

GROWTH POLICY
AGRICULTURE



BUREAU OF PLANNING
GOVERNMENT OF GUAM
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GROWTH POLICY

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Foreword

Public Law 12-200 authorizes the Bureau of Planning to develop policies that foster the socio-economic development of the Territory of Guam. The Agriculture Growth Policy presented in this report is a component of the overall Growth Policy which provides the basic philosophy and direction for guiding development plans. The Agriculture Growth Policy is not an agriculture development plan. A growth policy is essential to serve as a basis for development plans and allows the plans to be more specific in their approach.

This report was funded in part by the Economic Development Administration, U.S. Department of Commerce, as authorized under Section 302(a), of the Public Works and Economic Development Act of 1965 (as amended). While the staff of the Bureau of Planning were the primary participants in developing this growth policy, the cooperation of other Government of Guam departments/agencies, especially the Department of Agriculture and College of Agriculture and Business, UOG, was essential for its completion.

I. INTRODUCTION

A. Problem Setting. Various proposals have been advanced to hasten the development of agriculture and fishing on Guam. A number of recommendations have been given for specific projects but no major attempt has been made to date ~~to~~ analyze the potentials, supportive requirements, and constraints of the proposed individual projects on a long-term basis. As a consequence, priorities for development in the agriculture and fishery sectors have not been clearly delineated.

Agriculture and fishing are indigenous to Guam. Prior to World War II, Guam's economy was predominantly agricultural and basically self-sufficient. Non-commercial fishing generally supplemented peoples' diet. After the end of the war, the role of agriculture and fishing declined as a greater portion of the population was attracted to military and civil service employment. Two typhoons of unprecedented strength, occurring in 1962 and 1963, destroyed 80 percent of the island's physical assets and seriously setback agriculture. Typhoon Pamela, which ravaged Guam in May 1976, similarly caused extensive damage to agricultural crops and physical structures on the island.

However, growth has been experienced in agriculture. The value of local agricultural products increased from \$749,176 to \$3,542,537 for the period 1964 to 1974, a 372 percent increase during a ten-year period. As shown on Table 1 below, local agriculture and fishery products valued at \$3,673,537 represented 26 percent of the total amount consumed in 1974. The same table shows that the greatest degree of self-sufficiency was achieved in egg

Table 1

1. Local Production, Imports, and Total Consumption of Major Agricultural Products in FY 1974

<u>Commodity</u>	<u>A</u> <u>Local</u> <u>Production</u>		<u>B</u> <u>Imports</u> <u>(Estimate)</u>		<u>C</u> <u>Total</u> <u>Consumption (A+B)</u>	
	<u>Dollars</u>	<u>%</u>	<u>Dollars</u>	<u>%</u>	<u>Dollars</u>	<u>%</u>
Eggs	1,982,904	86	327,926	14	2,310,830	100
Fruits & Vegetables	798,065	26	2,304,490	74	3,102,555	100
Pork	563,200	22	1,962,684	78	2,525,884	100
Poultry	104,300	8	1,156,552	92	1,260,852	100
Fresh Fish	131,000	11	1,104,010	89	1,235,010	100
Beef	94,068	2	3,740,990	98	3,835,058	100
Totals	<u>\$3,673,537</u>	<u>26</u>	<u>\$10,596,652</u>	<u>74</u>	<u>\$14,270,189</u>	<u>100</u>

Source: Compiled by W.P. Leon Guerrero, R. Muniappan, J.T. Ishida, V.T. Artero, Trends in Agricultural Development in Guam and Micronesia, pp. 23-24.

production, where local production hit 86 percent of total consumption for that year. Importation of agricultural and fishery commodities, however, constituted 74 percent of the total consumption needs of the population in 1974. The value of imports as a percentage of consumption of each commodity are ranked as follows: beef (98%), poultry (92%), fresh fish (89%), pork (78%), fruits and vegetables (74%), and eggs (14%). The size of the agricultural and fishery market now filled by imports represents a demand that may possibly be met with local production.

In 1975, the Green Revolution Committee was formed to coordinate the effort of all Government of Guam endeavors relating to agriculture. Committee membership includes the heads of the departments of Agriculture, Commerce, Land Management, the Guam Economic Development Authority, and the University of Guam. The main purpose of the committee is to promote and encourage the development of agriculture as a contributing economic activity. The production of locally grown produce would serve to reduce the amount of dollars flowing out of the economy, increase employment and income, and contribute to a greater self-sufficiency in the economy.

Other reasons for promoting agriculture include:

- (a) There is a "social loss" when agricultural endeavor disappears, in that the unique contribution made on individual character and habits molded in a rural agricultural environment, is no longer available to the community. The maintenance of an agricultural sector of the economy would not only preserve an inherent aspect of Guamanian culture but also further enhance the attractiveness of the island to tourists.

- (b) Guam is an insular area and during shipping, airline, and dock strikes, an agricultural food crop base could at least partially meet the needs of the island.
- (c) Agriculture provides open space which is necessary for preserving the island's beauty.

However, the key factor determining society's cost of preserving agriculture is whether it is economically competitive to overseas imports. Government has provided promotional support, tax breaks, incentives, loans, and protection to agricultural lands; but in the end, agricultural enterprise must be feasible and competitive on its own basic economic merits if it is to be a viable, contributing industry on Guam.

B. Purpose and Scope. The purpose of this study is to examine potentials and constraints and the economic feasibility of current programs for agriculture and fishery, with the objective of determining the viable growth policies. The report will deal primarily with commodities that are already in production and have been the subject of certain research. The study will, therefore, touch briefly on some other commodities that show promise but which have not yet been researched thoroughly.

C. Organization of the Report. Section II will present growth elements. This section will cover both potentials and constraints which are most important to the industry. In Section III, the conclusion and recommendations will be given.

II. AGRICULTURAL GROWTH ELEMENTS:

There are several growth elements for Guam including:

- A. Field farming or conventional agriculture;
- B. Hydroponic farming;
- C. Mariculture; and
- D. Livestock farming.

