AN ANALYSIS OF THE EFFECTS OF CHANGING TECHNOLOGY ON SMALL GRAIN FARMS IN NICARAGUA

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by
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The undersigned, appointed by the Dean of the Graduate Faculty, have examined a thesis entitled

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[redacted]

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CHAPTER I

INTRODUCTION

Modernization of the traditional or subsistence agricultural sectors has become an important focal point for policy makers in developing countries and administrators of development assistance organizations. The issue is by no means new, but has taken on a position of higher priority in the early 1970's. The shortages of food and corresponding high prices of 1973 to 1975 were one factor contributing to the new focus on agricultural development. The World Population Conference in Bucharest along with the World Food Conference in Rome brought out the need for increased domestic production of food in the less developed countries (LDC's) to meet their growing requirements.

A second factor that brought agricultural modernization of the traditional sector to the forefront was the realization that many if not most of the development efforts in the 1960's - the development decade - failed to improve the lot of the poorest people in the LDC. If anything their relative economic position has declined.[1] In light of this the United States Agency for International Develop-

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1) SEE: Felix Paubert, "Income Distribution at Different Levels of Development: A Survey of Evidence" _International Labor Review_, Vol. 108, No. 2-3, Aug-Sept 1975.

ment (USAID), the International Bank for Reconstruction and Development, and other development agencies are focusing on the small farmer and rural poor in their assistance efforts.

In pursuit of these goals, many governments with the support of USAID and other agencies are investing more specifically in development programs for small farmers. These programs are based on the proposition that small farmers can be more productive and achieve increased income levels by adopting modern technology. Such programs are hoped to increase output and income in the rural areas.

The situation in Nicaragua is a typical example of the conditions described above. There has been little if any improvement in the incomes or productivity of the rural population in the past decade. The Government of Nicaragua with the support of USAID is currently attempting to develop...."a viable, effective, rural development institutional network, specifically created and mandated with improving the net and relative well being of its rural poor; including both the subsistence farmer and the rural resident."[2] A supervised credit program is envisioned as part of this institutional network. The technical assistance and access

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2) Ed Schaefer and Al Chable, "Constraints Analysis and Program Implications of the Agricultural Sector". (Unpublished Report, submitted to USAID Nicaragua, 1974) p.1.

to modern inputs are expected to enable small farmers to adopt modern technology thereby increasing their output and income.

In support of this policy, a study conducted in 1971 identified various technology levels for each of the basic crops. Corn yields for optimum technology were almost three times as great as yields for traditional technology. Similar potential increases in yield for rice, sorghum, and beans also were identified.[3] This study will attempt to predict some of the economic effects if more small farmers adopt the modern technology.

Problem Situation

Nicaragua is the largest country in Central America. It has a land area of approximately 48,000 square miles and an estimated population of two million people. It is bordered on the north by Honduras and on the south by Costa Rica. There is sharp topographic and climate divergence between the east and west.

The climate is generally tropical except at higher elevations where areas of mild climate can be found. In the western regions, mean annual rainfall is 78 inches with distinct rainy and dry seasons, each lasting about

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3) Philip F. Warnken, The Agricultural Development of Nicaragua, (University of Missouri Agricultural Experiment Station, Special Report 168, July 1975)pp. 81-82.

six months of the year with rainy season extending from May to October. The eastern half of the country experiences rain nine to ten months of the year with average annual rainfall as high as 259 inches.

Approximately 60 percent of the population is concentrated along the Pacific Coast and another 32 percent in the central highlands region. These are the major agricultural production regions of Nicaragua that will be included in this study, and are shown on Figure 1. The remaining eight percent of the population in the eastern half practice slash and burn agriculture concentrated along rivers that drain the Caribbean Coastal plains. This study excludes the Caribbean north and south regions since they are much less important in the economic life of the country and very little data exist for these regions.

It is estimated that about 52 percent of the labor force is found in the rural areas (in agriculture). It is further estimated that about 75 percent of the rural population lives at or near subsistence level. Many of these people live on small farms and have little or no formal education. With the resulting lack of marketable skills and lacking the resources to start new farms, it is not surprising that unemployment in this sector is estimated at something near 30 percent.

The economic and political power is securely held in the hands of a small minority of the population. It

Figure 1

NICARAGUA: MAJOR PRODUCING REGIONS

is this small minority that owns most of the land and enjoys a reasonably high standard of living on what profits there are in the agricultural sector. This situation is often considered one of the constraints to Nicaraguan agricultural development. While land reform and related programs may be important to achieving any long run degree of agricultural development such considerations will not be included in this paper.

Agricultural production is usually divided among the livestock sector, the export sector and the basic grains sector. The bulk of the export crops are produced on a relatively small number of medium to large size farm. Livestock production (beef and dairy) is also dominated by large farms. The bulk of the basic grain production is derived from a relatively large number of small to medium size farmers. This sector is generally characterized by traditional or subsistence technology with low yields, low per capita income and high levels of unemployment.

Some of the specific problems in Nicaragua were identified in an analysis of the agricultural production sector conducted by a University of Missouri team:[4]

- High levels of rural unemployment and underemployment
- Low labor productivity

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4) Philip F. Warnken, p. 128.

- Highly skewed income distribution
- Limited use of modern inputs
- Stagnated basic grains sector
- Low yields for most crops
- Extensive use of land capable of more intensive utilization
- Highly skewed land concentration
- Rapid rural population growth
- Insufficient roads and logistical network

The basic constraints they identified to the resolution of these problems include the land-holding pattern, limited foreign exchange, a low level of domestic capability to adapt and disseminate new technology, low levels of producers' technological knowledge, inadequate credit and a limited infrastructure. The resources available to the government to promote development in this sector are limited. The resources are especially limited if the program requires the use of foreign exchange to import inputs not locally available. Any program that makes demands on those resources will have to be justified by its effect on the complex of problems noted above.

On the brighter side, the analysis was able to identify the existence of "higher levels" of technology that used highly divisible purchased inputs. Producers using more of these purchased inputs were found to have higher yields, higher incomes, higher returns on capital and possibly higher labor requirements. In light of these findings, they recommend policies be implemented to ...... "sharply increase the use of purchased inputs"......and ....."expand the capability of farmers to use these inputs."[5] A program which includes supervised credit is being proposed as a means of overcoming some constraints.[6] This type of program, it is hoped, will be capable of providing producers with both the knowledge of improved technology and the ability to apply it on their farms. While such a program can not overcome all the constraints to agricultural development, it is hoped that it will have a significant impact by relieving many of the problems at a minimal cost.

