Colonists eat very few vegetables, in my experience, even when they have hortas. Both the INCRA and ACAR-PARA social assistants have made attempts to convince the colonists to raise and eat more vegetables, but the colonists have not changed their ways.

The most common vegetables grown in the hortas are green onions (cebola), leafy cabbage (couve), and coriander (coentro). Other vegetables are lettuce (alface), okra (quiabo), and once in a while beets (beterraba), chicory (chicória), and head cabbage (repolho). Green peppers (pimentão), chile peppers (pimenta malageta), tomatoes (tomate), and squash (abóbora or jerimu), cucumber (pepino), and a bitter green vegetable called "gibó" are planted in small quantities in the field. There are a few other vegetables of minor importance which appear occasionally.

There has been one attempt made in the intensive study area to grow tomatoes as a cash crop. This was not successful. Outside of the intensive study area in the area of terra roxa near Km 90, however, there is one Japanese colonist who is cultivating vegetables as a cash crops quite successfully. The approach is much more capital- and labor-intensive than the agricultural endeavors of the colonists in the intensive study area. Lettuce, tomatoes, coriander, and green onions are all being grown. The colonist owns a truck, with which he takes the produce to Altamira weekly for sale to COBAL (the Brazilian Food Company, a government-run retail food outlet). He also has a microtractor for cultivating the vegetable plots, as well as a small diesel irrigation pump. He also applies regular treatments of fertilizers and pesticides. He also has one of the best lotes in the entire Altamira area: terra roxa, almost level, and located on the roadside. His origins as a farmer in Japan and as a self-made man in other Japanese settlements in Amazōnia give him an ideal background for mastering a new agricultural system, conscientiously applying the inputs required, and for handling money responsibly. This ideal combination of financial, physical and cultural conditions is highly atypical, and the pattern of agriculture resulting can not be interpreted as foreshadowing a shift in this direction in the area at large.

J.) COTTON:

One colonist in the intensive study area participated in an INCRA scheme for beginning cotton production in the area in 1974. The plantation was largely destroyed by insects and by rats carrying off the cotten as it ripened. No chemical treatments or fertilizers were applied. The colonist only bothered to harvest a small part of the planting for lack of a market. What was harvested was sent to São Luis in Maranhão for sale by INCRA, which was so expensive that almost nothing remained for the colonist. He says he will not plant cotton again.

Another colonist outside of the intensive study area made a small planting of cotton independent of the INCRA scheme and was satisfied with the results. He estimated his yield at 1500 kgs/ha (a very approximate figure with his small planting) which would put the yield on a par with those obtained elsewhere in Pará (Dos Santos 1973, p.6). No treatments were applied, but apparently insect problems were not serious in this case. Nevertheless, he decided not to continue planting cotton.

If cotton were to be planted continuously on a large scale in the area it could expect to encounter the same limitations that have been encountered under similar circumstances in other parts of the world. The ever-increasing problems with insect pests that have destroyed cotton industries in Peru and Costa Rica, or the heavy drain on soil nutrients that have impoverished soils in much of the Southern part of the United States, could be expected to occur on the Transamazōnica as well.

K.) PEANUTS:

Peanuts (amendoim) have been planted in small experimental plantings by a couple of colonists. One colonist got a satisfactory yield, although he later lost most of it when the stored peanuts were inadequately protected from rats. Another colonist had serious insect problems in one year and got no yield, and in the next year had no insects and got a good yield. He attributed the heavy insect damage in the first year to a poor burn quality in that year.

Peanuts will undoubtedly continue to be planted on a small scale by some of the colonists, but there are no indications of a trend to large plantings for cash purposes.

L.) TOBACCO:

Tobacco was one of the crops that INCRA considered introducing into the area when the colonization program began, but the plan was not acted on. I know of no tobacco in the intensive study area, although one colonist outside of the area has expressed his intentions of planting some for his own use.

Tobacco is a traditional cash crop in small plantings of less than 0.3 ha in the older settled area North of Altamira. Yields are sufficient to continue interest. Insect problems are a severe limitation. There is one insect larva which eats out the stems from the inside and another caterpillar which eats the leaves. An insecticide powder is used when the base of the stem is attacked, but the caterpillars attacking the leaves is picked off by hand. In one field examined this was being done every other day for a five-week period, requiring an estimated 40 man-days/hectare. The labor demand on the farmer is lessened by the use of child labor.