These elements are expected to reduce the importation of certain products and help create viable industries for Guam. Although the elements will be treated separately in this report, they can be combined in various ways to achieve certain objectives.

A. Element 1. Field Farming or Conventional Agriculture

1. Definition: Field farming is a branch of agriculture that deals with the cultivation of the soil and the raising of food crops.
2. Potential: Guam's agriculture potential lies in the local production of commodities presently imported by the island. As shown in Table 1, Guam imported an estimated \$9.5 million worth of agricultural commodities versus local production of \$3.5 million in 1974. The size of the agricultural market now filled by imports constitutes a good argument for agricultural development on Guam.

Recent data indicate that only 20 percent of the fruits and vegetables consumed by Guamanians are locally produced. In 1971, less than 2 million pounds of fresh vegetables and fruits were imported from the mainland, Japan, Taiwan, the Philippines, and the neighboring Marianas Islands of Rota,

Tinian, and Saipan. With military consumption included, it is estimated that present imports amount to over 10 million pounds, valued in excess of \$2 million annually. The consensus among agricultural experts is that a minimum of 80 percent of the local civilian and military imports can be met by local crops, thus ensuring high-quality fresh produce as well as monetary savings.¹

In field farming, the raising of fresh vegetables and fruits appears to show the greatest potential for development. Currently, there are approximately 300 acres under cultivation producing about 3 million pounds of fresh fruits and vegetables. This approximates 25-30 percent of Guam's local fruit and vegetable needs. In 1974, local production of fruits and vegetables were valued at \$798,065 versus an estimated importation of \$2,304,490. The quality of local produce is beginning to be recognized. In August, 1976, the U.S. Navy offered to purchase on a contract basis 14 types of local vegetables and fruits totaling 229,380 pounds. Weekly deliveries will have to begin in March, 1977, and continue for six consecutive months. According to the Navy, this is just a trial order to test whether local farmers can meet the Navy's requirements on schedule. If the trial orders prove successful, Guam's farmers can expect much larger orders in the future. The

¹Overseas Bechtel, Inc., Guam Economic Development Master Plan, Preliminary Survey, November, 1975, p. 5, 5-21.

University of Guam, College of Agriculture and Business (CAB), the Department of Agriculture, and the Guam Farmers Cooperative Association are working closely with a group of farmers in order to determine the crops which they can grow, the amount they can individually produce, and the price at which they would sell their produce to the Navy.

CAB estimates that a 50% reduction of replaceable imports can be accomplished over a three-year period using the same amount of acreage that is currently under cultivation. This estimate, however is not supported by a detailed plan. Furthermore, CAB believes that this goal can probably be achieved in less than three years if corporate farming is employed. Corporate farming will probably accomplish the above goal in less time than family or privately-owned farming due to the economies of scale realized in operating large size farms. In this regard, available data indicate that in the southern half of Guam, lands in the municipalities of Yona, Talofofo, Inarajan, Merizo, and Umatac show considerable potential for large-scale agricultural development. As shown in Table 2, available land for agricultural use in Southern Guam, totals 5,197 acres or 3.83% of Guam's total land area. Although small scale fruit and vegetable farming and livestock raising is carried on in northern Guam, the southern portion of Guam offers the best potential for commercial intensive farming.

Table 2
ARABLE LAND AVAILABLE
FOR AGRICULTURE USE IN SOUTHERN GUAM

District and Class	Net Arable (acres) (A)	Percent Available for Agricultural Uses ⁽¹⁾ (B)	Net Available for Agricultural Use (acres) (C=AxB)
Yona			
River Bottoms	400	(50)	200
Coastal Uplands	650	--	--
Inland Plateaus and Hills	2,085	(50)	1,042
Subtotal			1,242
Talofofo			
River Bottoms	400	(90)	360
Coastal Uplands	450	(50)	225
Inland Plateaus and Hills	2,370	(50)	1,185
Subtotal			1,770
Inarajan			
River Bottoms	1,025	(40)	410
Coastal Uplands	575	(60)	345
Inland Plateaus and Hills	1,620	(50)	810
Subtotal			1,565
Merizo			
River Bottoms	300	(50)	150
Coastal Uplands	16	--	--
Inland Plateaus and Hills	340	(50)	170
Subtotal			320
Umatac			
River Bottoms	125	(50)	62
Coastal Uplands	--	--	--
Inland Plateaus and Hills	240	(80)	192
Subtotal			254
TOTAL			5,197

Note: ⁽¹⁾ Based on existing zoning, discussions with Government of Guam planning staff, and current trends in development in southern Guam.

Source: Overseas Bechtel, Inc., Guam Economic Development Master Plan, Preliminary November, 1975, p. 5-29

3. Constraints and Supportive Requirements. Despite Guam's ideal tropical climate, there are many problems associated with profitable production of agricultural commodities. Some of them involve the physical factors -- the soil, slope of land, climate, tropical insect pests, disease, and endemic vegetation. Others are related to land ownership patterns and land tenure, water shortage, farm labor shortage, marketing, alternative land uses, lack of support infrastructure, and competition from other producing areas. In the following paragraphs, the important factors are discussed.
- a. Land Ownership Patterns and Land Tenure. World War II witnessed massive bombardment of Agaña, which resulted in the loss of land records and many landmarks and created great confusion in property rights. After World War II, the U.S. Government acquired additional land regarded as strategic. In many cases, these land areas were among the most productive agricultural areas of the island. Much of this land presently remains idle in terms of its crop production. Of the total area of approximately 135,525 acres on the island, about 45 percent is privately owned, 35 percent is federally funded, and 20 percent is Government of Guam land (see Table 3). Land ownership is considered highly prestigious in the Chamorro culture. The land is kept in the family and almost never sold, no matter how small the holding. Therefore, the average parcel size of privately owned land is small on Guam.