This study will focus on the difference between the various technology levels existent in Nicaragua and evaluate some of the expected results if a credit program is successful in inducing small farmers to shift from traditional technology to a more modern technology that incorporates the use of improved seed and other purchased inputs. The study will estimate the magnitude of the impact such a program will have on the problems above under varying degrees of implementation.

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5) Philip F. Warnken, pp. 128-129.

6) Ed Schaefer, p. 64.

Selected Review of Literature:

The Role of Agriculture in Economic Development

The literature dealing with agricultural development in the LDC's, is indeed extensive. In 1968, D.H. Penny said:

> ...."there is a growing literature on how to turn a static agriculture into a developing one. Unfortunately, the literature grows more rapidly than the income of the peasants."7

There seems to be three different areas of that literature that apply to the basic grains sector of Nicaragua and the proposals for modernizing it. The dualistic development models offer one way of reviewing the relationship between the basic grain sector and the rest of the economy. The works of Johnston, Mellor and Mosher provide a theoretical background with which one can examine proposals specifically for developing traditional agriculture. Finally, a brief look at the supervised credit literature is in order as a credit program is being proposed as the tool to break the cycle of poverty and enable agriculture to develop.

The Dualistic Models

While separation of the Nicaraguan economy into two sectors may be an oversimplication of reality, applying the dualistic models, may shed light on why the basic grains - food production-sector is characterized as static with a

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7) D. H. Penny, "Farm Credit Policy in the Early Stages of Agricultural Development," Australian Journal of Agricultural Economics, Vol. 17, No.1, June 1968 p.32.

low level of productivity.

The static dualism models are classified as "sociological" and "enclave" dualisms.[8] The sociological dualism is best characterized by Boeke's explanation of the coexistence of a capitalist and a traditional agriculture sector in Indonesia. He argued that the problem in the latter sector was not lack of research, education, or input. The lack of growth he hypothesized, was due to cultural differences.

The enclave dualism was formulated by trade theorist such as Benjamin Higgins and Hla Myint, partially in reaction to Boeke's theory to explain the difference between export-oriented sectors with high productivity and "domestic market-oriented" sectors with low productivity. They hypothesized that the difference is in the imported technology and foreign market demand in the export sector leading to high levels of productivity, while the domestic-oriented sector uses labor intensive methods and is constrained by savings.[9]

The dynamic dualism models characterized by those of Lewis and Ranis and Fei were formulated to enable

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8) Vernon Ruttan W., "Growth Stage Theories, Dual Economy Models, and Agricultural Development Policy" Reading in International Agriculture Development (New York MSS Education Publishing Co.) pp. 16-18.

9) Ibid, pp. 18-19.

society to deal with the lack of capital labor market relationship between the modern and traditional sectors. They identified increases in per capita productivity of the agricultural sector as a mechanism for labor reallocation between the agricultural and industrial sectors. Most of these models see the movement of labor out of agriculture, where there is surplus, into industry with a simultaneous increase in agricultural production.

The Lewis[10] and Ranis and Fei models both start with a zero marginal value product (MVP) of labor in agriculture. Lewis' bases his model on the assumption that there is an unlimited supply of labor relative to capital in less developed countries. He sees development taking place through an increase in savings and capital accumulation. This capital will allow agriculture and industry to develop while paying a wage rate lower than the MVP of labor leading to further capital accumulation and development. The Ranis and Fei model of development was formulated to explain how growth in the industrial sector could take place through the absorption of labor into industry substituting for capital until the marginal value product of labor in agriculture equalled the wage rate. Increased

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10) W. Arthur Lewis, "Economic Development with Unlimited Supplies of Labor" Manchester School of Economics and Social Studies, 22 (May 1954) pp.139-191.

capital accumulation from this, along with innovation would lead to more labor absorption with no increase in the wage rate until the MVP in agriculture would equal the wage rate.[11]

Jorgenson's dual model rejected the assumption of zero MVP of labor. He held, along with T. W. Schultz,[12] that any reduction in labor would lead to a decline in agricultural output. In Jorgenson's model, technological change must be introduced into the agriculture sector from the very beginning of any growth process.[13]

These models all dealt with the dualism that seems to exist, but there are two reasons why no one of them is directly applicable to the situation in Nicaragua today. The first reason is that while all of the models are built on different sets of assumptions, and many of the assumptions do apply, none are completely consistent with the present situation. The second and more critical problem is that the programs now being considered are not aimed at developing the "modern," "industrial," "developed" societies on which the models focused. Rather the programs focused more directly on development of the agricultural

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11) Yujiro Hayami and Vernon W. Ruttan, <u>Agricultural Development: An International Perspective</u> (John Hopkins Press, Baltimore 1971, pp. 20-23.

12) Theodore W. Schultz, <u>Transforming Traditional Agriculture</u> (New Haven: Yale University Press 1964)

13) Yujiro Hayami, pp. 24-25.

sector itself. This focus is more consistent with the development theory exemplified in the works of such authors, as Johnston, Mellor, and Mosher.

Developing Agriculture

Johnston and Mellor rejected the sharp dichotomy between the two sectors and attempted to analyze the role of the basic agricultural sector as it relates to the rest of the economy. They listed the contributions of agriculture to development as follows:[14]

1. Provide increased food at equal or lower real prices
2. Provide foreign exchange earning
3. Supply labor for other sectors
4. Supply needed capital
5. Supply a market for manufactures

They held that current low levels of income and productivity were due to the lack of complementary inputs. These needed inputs did not require large capital investment but were technological and institutional in nature.

These technological and institutional inputs are divided by A. T. Mosher into the ...."essentials for agricultural development".... and ...."accelerators of

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14) Bruce F. Johnston and John W. Mellor, "The Role of Agriculture in Economic Development" <u>American Economic Review</u>, September 1961, Vol. 51, No. 4 pp. 566-593.

agricultural development." The essentials enumerated by Mosher are:[15]

1. Markets for farm products
2. Constantly changing technology
3. Local availability of supplies and equipment
4. Production incentives for farmers
5. Transportation
6. The general requirements for orderly human activity

If all of these are present then agricultural development will take place but if any one is lacking then there can be no development. While he considers these both necessary and sufficient for development, the pace of development may not be as rapid as is generally desired.

He further contends that it is possible to increase the rate of development through accelerator programs. These accelerators are:

1. Education for development
2. Production credit
3. Group action by farmers
4. Improving and expanding agricultural land
5. National planning for agricultural development

The major difference between the "accelerators" and the "essentials" is that while <u>all</u> the essentials must be present, this does not hold for accelerators. Any one or combination of more than one of the above is sufficient to increase the rate of development.