M.) <u>SOYA BEANS</u>:

Soya beans (soja) were planted by one colonist in the intensive study area as a part of an INCRA project to establish soya beans in the area. Unfortunately due to the late arrival of the seeds they were planted in July whereas they should have been planted earlier; the result was no yield. There is some confusion over the proper planting date for soya beans in the area: an INCRA publication with recommendations for the Altamira area lists the proper time as December, whereas IPEAN experiments (presented at 1º dia do campo, Km 23, June 15, 1974: unpublished) lead IPEAN tècnicos in the area to recommend the beginning of May.

Interest in soya beans appears to have cooled.

N.) <u>SORGUM</u>:

Sorgum (sorgo) has been experimented with by one colonist in the intensive study area. The plants appeared reasonably healthy, with vigor more or less equivalent to that of maize on the soil type used. He does not intend to continue planting sorgum.

O.) <u>CASTOR BEANS</u>:

Castor beans (mamona) have been planted by a few colonists in the intensive study area both for subsistence purposes and as an experiment intended to evaluate their performance as a potential cash crop. The plant gives noticeably better growth on better soil. Oil is pressed from the seeds and used for subsistence purposes; none has been sold and their is no market. Since the oil is relatively cheap in small quantities, some that have castor beans in their lotes buy the oil rather than press it themselves. To my knowledge no colonists intend to expand plantings for cash purposes.

III.) CONCLUSIONS:

The roster of annual crops in use in the colonization area of the Transamazônica contains crops with a wide variety of advantages and disadvantages qualifying them for different roles as subsistence and as cash crops. Characteristics of crops influencing the colonists' choices include: (1) mean yields, (2) the security of yields, (3) the amount of labor required and the distribution of the labor requirement throughout the year, (4) prices and marketing opportunities, (5) availability of seeds, (6) financing, (7) requirements for capital inputs, special equipment, etc., and (8) preference for different crops based on the individual colonist's previous experience and culture-related preferences.

A number of crops have been tried by colonists in a spirit of experimentation. Experiments with different varieties and agricultural practices such as planting dates have also been tried. The land devoted to these experiments probably has an importance much greater than its small area would indicate in shaping the future evolution of cropping patterns in the area.

The problems which limit crop yields are many and varied. The great variability in agricultural practices such as planting dates, planting densities, varieties planted, interplanting (including the choice of interplanted crops, interplanted crop density, and relative planting dates), chemical treatments (especially of seeds), effort spent in weeding, promptmess of harvesting, length of time harvested crops are left in the field, and numerous other behavioral differences between colonists adds to the variability in yields. Other factors such as differences in soil quality, weather, soil drainage, weed problems, insect losses at different stages in the production cycle, losses to vertebrates, and disease attack all contribute to the

the variability in yields. The great variability in these practices and problems and in the yields themselves justifies the emphasis on variance and stochastic processes which characterizes the carrying capacity modeling effort.

The availability of capital and labor have been very important in shaping crop choices and agricultural practices. The approach has been generally highly land-intensive, with virtually no expenditures being made on non-labor capital inputs such as fertilizers, insecticides, herbicides, fungicides, and liming. The continued presence of virgin land in the colonists' lotes means that changes in yields and cropping patterns from degradation of soil nutrients through cropping have not yet shown their full effect. Degradation effects will undoubtedly increase in the future.

Shifts in cropping choice related to agricultural problems limiting production (in addition to other factors) include decreased plantings of Phaseolus beans and maize as cash crops, and increasing importance of manioc. Future changes in prices and market availability could result in great changes in cropping patterns in this largely cash crop-oriented system.

The present and probable future patterns of occurence of the major annual crops, constraints on the choices of land-use open to the colonist from labor and capital requirements for the different crops, and the many factors contributing to variance in agricultural production will all be necessary components in the computer models to be used in simulating the system and estimating its carrying capacity.

IV.) LITERATURE CITED:

1.) Abelson, P.H. 1975. Energy alternatives for Brazil. Science 189:417

2.) Albuquerque, F.C. de, & A.F.F. de Oliveira 1973. Ocorrência de <u>Thanatephorus cucumeris</u> em feijão na região Transamazônica. Instituto de Pesquisas Agropecuárias do Norte (IPEAN) Comunicado Técnico no. 40. 7pp.