Table 3
USABILITY OF SOILS AND OWNERSHIP

Soil Unit	Soil Type		Ownership (Acres)			
			GovGuam	Military	Private	Total
I	10 and 11	Suitable for vegetable crop when drained. Too poorly drained for commercial citrus and other fruits. Suitable for rice and wetland taro where water is in adequate supply.	112 (4%)	774 (27%)	1,954 (69%)	2,840 (100%)
II	2, 3, 4, 6, and 9	Generally suited to all crops, however, due to excessive slopes, some areas better suited for range and grazing. Soil Type 2 suited for coconuts, sweet potatoes, and other root crops.	1,989 (9%)	4,524 (21%)	15,072 (70%)	21,585 (100%)
III	1, 5, 7, 8, 12, 13, and 14	Most suitable for forestry and grazing. However, soil type, suited for general agriculture, citrus, and other crops subject to depth limitation.	25,149 (23%)	41,724 (37%)	44,227 (40%)	111,100
Totals			27,250 (20%)	47,022 (35%)	61,253 (45%)	135,525 (100%)

Source: Planning Division, Department of Land Management, January, 1967. Soil types are mapped in Military Geology of Guam, 1959. (As quoted in Overseas Bechtel, Inc., Guam Economic Development Master Plan, Preliminary Survey, November, 1975, pp. 5-24 to 5-25).

Out of 10,038 private owners, 93.5% own property of 5 acres or less (see Table 4).

Data for 1974 for agriculture shows the average size of a truck or vegetable farm to be 0.88 acre or 38,332 square feet. Small farms on Guam have a number of disadvantages. First, many products required by the farmers come in big containers or packages (i.e. chemicals, pesticides, seeds, etc.). Wastage occurs when these products are not fully utilized during the year. Second, economies of scale is generally realizable with larger-size farm operations. In this regard, the smaller-size farms are at a disadvantage in competing with the bigger farms. Third, the small producers are often at a disadvantage when competing for contracts since marketing contracts for fresh produce are generally made for bigger orders.

Table 4

PRIVATE LAND OWNERSHIP PATTERNS ON GUAM

Size of Land Holding	Private Owners	Percent
Less than 1/4 acre	6,378	63.5
1/4 to 5 acres	3,000	30.0
5 to 300 acres	600	6.0
300 to 1,000 acres	50	0.5
More than 1,000 acres	10	-
TOTAL	10,038	100.0

Source: Guam; Its Economy and selected Development Opportunities, Stanford Research Institute, Menlo Park, California, 1959. (As quoted in Overseas Bechtel, Inc., Guam Economic Development Master Plan, Preliminary Survey, November, 1975, p. 5-25).

Much land remains in multiple ownership. Efficient large scale farms will not evolve unless the government consolidates land holdings or promotes the use of larger farms. There are several large tracts of land, both private and government, that are not in production either for livestock or crops but which could be developed for agricultural production. Areas of private land are not put to agricultural production as a result of the following factors:

- (1) Farming is generally considered by local residents as a less prestigious occupation.
- (2) A majority of agriculture landowners can afford to leave land idle because of the present tax structure.
- (3) Many landowners have little or no interest in agriculture. This situation is compounded by the difficulty in obtaining suitable land by purchase or obtaining long-term leases from private or public owners.

For crop farming, the southern half of Guam shows potential for a commercial type of agricultural development. The municipalities of Talofofo and Inarajan, with their relatively large areas of fertile land and available river water have special potential. Talofofo is presently one of the most important agricultural areas in southern Guam and is expected to hold this position in the future. The Inarajan area has considerable tourist-oriented recreational development, which may cause high land values that preclude use for agriculture. The Malojloj area, presently agriculturally important, is expected to remain so. Yona, largest of the five municipalities, will continue to expand in

urban and recreational development. The extent of agriculture in this area will likely remain static unless definitive steps are taken. The arable lands, approximated in the five municipalities of southern Guam, are shown in Table 2.

Guam's consumption of approximately 10 million pounds of fruits and vegetables can be realized on 299 acres under irrigation.² Intensive farming should be located on land determined most suitable for agricultural use. The government must designate suitable areas on the island as agricultural preserves. A mechanism for such designation was approved by the Governor on February 4, 1975 (Public Law 12-225). Bills 919 and 920 have been introduced into the Thirteenth Guam Legislature to amend the existing agricultural preserve legislation. Very briefly, Bill No. 919 provides for the determination of agricultural areas by the Central Planning Council (as part of the Master Plan) and administration of preserves by the Department of Agriculture. Generally, Bill No. 920 provides for re-definition of zoning regulations and established performance standards and minimum regulation to encourage the most appropriate use of land on Guam. It is the intent of these bills that the greatest possible protection shall be given to those lands with a high capacity for intensive cultivation as described in Section 12501 (c) of P.L. 12-225. A land use plan will take into account the desired economic and social conditions, the natural, environmental recreational, scenic, historic and other resources, and the provision of public capital facilities and social services.

²Overseas Bechtel, Inc., Guam Economic Development Master Plan, Preliminary Survey, November, 1975, p. 5-28.

b. Soil and Physiography, Guam consists of two physiographic regions. The northern part, a gently sloping limestone plateau, lies 150 to 300 feet above sea level. No streams drain the area; rain water sinks directly through the porous rock to the water lens. For the protection of Guam's water resource in the northern part of Guam, the area directly above the water lens has been designated as a water conservation area. The southern part of the island is mainly volcanic, containing remnants of a former limestone surface. Numerous streams have cut the surface in peaks, knobs, ridges, and basin-like areas. A nearly continuous mountain ridge rising up to 1,334 feet runs south from the highlands south of Piti to the southern tip of Guam. This ridge is about 1 - 2 miles from the coast and drops abruptly to the sea. To the east of the range, the land is hilly, dropping gradually from more than 1,000 feet to sea level. Flatland suitable for agriculture is relatively rare throughout the southern part of the island. The quality of Guam's soils is not generally high.³ The soils are often stony, badly leached of plant nutrients, and low in organic matter. Soils in the north, developed over limestone, retain moisture poorly and quickly dry after a rain. To help retain soil moisture and enhance nutrient status, the Department of Agriculture highly recommends adding organic matter in the form of manure, compost, or plant remains. Commercial fertilizers with equal amounts of nitrogen, phosphorus and potassium are

³Overseas Bechtel, Inc., Guam Economic Development Master Plan, Preliminary Survey, November, 1975, p. 5-23.