For the purpose of this study, it is assumed that

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15) Arthur T. Mosher, <u>Getting Agriculture Moving</u> (New York, Praeger 1965) pp. 63-179.

the essentials are already present unless proven otherwise in the course of the analysis. This will allow us to focus on the expected results if two of the accelerator forces, production credit and education, are brought into the system in the form of supervised credit.

Supervised Credit

Supervised credit is not new to development programming. It has been attempted in many countries with various degrees of success and failure. Many programs in Latin America, especially the ACAR Program in Brazil, have been analyzed and reported on extensively in the literature.

The Supervised Credit Program of the Associacao de Credito e Assistencia Rural (ACAR) was initiated in the State of Minas Gerais, Brazil in 1948. Within five years it had been expanded to cover more of Brazil and has become recognized as an example of a successful approach to the problems of Rural Development. The first study of the impact of the program by Mosher showed a general upward trend in the net worth of participants, especially subsistence farmers.[16] A later study by Wharton in 1958 revealed a growth rate in aggregate output of between 21 and 32 percent and growth rates in productive efficiency between seven percent and 16 percent per year for semi-

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16) Arthur T. Mosher, Technical Cooperation in Latin America, (Chicago, University of Chicago Press) Chapter 8.

subsistence farmers.[17] In more recent studies, the ACAR program has come under criticism in the area of program costs, economic efficiencies, and interest subsidies. In defense of the high cost argument, Wharton argues in 1969 that if credit cost were viewed as investment in human capital and compared with output not accounted for by changes in input, then the return on investment was in the range of 6.5 to 1.[18]

In spite of some problems, the ACAR program is still considered to have been quite successful in a number of ways. Many programs though implemented in other countries to assist the small farmers, have not achieved the level of success of the Brazilian experience. In Peru, the default rates on loans were considered too high and credit was not sharply increasing farmer output. Farmers did not have sufficient resources to use credit profitably and appropriate technology for increasing productivity was not available.[19]

D.H. Penny[20] reviewed the poor performance of many other government credit programs in low income countries and argued that in early stages of development, cheap

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17) Clifton R. Wharton, "The ACAR Program in Minas Gerais, Brazil" Change in Agriculture, edited by A.H. Bunting, (New York, Praeger Publishers, 1970) pp. 525-532.

18) Ibid, p. 530.

19) U.S. Agency for International Development, Agriculture Credit and Rural Savings, USAID Bibliography, Series No. 7, p. 27.

20) D. H. Penny, pp. 32-45.

credit is unlikely to be a useful growth stimulus. In defense of his position, he sites examples in Honduras, the Philippines, India, and Indonesia. In these programs the cost of providing credit ran as high as five times the interest rate charged to farmers and repayment rates were between 25 percent and 58 percent of the funds loaned out. He concluded from these examples and others, that ...."credit programs are an expensive and wasteful way of encouraging agricultural development."[21] In spite of what.... "should be clear".... he finds that governments continue to advocate credit programs for four reasons:

1. Governments and economists are unaware of attitudes of peasant farmers who are unwilling to use credit developmentally.
2. Governments see credit as an easy way to increase capital flows to the rural sector but fail to recognize that money is not capital especially if it is used for consumption.
3. Governments do not realize that credit institutions are as much a result as a case of development and can not be created by a stroke of the pen.
4. Governments fail to recognize the powerful economic reasons for high nominal rates of interest. Real rates of interest are much

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21) Ibid, p. 41.

> lower than the nominal rates charge by non-institutional credit sources.

He contended that governments should be more careful in how they use scarce resources under their command. "There are many possibilities in addition to credit programmes: agricultural research and extension, roads, processing facilities, a market information service, administering a land reform, land settlement and fertilizer factories."[22]

He does not say that credit programs cannot be profitable - to the government and the economy as a whole - but will be profitable only if:

1. there is unexploited productive potential in the farming areas where the loans are to be made
2. the farmer-borrowers and the lenders know what the economic opportunities in each locality are
3. the farmers are willing to borrow and to use the loans productivity, and
4. steps are taken to raise the propensity to save

In Nicaragua, it has been shown that some of the conditions cited above by Penny and by Mosher in his essen-

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22) Ibid, p. 43.

tials for development do indeed exist. Different technology levels exist that are more productive than those used by the majority of the farmers. The supplies and equipments that are available are being used on some farms. Other conditions necessary have been cited and are expected to be met as the proposed credit program is being implemented. Other social, economic and/or political conditions are assumed to be favorable or at least not detrimental to the success of the proposed credit program. However, accepting the presence of all conditions necessary for development, the many problems remain.

Problem Statement

The country of Nicaragua faces a serious problem of low levels of productivity, low per capita income, and high levels of unemployment in its agricultural sector. Within the basic grain sector though some farmers were identified who had achieved a higher level of technology through the use of purchased inputs.[23] An analysis of this technology indicated that it resulted in a higher level of production and income per unit area cultivated. Extension and credit programs that will enable farmer to adopt the higher level of technology are now being considered. If such a program is successful and farmers do switch from traditional to

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23) Philip F. Warnken, p. 128.

modern technology what will be the magnitude of the impact on food grain production? What will be the impact on rural employment and foreign exchange? And what will be the impact on producer and total rural income under estimated future prices?

Objective and Hypothesis

The objective of this paper is to develop a simple model that can be used by policy makers to examine some of the questions raised above. In order to keep the model simple, it will consider only the production of basic grains: corn, beans, grain sorghum, and upland rice in the six major agricultural regions. The model will further assume that the farmers provided credit will in fact shift to the proposed technology and that their costs and returns will be similar to those of farmers already using this technology.

It will attempt to determine the magnitude of the impact of increased use of purchased inputs in the basic grain sector on:

1. The balance of payments position of Nicaragua
2. Annual production of basic grains
3. Income in the rural sector
4. Employment in agriculture

It is hypothesized that such a program will have a positive impact on all four of the above. The first three are consistent with traditional development theory and programs; but the fourth - an increase in employment in agriculture - is a departure from previous theory and the development processes that have taken place in the industrialized countries such as the United States.

Organization of the Study

Chapter II presents first, an overview of the use of simulation models in the evaluation of agricultural development policy decisions. Based on these earlier works, the process of developing the model of the basic grains sector is outlined along with a description of the model to be used in this study. The data and previous analyses of the data used to determine the coefficients in the model are also reported.

In Chapter III the data are analyzed to determine the aggregate production functions and the cost and returns for the different technology levels. The remaining coefficients and relationships that could not be computed from available data are estimated. The relevant and required assumptions are also reported.