3.) Albuquerque, M. de, M.C. de F. Guimarães, & R.M.F. Viégas. 1974. Epocas de plantio e de colheita em zonas mandioqueiras do leste Paraense. B. Téc. IPEAN, Belém 60: 193-221.

4.) Albuquerque, M. de, & E. Pinheiro. 1970. Tuberosas feculentes. Instituto de Pesquisas e Experimentação Agropecuárias do Norte (IPEAN), Série fitotecnia 1(3):1-115.

5.) Almeida, T. de C., & V. Canéchio Filho. 1972. Principais Culturas(2). Instituto Campineiro de Ensino Agrícola, Campinas, São Paulo. 395pp.

6.) A Província do Pará. 7 Oct. 1975. Mandioca: nossa arma para enfrentar a OPEP. cad. 2 p. 1.

7.) Brasil. Min. de Agric., Associação de Credito e Assistência Rural do Estado do Pará (ACAR-PARA). 1974. Levantamento realizado atraves de ACAR-PARA pelas comissões de representativas da comunidade. ACAR-PARA, Altamira, UCATNV/ Setor Social e Economico. (unpublished data).

8.) Cruz, E. de S., C.F. de Souza, & J.B. Bastos. 1971. Influência de adubação NPK no milho em terra roxa estruturada (Altamira, Zona do Rio Xingú). Instituto de Pesquisa Agropecuária do Norte (IPEAN) Série: Fertilidade de Solos. 1(3):1-17.

9.) Dos Santos, A.I.M. 1973. Recomendações para o cultivo do algodão na região leste do Estado do Pará. Instituto de Pesquisas Agropecuárias do Norte (IPEAN), Belém. Comunicado Técnico no. 17. 7pp.

10.) Fearnside, P.M. 1975. Soil nutrients and annual crop yield prediction for use in modeling human carrying capacity on the Transamazon Highway: summary of progress. (ms).46pp.

11.) Figueirêdo, M.M., & F.C. de Albuquerque. 1970. Podridão mole das raízes da mandioca (<u>Manihot esculenta</u>). Pesq. Agropec. Bras. 5:389-393.