The 1970 report by Austin estimated the water consumption rate of 110 gallons per day per person plus a 10% loss. Thus, the water supply required to service a population of 100,000 (in 1975) was estimated at 12.1 mgd.⁵ Recorded ground water pumpage for May, 1976, shows, however, the total quantity of ground water produced has already reached a peak of 20.3 mgd.⁶ This large discrepancy exists because the report did not account for the fact that the average water consumption rate tends to increase as the people's standard of living improves. Another factor contributing to the under-estimation of water consumption is substantial leakage due to faulty pipes. Based on the present groundwater pumpage required to service Guam's existing population of 100,000, it is estimated that by the year 2,000, when Guam's population is projected to range from 200,000 to 250,000, groundwater production will need to range between 40.6 mgd to 50.75 mgd respectively, a rate which might not be attainable.⁷

In the absence of economical desalination technology, in approximately 25 years Guam will have reached its maximum capacity for servicing the water requirements of its population.

⁵ Austin, Smith & Associates Inc., Conservation Requirements for the Preservation of Guam Water Resources, August, 1970, p. 7.

⁶ PUAG Report for May, 1976

⁷ No provision was made in the projection for possible savings in the supply of water due to a reduction in the rate of water loss presently experienced. However, the possible savings are expected to be mostly offset by the increase in water consumption rate (also unaccounted for) as a result of a rise in the people's standard of living.

Therefore, to ensure that the future water requirements of the local population are met, consideration should be made before implementing agricultural and non-agricultural projects that require relatively high volumes of water for their operations. A large scale agricultural industry is possible on Guam only if a dependable public irrigation system is developed. The development of an irrigation system in northern Guam is not advisable due to the danger of contamination of the most important source of water on Guam.

- d. Farm Management and Hired Labor. The problem of hiring farm labor is acute on Guam as local workers have shown a strong preference for jobs in areas other than agriculture. Presently most of the farm workers are non-immigrant aliens. In 1974, hired agricultural laborers numbered 120, of which 33% or 40 were of local hire. In the future, expansion of existing agricultural enterprises may be restricted due to the time-consuming process of bringing in alien workers. Given this situation, entrepreneurs may tend to favor the use of capital intensive agricultural practices versus labor intensive ones, and the employment contribution of the agriculture industry will be minimal. To reverse this trend, the island must attract persons with technical and managerial skills to agriculture. Encouraging young people to take farming as a career appears to be a difficult task on Guam. There are indications, however, that the youths are showing a reawakening interest in agriculture in the University of Guam. From 1974 to 1976,

this number increased from 8 to 29. Continued emphasis on agricultural training would definitely encourage agricultural development on Guam.

Government studies on labor requirements for various agricultural projects will greatly expedite the processing of requests for alien laborers. The amount of labor required generally varies with the kind of crop planted, type of equipment used, physical condition of the farm, and technology required. While the hiring of foreign labor is presently necessary for the development of agriculture, the government must find ways and means of attracting local labor to agricultural projects on the island.

- e. Production, Distribution, and Marketing. The production, distribution, and marketing aspects of agriculture on the island can perhaps be described as chaotic. For example, vegetable and fruit growing is done on plots generally too small to be economically viable. Many farmers also continue to raise crops without a firm contract with supermarkets and stores. In the absence of a contract, local farmers are often-times faced with very low prices for their products whenever a glut occurs in the market. Overproduction of particular crops frequently occur due to the difficulty of determining the demand and supply of fresh produce throughout the year.

One of the most important tools to farmers and to policy makers are the demand and supply data of major agricultural products. The lack of up-to-date data makes production planning

extremely difficult. Since Guam's market for fresh produce can be characterized as small, production of fresh commodities has to be planned carefully to avoid any overproduction. Whenever feasible, farmers should be encouraged to obtain contracts for a more orderly marketing of their produce. For the majority of farmers, who have no contracts, current information should be made available on the forecasted supply, demand, and price of a number of agricultural commodities. The pooling of produce through a cooperative also assists the small producer in marketing his crops more profitably. Guam presently has no central outlet for farmers to display their produce. A well-designed and strategically located public market can help Guam's farmers in the sale of their crops.

- f. Technology, Capital, and Infrastructure. The various alternatives that can be applied in agricultural development require specific technical knowledge to derive maximum economic yields. In many instances, technology applied elsewhere is not suitable to Guam's situation. Consequently, a great deal of time and money are normally required for research and testing before technology applied elsewhere can be applied successfully to Guam. It has been observed that in many cases, most farmers have their own favorite crops. A switch to a new crop with the prospect of a better financial return would represent a new and risky venture. For example, planting a new variety of vegetable would mean a new technology requiring a different kind of land preparation, planting, pest control, disease

control, fertilization, harvesting, packaging, and marketing. In encouraging farmers to try new technology, agricultural extension agents must ensure that the farmer fully understands the requirements of the new crops, thereby enabling him to successfully grow and market his produce. It is, therefore, important that in reviewing the various alternatives, careful consideration should be given to the following factors: kind and level of technology suitable for Guam; research and testing required locally; availability of trained personnel; and overhead costs and infrastructure required to apply the technology.

Increased research by the University of Guam and other government agencies should be encouraged in order to facilitate the selection of economic and high yielding technology.