Chapters IV through VII present the results of experiments conducted with the model for the four crops. For each of the crops the production possibilities, labor requirements and income changes and the balance of payments due to changes in technology are reported. Based on projections of the model, policy recommendation are made for each crop.

The summary of findings and conclusions for the various policy alternatives are presented in Chapter VIII. Recommendations for further study in Nicaragua using this model and possible use of an adopted model in other less developed countries conclude this study.

CHAPTER II

DATA AND METHODOLOGY

Simulation Models

The basic method that will be used in this study to examine the effects of shifts in technology in grain production on small farms is a simple simulation model. The simulation model has been selected because of its ability to focus on a number of objectives and consider the dynamic interrelationships taking place within a sector of an economy.[24] This model of the basic grains sector of Nicaragua focuses on a number of variables that policy makers would like to positively influence through a specific type of program. Experimenting with this type of model enables policy makers to review the favorable and unfavorable effects of the proposed program without actual implementation. It thereby allows them to adjust the program or add supporting programs to offset unfavorable results before they occur. It may further provide realistic goals, quantified over time, that may be used to evaluate the program as it is implemented.

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24) For further discussion of the abilities and strengths of simulation see: Noel R. Devisch, Application of the System Approach: An Information and Decision Model for the Hog Enterprise, (Unpublished Ph. D. Dissertation, University of Missouri-Columbia 1976) pp. 7-28 and pp. 154-170.

Ideally, the model should include all variables that might enter into the dynamic interrelationships involved. The inclusion of these and stochastic equations to account for such unpredictable variables as weather, could provide a very real picture of the range of outcomes that might be expected. But due to lack of reliable data in some instances, and the desire to keep the model simple enough to use the type of data available in most developing countries, only those variables which are considered most significant will be included. For the same reason, this model will be deterministic in nature and leave stochastic considerations up to estimation by policy makers or future models of this sector.

While no longer new to agricultural economics, simulation is one of the more recent tools used in agricultural economics research. It has been used in the farm management area to stimulate whole farm growth, specific enterprises, and subsystems of enterprises in order to provide answers useful to management. Use is expected to increase in this area especially in the form of firm growth models, as the availability of computer facilities increases.[25]

Sophisticated models of various subsectors and the entire agricultural sector of less developed countries

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25) Jack R. Anderson, "Simulation: Methodology and Application in Agricultural Economics" Review of Marketing and Agricultural Economics, March 1974 pp. 31-32.

while not abundant, have been developed and implemented in other countries. The most extensive work to date in agricultural development work is the "Generalized Simulation Approach to Agricultural Sector Analysis" by the Michigan State University team. The generalized model was based originally on Nigeria but by 1973 had also been applied in Venezuela, Colombia, and Korea. At that time, they drew the following conclusion about the usefulness of simulation and specifically their model.[26]

> "It is felt that the model and many of its components are ready for application.....that application should always be expected to involve extensive field work and interaction with decision makers which will reveal needed modification and further development of the models.....In addition to being useful in constructing models of the entire agricultural economy of different countries, components developed for the total model are potentially useful in designing, analyzing, and evaluating program and more detailed projects of the subsector level. It also appears that the processes which have been modeled are so important to the countries....that full use of these models requires their mastery by indigeneous personnel....Finally, policy decision makers, in evaluating simulated result, must be aware of the assumptions and simplification built into the model....The model is an economic model, it was not designed to answer social or political questions."

The advantages of such a model that will allow policy makers to consider the results of policies before they are

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26) The Michigan State University Agricultural Sector Simulation Team, "System Simulation of Agricultural Development: Some Nigerian Policy Comparisons" American Journal of Agricultural Economics, Vol. 55 No. 3, August 1973, p. 418.

implemented are obvious when dealing in the area of scarce resources. But the process is not without its critics. If dubious logic and shaky data are included in the model, then the projections are obviously questionable. In complex models the assumptions often become transparent as information is fed into and out of the computer.[27] The practicality of using such models is further questioned even if they can be accurately designed. The MSU team found substantial information reservoirs and research investigation are usually necessary in developing a _reasonably_ complex and _useful_ simulation model.

Trained personnel with access to a large computer and a large budget are required. The issue remains as to whether or not the use of the resources required for the development of a complex model is worth the information generated.[28]

The model used in this study is an attempt to avoid the cost problems while still taking advantage of a few of the possibilities available in simulation. This model is relatively simple and requires a minimal programming and computational capabilities. The assumption are apparent and can be rejected or modified by any user of

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27) Jack R. Anderson, p. 33.

28) P. J. Charlton and S. C. Thompson, "Simulation of of Agricultural Systems" _Journal of Agricultural Economics_, August 1970, p. 388.

the model. In spite of this simplification, the model still meets the definition of simulation as it is a numerical manipulation of a symbolic model over time.

The simulation modeling procedures followed in this study are basically the same as those found among the various authors on simulation in agriculture. The process or steps involved are described by Anderson in his review of Simulation in Agricultural Economics.[29] These steps are:

1. Specification of Goals
2. System Analysis
3. Synthesis and Model Implementation
4. Verification and Validation
5. Sensitivity Analysis
6. Model Experimentation & Interpretation

The first step in the process, the specification of the goals of the model, are defined in Chapter I in the objectives of this study for this model.

The systems analysis is the analytical stage. In addition to being critical to the model and any experimentation with the model, it is of significant value in its own right. In this stage, the significant variables and their relationships must be identified and in so doing, useful knowledge is provided for policy makers and program designers.

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29) Jack R. Anderson, pp. 7-23.

Information provided in the systems analysis provides the subsystems and variables to be logically structured in the system synthesis. Adequate and meaningful data must then be analyzed to define the coefficients and equations to be used in the model. The availability and reliability of this data will often determine the complexity and usefulness of any model. Once the relevant equations have been determined and logically structured, the system can be programmed for rapid manipulation of the data by the computer.

The model is now ready for verification and validation. The verification consist of debugging the computer program and comparing anticipated with actual behavior of the model. Once the simulator has decided the model does what he wants it to do, it is ready for validation. No matter how sophisticated the equations, and beautiful the geometry of the flow patterns, the model is only useful if it can mimick the real world.

The model can be further tested in terms of its sensitivity to changes in individual or combinations of variables. Those variables in which slight changes affect the results of the model may be re-checked to insure their accuracy and further improve the accuracy of the model. Once the simulator is satisfied that they are accurate, they can be focused on in policy considerations as areas to be controlled to bring about the desired changes in the real world that the model simulates.