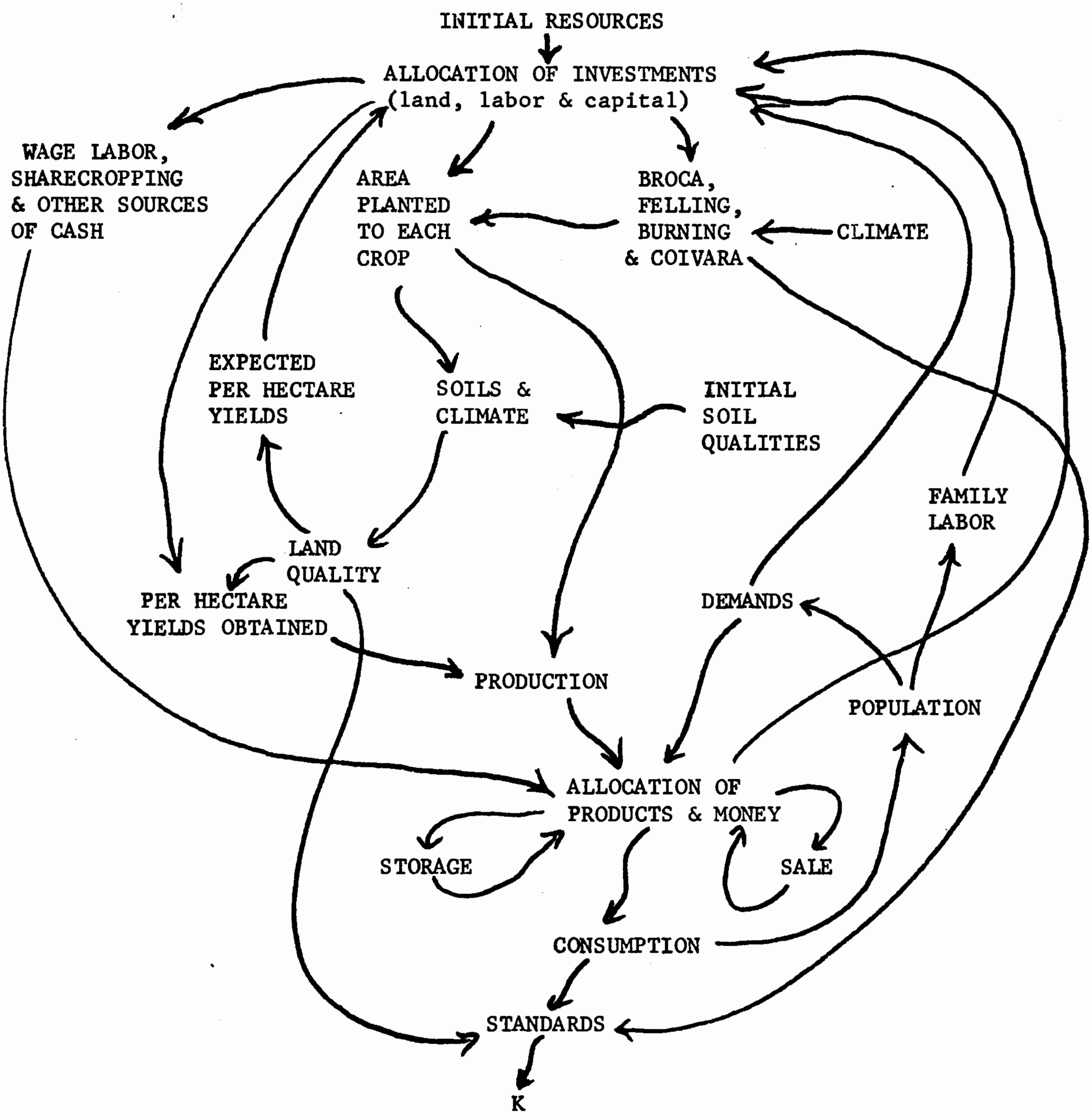
12.) Gonçalves, J.R.C. 1969. Queima da fôlha do feijoeiro causada por <u>Rhizoctonia microsclerotia</u>. Instituto de Pesquisas e Experimentaçao Agropecuárias do Norte(IPEAN), Belém. Comunicado no. 12. 3pp.

13.) Harris, D.R. 1971. The ecology of swidden cultivation in the upper Orinoco rainforest, Venezuela. Geog. Review 61(4):475-495.

14.) Lopes, A. de M., D.L. Kass, J. Furlan Júnior, & A.F.F. de Oliveira. 1973. Espaçamento e densidade de plantio para o arroz de "sequeiro" na Zona Bragantina, Campo Experimental de Tracuateua-Bragança, Pá. Instituto de Pesquisas Agropecuárias do Norte (IPEAN), Belém. Comunicado Técnico no. 20. 6pp.

15.) Prabhu, A.S., J.F. de A.F. da Silva, F.J.C. Figueiredo, & R.M. Polaro 1975. Eficiência relativa de fungicidas para o controle da murcha da teia micélica do feijoeiro comun na reigião à Transamazônica. Empressa Brasileira de Pesquisas Agropecuárias-Instituto de Pesquisas Agropecuárias do Norte (EMBRAPA-IPEAN), Belém. Comunicado Técnico no. 49. 16pp.

16.) Viégas, R.M.F.,& D.C.L. Kass. 1974. Resultados de trabalhos experimentais na Transamazônica no periodo de 1971 a 1974. Empresa Brasileira de Pesquisa Agropecuária-Instituto de Pesquisa Agropecuária do Norte (EMBRAPA-IPEAN). 54pp.


INITIAL RESOURCES
ALLOCATION OF INVESTMENTS (land, labor & capital)
WAGE LABOR, SHARECROPPING & OTHER SOURCES OF CASH
AREA PLANTED TO EACH CROP
BROCA, FELLING, BURNING & COIVARA
CLIMATE
EXPECTED PER HECTARE YIELDS
SOILS & CLIMATE
INITIAL SOIL QUALITIES
FAMILY LABOR
LAND QUALITY
PER HECTARE YIELDS OBTAINED
DEMANDS
PRODUCTION
POPULATION
ALLOCATION OF PRODUCTS & MONEY
STORAGE
SALE
CONSUMPTION
STANDARDS
K