Supporting a viable agricultural industry on Guam would require varying levels of capital (for the project itself and for needed infrastructure such as roads, etc.) depending on the project chosen, location of sites, size of operation, technology applied and required infrastructure. Various projects, namely, feeder roads, irrigation dams, a central market, refrigeration facilities, a cannery (for excess vegetables) and animal slaughter houses have been considered for assisting agricultural development. These projects require a thorough cost/benefit study in order to assist government planners in developing alternative growth options for agriculture.

B. Element 2. Hydroponics

1. Definition: Hydroponics is the science of growing plants without soil under controlled temperature, humidity and light. In hydroponics, plants are grown with their roots immersed in a water solution containing necessary minerals or rooted in a sand medium kept moistened by such a solution. A typical hydroponic technique has plants supported in a bed of peat, wood fiber, or similar material, or on a wire screen with the roots dipping into the solution below. Aeration of the solution is provided. In another method, the plants are rooted in a medium of sand or gravel contained in a shallow tank into which the solution is pumped at intervals by automatic control. Between pumpings, the solution drains slowly down into a reservoir tank.
2. Potential: Before typhoon Pamela, there were six hydroponic farms in operation on the island estimated to be producing over 200,000 pounds of vegetables per year. One hydroponic farm reportedly experimented with flower production and found the initial results encouraging. Using hydroponics, a wide variety of vegetables and florist crops can be grown satisfactorily. In fact, hydroponics may have special applicability in Guam where soils are generally poor and land values are high. Principal advantages of hydroponics include:
 - a. Savings of labor by automatic watering and fertilizing;

- b. Production of crops when the rainy season is limited;
- c. Production of quality products commanding higher prices.

3. Constraints and Supportive Requirements: Except for "soil and physiography," all of the constraints discussed in Section II.A. also apply to hydroponics, although perhaps in varying degrees.

a. Land. Land requirements are not as extensive in hydroponics relative to field farming. In hydroponics, crop yields of some plants can be obtained fully equal to those obtained on fertile soil. However, a hydroponic farm can yield a higher total output per year than a similar size field farm due to the following factors:

1. A hydroponic farm under greenhouse conditions can control environmental factors, thus reducing risk and maximizing yields.
2. With some crops, such as tomatoes and cucumbers that can be trained to grow upward on supporting wires, more plants per unit area can be grown.
3. Hydroponics in a greenhouse are not affected by rainy weather, allowing more plantings per year. Hydroponic farms can be located on most types of land provided they have access to a road, water supply, and utilities.

- b. Water Supply: The availability, adequacy and purity of water is crucial in hydroponic operations. The plant nutrients are made available to the plant in a solution. Thus, the supply of water must be assured. Drinking water is presently used for hydroponic operations. While irrigation water can possibly be utilized, it will have to meet certain standards and be regularly tested for purity. Water consumption data on hydroponic operations is not available. The amount of water required for an economical operation must be studied.
- c. Lack of Market Information: Forecasting of supply and demand of vegetable crops that can be grown by hydroponics is often hazardous due to the lack of reliable market data. The need for supply and demand data is more acute with hydroponic farming than with regular crop farming. With the relatively higher investment in hydroponic farming versus regular crop farming, the hydroponic farm manager cannot afford to make mistakes in forecasting the selling price of his products. Until up-to-date supply and demand data is made available, hydroponic farmers must resort to the use of fixed contracts for a more orderly marketing of their produce. Hydroponic farms, under greenhouse conditions, are in a better position to meet production targets and grading requirements. Consequently, hydroponic producers should have less difficulty than regular crop farmers in obtaining fixed marketing contracts.

- d. Technology and Capital: A serious constraint to hydroponic farming is the high investment and technical know-how required for this type of business. While actual cost figures for running a hydroponic farm are not available, it is generally known that a hydroponic farm requires a higher initial investment than conventional farming. Therefore, any decision to invest in hydroponic farms must not only carefully assess the total investment required but also determine the return on investment.

A higher degree of technology is necessary to operate a hydroponic farm successfully. Management must fully understand a wide range of technical matters and often-times should be able to conduct some research to solve day-to-day problems that crop up during operations. The following are some of the technological problems that has been identified on Guam. First, there is the problem of maintaining the recommended day and night temperatures for crops to achieve maximum yield. Second, there is the need to identify a suitable growth medium for hydroponics. Third, an economical irrigation system must be developed for hydroponic farms. Fourth, there is the need for more information on proper fertilization and disease control.

- e. Labor Requirements: The labor requirement for hydroponic farming is generally lower than regular crop farming due to the following factors. First, hydroponics makes use

of automatic watering and fertilizing. Second, hydroponics eliminates the need for land preparation and weeding. Third, harvesting is facilitated where crops can be grown on supporting wires under greenhouse conditions. Furthermore, pest and disease control is more effective under greenhouse conditions. Since planting can be more easily staggered under hydroponics, harvesting can be spread out easily to accommodate part-time laborers. This system of harvesting has applicability on Guam where housewives are willing to work on a part-time basis.

C. Element 3, Mariculture

1. Definition: "Mariculture" is defined as the production or harvest of fish and shell fish, both cultured and wildstock, from the marine as well as from brackish and freshwater habitats. The culture of useful aquatic animals and algae under controlled conditions that are similar to the techniques applied in raising agricultural crops and animals is usually referred to as aquaculture.
2. Potential. Guam depends heavily on imports to satisfy the island's demand for fish. In 1974, Guam consumed an estimated \$1,235,000 worth of fish, \$1,104,000 of which were imported and \$131,000 locally produced. Disregarding the fish consumed in the tourism sector, the current annual demand for fresh frozen fish on Guam is approximately 2.2 million pounds.

With a local catch of no more than 0.2 million pounds (10 percent), and 0.8 million pounds of fish imported annually, an unmet demand balance of 1 million pounds remains.⁸ By 1980, Guam will need approximately 5 million pounds of fish and fishery products to satisfy the needs of the resident population and visitors.⁹ Thus, commercial fishing, if it can be developed on Guam at competitive prices, could become a means of broadening the island's economic base.