These steps need not, and in fact, usually are not completed in the sequence specified. Most steps feed back into one another as the model is refined to meet the goals originally specified. At this point, the model is ready for experimentation. This is why it was built and the results of these experiments should provide the answers to questions about policies and programs being considered.

Data

The data used in this model are derived from four sources: 1) the National Agricultural Census, 2) Annual Reports of the Central Bank of Nicaragua, 3) A National Agricultural Survey conducted by the Sector Analysis Unit (UNASEC) in 1971, and 4) 1975 Input/Output Prices collected by Philip F. Warnken with the assistance of the UNASEC staff in January 1975. No survey data were collected specifically for this model. This limits the model but reliable data is a limitation in any developing country. The major strength of this type of model lies in its ability to provide further information or clarification of a given situation with relatively low cost to its users by using only available data. Therefore, acceptance of the limited data available is sufficient and consistent with the goals of the study.

The cost and returns data of the UNASEC study provide most of information built into the model. These data are used to disaggregate the basic grain production sector into the four different populations by technology. It is further used to determine the cost and returns per manzana that are aggregated to determine the values of output variables on a national basis. This aggregation further relies on the National Census and Central Bank reports of: total area in production, consumption, and labor available.

The UNASEC data is derived from a survey of 677 farms (220 for beans, 293 for corn, 94 for sorghum, and 60 for rice). The year the data were collected (1971) was assumed to be a normal crop year, therefore, any output of the model should be expected to represent only normal crop years. While the sampling was not random in the general statistical meaning of that term, it is assumed to be sufficiently random to give a representation of the cost and returns per manzana for farmers in the different technology levels.

In the earlier analysis of this data by Warnken, Finley, and Swenson,[30] each sample farm was categorized into one of three different technology levels. These technologies were defined as:

I. Traditional Technology - farms that engaged in tradition system of agriculture

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30) Philip F. Warnken and Walter L. Swenson, An Analysis of Agricultural Production in Nicaragua, (Unpublished Report for USAID, June 1974).

II. Intermediate Technology - farms that used one modern commercial input as well as animal and machine energy

III. Optimum Technology - farms that used the most adequate technology available for the activity under study

Their analyses of the cost and return for those technological classifications in 1971 (Table 1) showed that yields are sharply increased with the use of purchased inputs while per unit production cost are not significantly affected. They also found that "increased use of modern inputs is one means of increasing the level of labor employed," and the wage rate.[31] It was thus concluded: "non-traditional inputs must therefore be the basis for any program which has the objective of reducing unemployment, increasing rural income, and raising agricultural production."[32]

In order to determine if these recommendations were still valid after the dramatic shift in prices between 1971 and 1975, the same cost and returns concepts were computed using 1975 input and output prices.[33] Production

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31) Philip F. Warnken, The Agricultural Development of Nicaragua, p. 83.

32) Ibid, p. 84.

33) Philip F. Warnken, <u>Shift in the Competitive Advantage of Traditional and Energy Intensive Agriculture Under Rising Energy Cost</u>, (Unpublished paper presented at the 1975 Annual American Agricultural Economics Association).

TABLE 2.1

SELECTED COST AND RETURN CONCEPT FOR BASIC GRAIN CROPS IN NICARAGUA BY TECHNOLOGY 1971 PRICES EXPRESSED IN CORDOBAS*

COST RETURN CONCEPTS	TECH	CORN	BEANS	SORGHUM	UPLAND RICE
Total Cost/ Manzana**	1	327.00	453.00	314.00	571.00
	2	573.00	569.00	578.00	847.00
	3	841.00	717.00	873.00	1234.00
Yield/Manzana	1	15.12	10.49	14.02	25.92
	2	24.17	12.59	24.45	30.28
	3	42.62	25.00	34.10	50.38
Cost/cwt.	1	21.60	43.17	22.39	22.03
	2	23.69	45.23	23.63	27.98
	3	19.71	28.68	25.59	24.50
Net Income/ Manzana	1	85.27	189.03	1.39	307.45
	2	105.62	215.12	3.71	422.23
	3	260.77	1432.98	-113.69	682.77
Net Cash Income/ Manzana	1	217.67	331.68	144.17	481.91
	2	306.68	393.35	220.38	647.95
	3	499.28	1664.48	104.52	1033.32
Labor Requirement/Manzana	1	36.1	44.6	38.6	70.0
	2	43.5	40.2	41.4	91.9
	3	40.1	26.0	42.0	41.2

Source: Warnken, Philip F.; <u>An Analysis of Agricultural Production in Nicaragua</u>

* 7 Cordobas = One U.S. Dollar

**1 Manzana = 1.7 Acres

coefficients were left unchanged. Traditional agriculture gained in competitive advantage relative to more extensive use of modern inputs during this period, but it did not gain sufficiently to offset the earlier recommendation. Both cash and net income continued to be substantially greater for technology level III except in the case of grain sorghum (Table 2.2).

In the model used in this study, the same data and cost and returns procedure will be used as in the Finley, Warnken, and Swenson studies except for one important change. The farms are re-categorized into four technology levels in an attempt to separate the small farms from the larger mechanized farms.

The Model

This model of the Nicaraguan Basic Grain Sector disaggregates the production into four populations (See Figure 2).[34] These population will be referred to in the rest of this paper as technology I representing tradition agriculture, technology II representing those farmers that use an intermediate level of technology, technology III representing optimum technology available to small farmers and technology IV representing the large and mechanized farms.

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34) For an explanation of the disaggregation procedure, see pp. 42-45.

TABLE 2.2

SELECTED COST AND RETURN CONCEPTS FOR BASIC GRAIN CROPS IN NICARAGUA BY TECHNOLOGY

1975 PRICES EXPRESSED IN CORDOBAS

COST RETURNS CONCEPTS	TECH	CORN	BEANS	SORGHUM	UPLAND RICE
Total Cost/ Manzana	1	536.00	741.00	544.00	927.00
	2	1123.00	1077.00	1064.00	1683.00
	3	1609.00	1666.00	1704.00	2254.00
Cost/cwt.	1	35.26	70.48	38.62	34.84
	2	46.37	85.12	43.45	54.07
	3	37.75	66.65	49.96	44.71
Net Income	1	143.10	759.84	6.70	850.33
	2	-7.13	761.17	-54.73	876.75
	3	200.68	3345.35	-386.82	1567.25
Net Cash Income	1	378.15	1010.97	261.41	1155.27
	2	332.00	1071.60	316.58	1283.96
	3	603.05	3728.62	-7.51	2166.15