Depending on the species of aquatic animal to be raised, the yield of harvestable products from 600 acres considered suitable for aquaculture ranges from 1.8 million pounds to 14.9 million pounds. Since a one-species crop for the 600 acres would not be advisable, a more reasonable long-range estimate of a diversified aquaculture harvest, based on a goal of 600 acres put into production, would be closer to 5 million pounds (See Table 5).

⁸Overseas Bechtel, Inc., Guam Economic Development Master Plan, Preliminary Survey, November, 1975 pp. 5-15 to 5-21.

⁹Isaac I. Ikehara, "The Mariculture Potential for Guam," The Social-Economic Impact of Modern Technology Upon A Developing Insular Region: Guam II, p. III-83.

Table 5

MARICULTURE ESTIMATIONS FOR GUAM

Organism	No. Acres	Estimated Productivity (Lbs. per acre)	Total Production (lbs.)	Price (per lb.)	Total Value
Shrimps	120	4,000	480,000	\$3.00	\$1,440,000
Catfish	120	8,000	960,000	1.00	960,000
Carp	120	8,000	960,000	.80	768,000
Tilapia	120	8,000	960,000	.80	768,000
Eels	30	25,000	750,000	2.50	1,500,000
Oysters	10	40,000	400,000	1.00	400,000
Mullet	10	3,000	30,000	1.00	30,000
Milkfish	20	3,000	60,000	1.00	60,000
Tuna Bait	50	10,000	500,000	2.00	1,000,000
TOTAL	600		5,100,000		\$6,926,000

Source: Isaac I. Ikehara, "The Mariculture Potential for Guam," The Social-Economic Impact of Modern Technology Upon A Developing Insular Region: Guam, II, p. III-94.

Fishing operations can be accomplished in two ways: harvesting of wildstock and production of cultured stock. The harvesting of wildstock depends primarily on the availability of the resource in commercial quantity and the technology to harvest the resource economically. The success of the production of cultured stock depends primarily on production cost, state of the technology, availability of a suitable habitat (especially the availability of large quantities of unpolluted water), and the salability of the product at a price greater than the production cost.

The harvest of wildstock of fish will likely be based on the exploitation of the skipjack tuna resource of the Western Pacific and the harvest of deepwater snappers, groupers, jacks, mackerel, and possibly, yellowfin tuna. The availability of tuna and the technology to be used in harvesting the fish is presently being researched. The Pacific Island Development Commission (made up of the chief executives of Hawaii, Guam, American Samoa, and the Trust Territory of the Pacific Islands) created the Pacific Tuna Development Foundation in order to develop tuna fishing in the Pacific. Two modern U.S. purse seine fishing vessels recently arrived on Guam to begin testing and modifying the net fishing technique for the skipjack tuna resources of the Western Pacific.

There appears to be small likelihood that the fish resources of the shallow reef and lagoon habitat would be able to provide a substantial increase to the present fish production of Guam. Most of these areas are now heavily exploited and are generally in an overfished and badly abused condition. The potential for a substantial increase in harvesting wild stock from the freshwater habitat is negligible, except for the 175 surface acres of the military-controlled Fena Water Reservoir.

Although tests by the University of Guam, College of Agriculture and Life Sciences have not yet been completed, the partial results indicate a potential for aquaculture production of

various fresh or brackish water species. The following is a list of species that appear to be prime candidates for culture on Guam. The species are arranged in order of priority, based primarily on the extent of their readiness for culture and potential economic importance:

- | | |
|--|-------------------------------------|
| (1) Giant Malaysian prawns | (9) Oysters |
| (2) Channel catfish and Asian catfish | (10) Rabbitfish |
| (3) Combined silver, grass, & big head carps | (11) Tuna bait-fish |
| (4) Freshwater eels | (12) Mussels |
| (5) Tilapia | (13) Fresh and brackish-water crabs |
| (6) Milkfish | (14) Coconut crabs |
| (7) Mullet | (15) Green sea turtles |
| (8) Brackish-water shrimps | (16) Bullfrogs |

Freshwater eels are presently grown on a limited scale in the southern part of the island. In September, 1976, nearly one million baby shrimps were donated to Guam shrimp farmers by the Hawaii State Fish and Game Department. The baby shrimps were distributed among four shrimp operators in Inarajan and Talofofo who were farming a total pond area of 10 acres. The shrimps will be harvested in six to eight months.

3. Constraints and Supportive Requirements. The following factors have been identified as hindering the development of commercial fishing on Guam.

- a. Infrastructure. Commercial operations require a large harbor area where fishing vessels can easily enter and dock. The present port facilities at Apra Harbor are limited and expansion is necessary to accommodate commercial tuna fishing.

Land will also be required for auxilliary facilities including a refrigeration plant, fuel storage, a cannery and other facilities. Federal research is still continuing on the possibility of developing commercial tuna fishing in the Western Pacific. The major concern of this research is to determine whether there is a sufficient amount of fish in this area to justify the substantial investment required for a commercial tuna operation.

The selection of a tuna cannery site is a major task that must be accomplished in the event a tuna cannery is shown to be viable in Guam. This is a most difficult task because of the problems involved in securing land in Apra Harbor. When the land problem is solved, supporting facilities such as the cannery, refrigeration plant and other facilities must be considered. The demand for tuna products and the supply of tuna and other factors of production in the years to come will determine to a great extent the size of operations most suitable for Guam.

The expansion of existing boat harbors or creation of new ones should be considered as these facilities are badly needed by commercial fishermen.

- b. Legal Restrictions. Currently, United States law prohibits Japanese, Korean, or other foreign fleets in U.S. ports to off-load tuna. However, American Samoa, where Van

Camp and Star Kist both have tuna operations, has been granted an exemption from this requirement. It is possible that Guam also shares this exemption.

- c. Water. An ample supply of processing water is essential for tuna canning. According to a study prepared by the Planning Research Corporation, a Guam tuna cannery capable of processing 12,500 tons of tuna per annum would require 25 million gallons of water per year.¹⁰ To meet the cannery requirement, a greater amount of water has to be pumped due to water losses existing within the system. Assuming a 40% water loss, total pumpage needed is 35 million gallons of water per year to meet the cannery's requirement. This volume is equivalent to the yearly water consumption of 871 individuals based on an individual water consumption rate of 110 gallons per day. While fresh water requirements for canning a number of fresh or brackish water animals for Guam have not yet been determined, they are generally considered high users of fresh water. Expansion of the agricultural and fishery sectors of the economy must be evaluated in terms of their long-term impact on the supply of potable ground water, keeping in mind projected water consumption and local population forecasts, including tourists.

¹⁰Planning Research Corporation, Economic Development of the Territory of Guam, Part 2, February, 1966, pp. 12-21.

- d. Bait Study. A ready supply of economic bait fish in commercial quantity is required for tuna fishing. Proximity to both live bait and the fishing grounds are important factors in the location of tuna operations. The availability of a bait fish supply to support a fisheries industry based on Guam needs to be investigated.
- e. Manpower. Commercial fishing is seriously hampered by a lack of trained personnel and a lack of interest on the part of local young people to enter this trade. Rapid development of fishing may necessitate the importation of trained personnel. However, it is estimated that the size of labor force available on Guam could probably supply the workers needed for a major cannery on Guam.
- f. Land Requirements. At least 600 acres of marginal lands with clay soil that lie adjacent to adequate streams have been deemed suitable for aquaculture use on Guam. These lands are located in the central and southern areas of Guam.
- g. Production and Marketing. As mentioned earlier, the outlook for a tuna operation on Guam is contingent on a number of factors, including the discovery of an abundant and economical supply of tuna in the areas around Guam. The availability of tuna is still being researched. Similarly, the production of cultured stock is still under study.

Preliminary findings indicate good potential for some animals. However, detailed production and cost studies are badly needed but are not yet available. With very little production ~~on~~ ^{at} a commercial scale, there is little organized marketing of fish products on the island. With increased production, commercial fishermen may find a number of advantages in organizing themselves and marketing their products through one organization.

- h. Capital and Technology. Like hydroponics, mariculture production requires a high degree of technical knowledge. The capital requirement for commercial fishing and aquaculture is higher than that required by hydroponic farming. In view of the high capital requirements, complex technology and risks in this type of business, it is probable that only qualified individuals or corporations who have ~~had~~ previous experience and success in this business would be interested in investing in this type of venture on Guam.
- i. Clarification of Legal Questions Affecting Tuna Operation. To encourage potential investors, rulings should be obtained from the Federal Government so that all doubt is removed regarding: (1) the ability of foreign fishing fleets to unload their catches ~~on~~ ⁱⁿ Guam; (2) the ability of a local operation to ship canned tuna directly to the United States ~~on~~ ^{on} a duty-free basis.

per acre. Given its limited land resource, commercial cattle farming is not one of the better alternative uses of Guam's land.

D. Element 4: Livestock Production.

1. Definition. Livestock production is defined as the raising of domestic farm animals, such as cattle, swine and poultry for personal or commercial purposes.
2. Potential. Guam imports a large percentage of its domestic meat consumption. In 1971, island imports amounted to 1.7 million pounds (\$900,000) of pork, 2.3 million pounds (\$880,000) of poultry, and 3.4 million pounds (\$2,500,000) of beef. The domestic production of pork, poultry, and beef were 20%, 6% and 5%, respectively, of total consumption for that year. S., it is necessary for a poultry and swine producer

to keep at least a couple of months of feed to ensure a stable supply. The need to carry such a large inventory during "fiestas" and numerous social occasions throughout the year, "roasting" pigs are normally served. The five-year development plans of the Department of Agriculture calls for a 1979 production of 30,000 head of swine. The use of local crops as

The poultry industry in Guam has developed rapidly in the last few years. Prior to typhoon Pamela, Guam had 80 percent self-sufficiency in egg production. It is estimated that 60 percent of the laying flock on the island are replaceable and available for meat slaughtering annually. However, there is no broiler industry on the island where chickens are raised primarily for meat production.

Increased production of domestic beef does not appear promising due to the large acreage required for cattle to become profitable -- an annual carrying capacity equivalent to at least one animal

per acre. Given its limited land resource, commercial cattle farming is not one of the better alternative uses of Guam's land.

3. Constraints and Supportive Requirements. Very little information is available on livestock production on Guam. Consequently, this paper will touch only on those areas which have been discussed with a number of farmers on Guam.

a. High Cost of Feed. This appears to be a most serious problem facing swine and poultry producers on island. Since Guam is far away from the source of feed supply in the U.S., it is necessary for a poultry and swine producer to keep at least a couple of months of feed to ensure a stable supply. The need to carry such a large inventory ties down the farmer's working capital and raises his cost of operation. Furthermore, the high transportation cost of the feed to Guam adds substantially to the high cost of poultry and swine production. The use of local crops as feed to swine must be researched to see if the costs of raising swine can be accomplished at a lower cost.

b. Swine Slaughterhouse and Poultry Processing Plant. These major capital improvement projects have been proposed as essential to encourage meat production on Guam. However, in the case of a poultry processing plant, it has been reported that "the Guam Economic Development Authority (GEDA) will seek to foreclose a loan to C & H Farm for

\$113,697.77 used in purchasing a poultry processing plant."¹¹ This unfortunate development points out the need for a thorough study on the feasibility of a poultry processing plant for Guam before additional investment is made. Broiler production is generally accomplished on a wide scale in the mainland, giving rise to economies of scale. Guam must consider carefully her ability to compete in the broiler business before embarking on any capital assistance program to Guam's poultry farmers.

In this case of a swine slaughterhouse, there are no indications or studies to show that such a slaughterhouse can pay for itself on Guam. A majority of the pigs grown locally are reportedly slaughtered in individual homes where they are to be roasted. Thus, given Guam's unique market for pigs, the proposed slaughterhouse does not appear warranted. There may be some potential for a slaughterhouse if piggery farmers become interested in raising swine for slaughter and processing into various pork cuts and products. Again, Guam's ability to compete with imported pork products must be studied before any action is taken regarding the proposed slaughterhouse.