Source: Warnken, Philip F.; Shifts in the Competitive Advantages

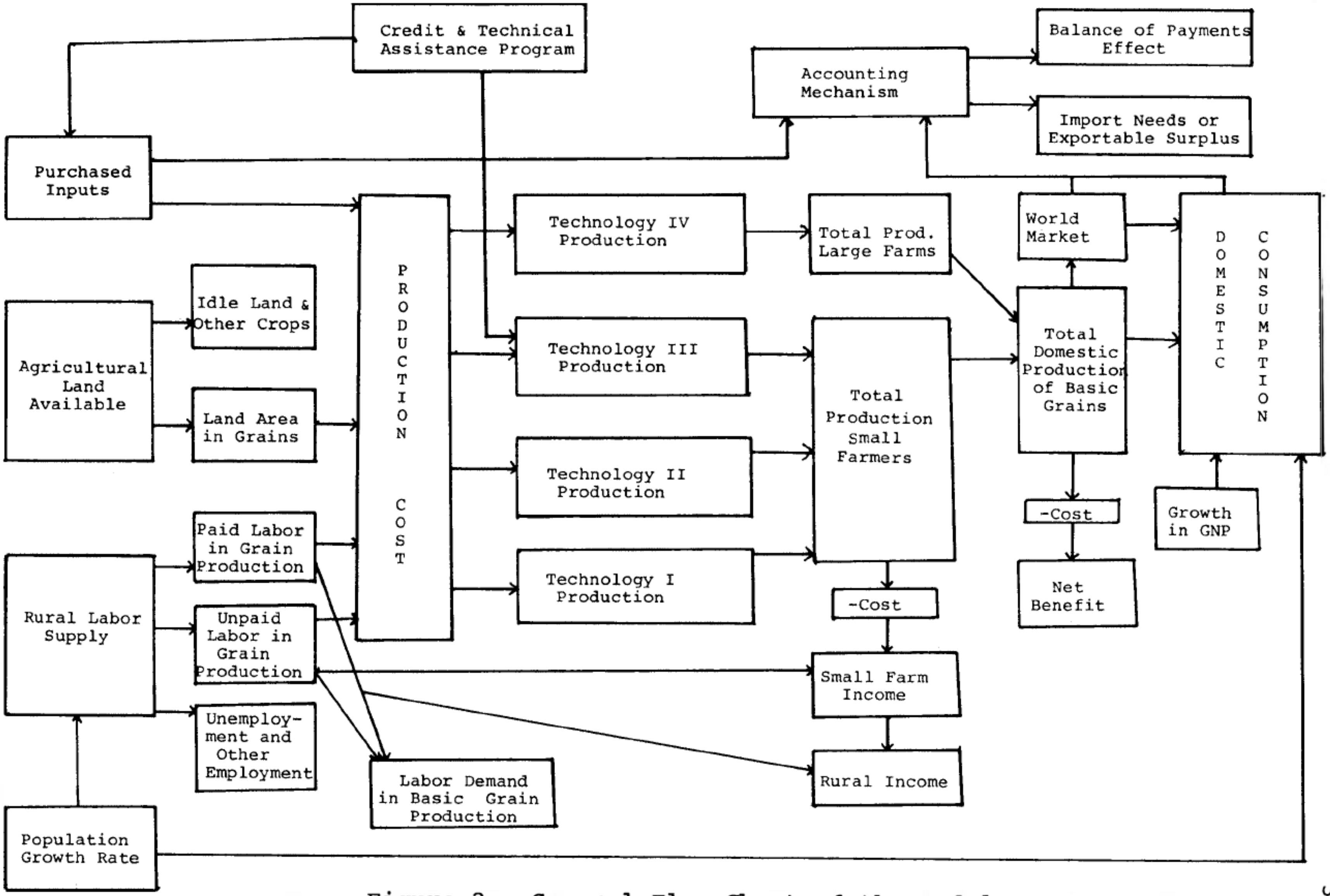

Figure 2: General Flow Chart of the Model

Input Variables

The model considers the inputs into the production process in terms of the three tradition agricultural inputs: land, labor, and capital. The land area devoted to each of the four crops is determined from available census data and reports of the Banco Nacional de Nicaragua. The area planted is allowed to increase in the model at a constant rate consistent with recent reports. The rate of change in land area for each crop and each technology level is subject to and dependent upon assumptions exogenuous to the model.

The total labor input is allocated to the various technology levels according to labor use patterns identified in the UNASEC study. While labor is an input in the production process, the amount of total labor demanded is an output variable of the model, because the effect on employment or unemployment of any program is of significant interest to policy makers.

The capital component considers only those purchased inputs that are used by small farmers. (Mechanization in technology IV and other forms of capital that are not directly affected by shift in the three lower levels of technology are not considered). As the use of purchased inputs increases, it is assumed that the farmers gain the knowledge sufficient to use this capital as efficiently as those already included in the technology III category. In this way, education is indirectly considered in this model.

Output Variables

The results or effects of shifts from technology I to technology III are measured in terms of total employment as mentioned above, total domestic production, income for small farmers and income in rural areas, and the balance of payments effect. Total employment includes both hired and unpaid family labor measured in manyears where one manyear equals 260 mandays of eight hours per day. Due to the seasonality of work involved, the number of individuals involved will obviously be greater than the number of manyears employment generated. But, as unemployment is estimated at 30 percent, it is assumed that the population in rural areas will be sufficient to supply the labor required.

Total production is simply the sum of the production of the four population groups.

The income of small farmers is defined as the net returns from the production enterprise plus the value of family supplied labor for the first three technology levels. It is assumed that all farmers pay rent in one form or another, therefore, rent has been deducted as a cost for all farms.

Rural income is defined as small farmers' income plus the total amount paid for labor in all four technology levels. Animal unit costs are included in rural income as animal units represent payment to the laborers working with animals as opposed to laborers with hand tools.

The balance of payments effects computed in the model are only the change in the balance of payments, costs and benefits, if the credit program is implemented. The costs are an estimate of the cost of importing the increased agricultural chemicals, machinery, and fuel to enable the farmers to shift from technology I to technology III. The benefits are the value of the increased production at estimated world market prices. It is assumed this increased production could either substitute for imports or add to exportable surplus. This output variable is only an approximation of the magnitude and direction of the balance of payments effects as more accurate data and sophisticated modeling would be required to present a more accurate estimate of the foreign exchange effects.