- c. Feasibility Study. A feasibility study for broiler and swine production should be undertaken in order to determine the viability of a commercial type of operation for Guam. The study should cover not only the production aspects, but also the marketing and the distribution aspects of the business.

¹¹ Pacific Daily News, September 2, 1976

III. CONCLUSION AND RECOMMENDATIONS.

Agriculture and fishing have been major sources of livelihood for Guamanians for centuries. The importance of agriculture, however, has been declining steadily since World War II due to the competition of several newly emerged economic sectors including trade and commerce, tourism, government and the military. Governor Bordallo's agricultural development program and the "Green Revolution" movement have generated a great deal of interest in agriculture.

The growth of agriculture is expected to help reduce the importation of food, reduce the excessively high volume of imports over exports, and move the economy towards self-sufficiency. An important advantage of promoting agriculture includes the maintenance of open space. This will not only help preserve the beauty of the island for the enjoyment of its citizens, but also promote a better physical environment for the growth of tourism.

There are, however, some important factors affecting the contribution of agriculture to the island economy that should be carefully considered.

One of the major constraints to the growth of agriculture, as well as other industries, is the limited water resources of Guam. It is estimated that with present technology, the maximum amount of water per day that can be obtained from underground sources on Guam is 50 million gallons. Assuming there is no large increase in the number of highly water consumptive industries, the present trend indicates that potable water will approach its production limit by

the turn of the century, when population will range between 200,000 to 250,000.

Any increase in the water consumption rate will mean a smaller population the island water resource can support. Agricultural crops, therefore, should be encouraged only when the water requirement to maintain these crops is minimal.

Another important consideration in agriculture is the economic factor; in a free economy, the basic test for any industry's survival is whether or not it is economically competitive to imports. The present promotional supports to agriculture, such as tax breaks, low interest loans, reduced water rates, government insurance availability, etc., provide needed incentives; but in the end, the agriculture industry must be able to compete on its own basic economic merits if it is going to be a viable contribution to the economy and the well-being of the people of Guam. Government support therefore, must be selective. Farmers who demonstrate the ability to independently compete in the open market after the initial supporting period should receive more government encouragement and support. Indiscriminate treatment of all potential farmers without evaluation of their economic potential would create a new class of welfare recipients who are supported by tax payers in more productive economic sectors.

Four basic agriculture growth options were considered: field farming, hydroponics, mariculture, and livestock.

A. Field farming deserves to receive government support for the following reasons:

1. It provides an effective means of promoting open space and preserving the beauty of our island.
2. It has been proven successful for some island farmers, and is expected to assist in reducing Guam's dependence on imported foods.

Agriculture experts believe that the delivery of produce to markets according to the requested schedule is of primary importance. This is one of many factors that encourages local supermarkets to purchase Guam's produce and increases the demand for local products. Timely deliveries can be most effectively achieved by commercial farming where producers are well informed of the future market demand and are motivated by capital returns. Therefore, government policy must be directed to commercial types of farming to make the most efficient use of the island's resources.

It is recommended that the problem of water shortage be kept in mind since some types of crops require more water than others. This problem can be partly resolved by constructing the Ugam river dam in southern Guam. The dam, after construction, is expected to supply a new source of irrigation water for farmers at a moderate cost. However, since this project will require a substantial financial contribution by Government of Guam, a cost-benefit study must be conducted before the construction takes place.

- B. Hydroponics has been tried successfully on Guam and appears promising in providing certain types of vegetables and florist crops. Hydroponics is actually not in direct competition with field farming when hydroponic production is concentrated on crops that cannot be grown economically in field farming during the rainy season. Because of its ability to control environmental factors, hydroponic farming can also concentrate on the higher quality produce that commands higher prices.

Hydroponics has special applicability on Guam where farm labor is scarce and relatively expensive. Furthermore, land requirements are generally less in hydroponics than in field farming. As land becomes more scarce and expensive on the island, hydroponic farming will assume a more important role.

It is recommended that the government encourage hydroponic farming on a limited scale initially and provide the industry technical assistance, especially in the area of research and technology. Concurrently, the industry should be studied more closely in terms of the size of hydroponic farming that the island can support economically.

- C. There is little, if any, commercial fishing going on in Guam despite the heavy demand for fresh and frozen fish. The harvesting of wildstock, especially the skipjack tuna in the Western Pacific, is being researched by the Federal Government. While waiting for the results of the research, the various

constraints applicable to a cannery operation must be carefully studied. Since the cost of labor on Guam is high, we may not be able to compete with other tuna canneries that utilize lower labor. A tuna cannery in American Samoa reportedly has a lower labor cost than Guam's minimum wage. Another major constraint is the high water requirement of a cannery and the limited water supply on the island. Any decision to allow a cannery operation on Guam must take into account its future impact on the drinking water supply of the island.

The production of various freshwater species like shrimp and eel is technically feasible. Experiments are presently underway to demonstrate that these species can be raised successfully under Guam's conditions. However, some sources have indicated that Guam's cost of production is too high. Thus, detailed production and cost studies must be conducted to determine whether these projects are economically viable. Attention should also be given to the project's water requirements, especially if the source of water in the future will be ground water.

Government assistance in the form of pilot fresh-water farming projects should be continued. However, these project studies should cover not only the production side but also the marketing and distribution aspects of business. For these businesses to succeed, they must be able to compete with imported fish products.

D. A feasibility study must be done to determine the potential for livestock production on Guam. The animals that show some promise for meat production are poultry (broilers) and swine. The viability of commercial broiler or swine farming must be demonstrated sufficiently to justify consideration of a swine slaughterhouse and poultry processing plant for Guam. Given its limited land resources, commercial cattle farming is not one of the better alternative uses of Guam's land.

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