CHAPTER III

SYSTEM SYNTHESIS AND MODEL VALIDATION

The system synthesis is essentially the mathematical formulation of the relationships identified in the analysis of the system. In this Chapter, the data from the four sources discussed in Chapter II are analyzed to quantify those relationships. The relationship of the production inputs, both endogeneously and exogeneously determined in the model, to the output variables are first analyzed by traditional production function techniques. The production functions computed from the available data generally describe the relationships as expected but are rejected as a basis for the model because they were not able to explain enough of the variation in the output variables.

The relationship of the input variables to output were determined for each crop by technology level. The expected area planted under each level of technology for each crop is computed and the output variables is used to quantify the output variables for the country and rate of change in those variables. The projection of the model are then compared to historical data to insure that the model is a reasonably accurate representation of the real world.

System Synthesis

The first step in making the model workable was the specification of equations in which those variables to be examined are a function of the variables that would be exogeneously determined by policy. As purchased inputs are to be manipulated by the program, the first step in the systems synthesis was to define the relationship between them and the output variables of the model. These relationships can and are often defined through statistical regression analysis to determine production functions.

The production functions were computed from the UNASEC data with yield the dependent variable and production inputs the independent variables. Multiple stepwise regression using least square estimation was used to determine the production functions. Using this method, production functions were determined for each of the four crops in the form:

Yield = f (Labor, Animal Units, Machine Units,
Seed, Fertilizer, Insecticide, and
Herbicide)

In all crops except rice, fertilizer and seed were among the three most important variables in explaining the difference in yield. They were two of the first three variables entering the stepwise regression model. To the extent that the purchased inputs were positively and significantly related to yield (Table 3.1) it seems reason-

TABLE 3.1

STATISTICAL RESULTS

PRODUCTION FUNCTION COEFFICIENTS BY CROP

INDEPENDENT VARIABLES	CORN	BEANS	SORGHUM	UPLAND RICE
Labor	.062* (.035)	.085* (.022)	.088 (.070)	.081 (.058)
Animal Unit	.023* (.012)	-.006 (.010)	.004 (.022)	-.033 (.033)
Machine	.06* (.009)	.021* (.010)	.024 (.016)	.036* (.018)
Seed	.092* (.029)	.033* (.010)	.185* (.044)	-.012 (.033)
Fertilizer	.016* (.004)	.012* (.002)	.022 (.009)	- -
Insecticide	.005 (.020)	-.005 (.012)	.012 (.072)	.063 (.039)
Herbicide	.118 (.094)	- -	-1.04 (.75)	.080 (.049)
Constant	10.327	3.75	9.82	24.88
R^2	.42	.23	.33	.41
F	26.47	12.99	7.5	5.09

*Variable Significant at 5 percent level able to conclude that a program that increases purchased inputs use would increase production.

The variables included in the production function however, were able to explain less than half of the variation in yield. R^2 values ranged from .42 to .23. This was not unpredictable as such factors as quality of land, climatic differences, and management ability on the different farms could not be included due to lack of reliable data. For this reason, the production function equations were rejected as the basis of model.

Classification by Technology

It was decided that the disaggregation of the farms into different technology groups with farms being transferred from one technology level to a higher one would provide a better estimate of the change in production and in other output variables. The change in output variables thereby is effected by a change in purchased inputs, energy use, and management ability of the farmers. A supervised credit program, if successful, should change all of these variables in discreet amounts. From the coefficients for each technology level, the aggregate yield, income, and employment levels are then estimated by equations of the form.

$$Y_{ti} = Y_{1i}A_{1i} + Y_{2i}A_{2i} + Y_{2i}A_{3i} + Y_{4i}A_{4i}$$

Where:

Y_{ti} = Total production of crop i

Y_{1i} = Production/Manzana for technology I crop i

A_{1i} = Area planted to crop i using technology I

Classification Criteria

The farms in the survey are categorized into different technology levels by the amount of machinery and purchased inputs used (Table 3.2). The classification by mechanization is an attempt to separate out those farms that use mechanization in more than one phase of the production process. These farms represent large farms and a level of technology not immediately available to the small farmers. Those farms whose machine unit costs were less than 125 cordobas per manzana were retained in technology categories I, II, and III. This level of mechanization was not considered a significant shift in technology but only an alternate method of initial land preparation. This level of mechanization is available to most of the smallest farmers in the form of a service for hire and typically, does not represent any investment in capital by the farmer. It is simply a production expense to be paid in the short run production period.

The classification by seed is based on the proposition that those farms using improved varieties were in a higher technology level. No information was available by

TABLE 3.2

TECHNOLOGY LEVELS FOR CORN DEFINED BY AMOUNT OF PURCHASED INPUT USE AND LEVEL OF MECHANIZATION

VARIABLES	TECHNOLOGY I	TECHNOLOGY II	TECHNOLOGY III	TECHNOLOGY IV
Mechanization	125.00*	125.00	125.00	125.00
		Any of the following	Any two of the following	Any amount of the following
Seed	< 30.00	Seed > 30	Seed > 30	Seed
Fertilizer	< 50.00	Fert. > 50	Fert. > 50	Fertilizer
Insecticide	< 10.00	Insect. > 10	Insect. > 10	Insecticide
Fungicide	< 10.00	Fung. > 10	Fung. > 10	Fungicide
Herbicide	< 10.00	Herb. > 10	Herb. > 10	Herbicide

Technology levels for sorghum same as above except Seed = 30.00

Technology levels for beans same as above except Seed = 105.00

Technology levels for rice same as above except Seed = 100.00

*All values measured in cordobas

farm as to what varieties were actually planted so it was assumed that those which used expensive seed used improved varieties and better seed. The value of seed used as a cut off between levels was based on reported prices of improved seed varieties.

Those farms using purchased chemical inputs were also considered to be in a technology category higher than the traditional farms. Values for these input were set at some level greater than zero. It was assumed that amounts below those specified in Table 3.2 would have no effect on yield, therefore, were equivalent in practice to zero use of these inputs.

Those who used any one of the purchased inputs specified were considered to have moved only one level above traditional technology. Those farms which used two or more of these inputs were included in technology level III. This is based upon the recommendation from the various international research centers that a "package of inputs" is necessary to gain maximum returns from the individual inputs used.

Input/Output Analysis by Technology Level

Once the stratification criteria had been specified, the farms were divided among these technology levels and

and the cost and returns, yields, and labor requirements per manzana, were computed for each technology level for each crop. The prices used were from January 1975.[35] The input levels were determined from the UNASEC survey in 1971-1972 inflated to show the cost of production in 1975. The returns or gross income were computed from the yields, reported by farmers in the same survey, multiplied by the government support prices. The following is a summary of the input/output analysis for each crop.

Corn

Of the 293 corn farms included, 119 were in technology I, 66 in technology II, 68 in technology III, and 45 in technology IV. As was expected, there was a significant difference in yield between technologies I and III, 14.68 vs. 26.12 hundredweight per manzana. Value of production was directly proportional to yield as prices were assumed the same for all farms and equal to the Nicaraguan Government set price of C$45/hundredweight (cwt). Use of technology III produced another benefit in that it also generated more employment (Table 3.3). Unfortunately though, even with the additional yield, farmers in technology III

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35) The source of these prices is reported in Chapter II, p. 29.

TABLE 3.3

INPUT/OUTPUT ANALYSIS FOR CORN
BY TECHNOLOGY LEVEL*
(1975 PRICES)

	TECH I	TECH II	TECH III	TECH IV
Total Cost	511.46	878.52	1259.49	1757.53
Variable Cost	358.54	679.03	944.77	1397.51
Labor	292.04	357.67	346.44	308.09
Machine	1.98	4.21	29.55	284.86
Animal	29.10	83.30	93.30	30.17
Purchase Input	21.21	206.08	432.60	714.20
Seed	13.51	22.95	42.13	62.71
Fertilizer	.05	165.51	333.68	483.29
Insecticide	.00	7.29	43.91	104.18
Fungicide	.0	.0	.23	3.58
Herbicide	.0	.0	.45	3.17
Repair & Energy	.0	.0	1.43	38.57
Other	7.64	10.32	10.74	18.00
Interest	14.03	10.67	20.52	33.16
Fix Cost	152.91	199.49	314.72	360.02
Labor	13.58	1.78	82.02	106.93
Land	125.29	187.02	212.16	219.92
Depreciation	14.03	10.67	20.52	33.16
Gross Income	660.93	748.01	1177.39	1992.60
Net Income	149.47	-130.50	-82.10	235.07
Farmers' Income	232.10	-32.56	44.21	-
Rural Income	684.19	313.97	443.10	475.78
Yield (cwt.)	14.68	16.62	26.16	44.28
Labor days	32.81	40.21	39.13	32.17

*All data are computed on per manzana basis.

All values are in Cordobas except where noted.

had much lower income[36] than the traditional farmer. The marginal cost of purchased inputs had clearly exceeded their value in corn production under 1975 price conditions.

If production and small farmers income are both to be increased, it is obvious that an improved technology must be provided or the ratio of input/output prices must change. In terms of the objectives of this study and the proposed program, one might also be tempted to conclude from this analysis that if farmers are rational, they will not switch technologies. If they could be provided with this type of information and advised that they would likely be worse off after joining the program, they probably reject the opportunity to participate.

Unfortunately, this type of information is usually not available to the credit program personnel nor the farmers the program is intended to serve. The extension agents generally base their recommendations for adopting the new technology on cost and returns computed under experimental conditions. Some farmers, unaware of looses incurred by other farmers who have attempted to follow this same technology, will join the program in hopes of a higher income. Other farmers seek credit to meet imme-

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36) Income levels are defined in Chapter II, pp. 37-38.

TABLE 3.4

INPUT/OUTPUT ANALYSIS FOR BEANS BY TECHNOLOGY LEVEL*

(1975 PRICES)

	TECH I	TECH II	TECH III	TECH IV
Variable Cost	562.85	807.98	1018.26	1237.72
Labor	416.87	430.85	461.98	480.96
Animal	40.96	56.21	61.27	19.81
Machinery	.38	12.45	12.72	220.50
Purchase Input				
Seed	65.24	90.11	117.88	105.93
Fertilizer	0.00	132.80	260.14	291.70
Insecticide	.30	11.15	43.47	40.30
Fungicide	0.00	0.00	0.00	0.00
Herbicide	.00	.00	.00	-
Energy & Repair	-	27.77	-	19.55
Other	16.82	12.83	15.74	9.11
Interest	22.25	33.78	45.04	49.84
Fix Cost	156.83	222.87	201.99	215.78
Land	142.21	164.67	177.25	173.33
Labor	427.32	446.08	473.67	480.96
Depreciation	4.17	42.97	13.03	42.45
Total Cost	719.68	1030.86	1220.25	1453.51
Gross Income	1434.38	1913.82	2042.01	2455.33
Net Benefit	714.69	882.96	821.76	1001.81
Farmers' Income	820.53	996.54	905.70	-
Rural Income	1183.00	1393.00	1358.00	500.77
Labor days	43.51	44.24	46.14	44.53
Yield (cwt.)	9.89	13.19	14.08	16.93

*All data are computed on per manzana basis.

All values are in Cordobas except where noted.

diate family needs and production cost even if they are not convinced of the possibility of higher future increases.

Beans

For beans, the 220 farms sampled were distributed 82 in technology I, 93 in technology II, 39 in technology III and only six in technology IV. Yields are also higher for farmers in technology III, 14.08 vs. 9.89 (Table 3.4). Value of production is again computed for all farms using the government price of 145 cordobas per cwt, giving the technology III farmers a 50 percent higher gross income than traditional bean farmers. In contrast to the situation for corn, the income of bean farmers increased but not as dramatically as might be expected from a 70 percent increase in cost. It seems reasonable to expect bean farmers to be willing if not anxious to participate in the proposed supervised credit programs.

Switching technology in bean production however, will have little or no effect on rural employment as labor days required varied only 43.51 to 46.74 and these differences were not statistically significant (Table 3.7).

Grain Sorghum

The situation for grain sorghum is similar to corn in many ways. The majority of the farms sampled, 38 of 94 were in traditional technology with 18, 17, and 21 in technologies II, III, and IV, respectively. Again, the use of purchased inputs brought about a dramatic increase in production, 25.50 cwt per manzana for technology III against only 14.42 hundredweight per manzana for traditional technology (Table 3.5). There is also a significant positive effect on employment. The farms in technology III require 58.77 mandays of labor while traditional technology employs only 35.15 mandays of labor.

The income situation for sorghum though is worse than that of corn. Not only did the sample farms in technology III earn less than those in technology I but had a net loss of 319 cordobas with their own labor valued at zero. It seems unreasonable in this situation to expect that any reasonable change in the input/output price ratio will be sufficient to provide a competitive advantage to the technology level III identified on farms in the survey. Therefore, any change in sorghum production will require further research before advances can be made in the production of this crop. Sorghum then should probably continue to be planted by small farmers using traditional practices, only as a low risk crop when no other crop is possible. Financing farmers to use purchased inputs will be a disservice to the farmers and the lending institutions as the repayment rate on loans will be very low.

TABLE 3.5

INPUT/OUTPUT ANALYSIS FOR SORGHUM BY TECHNOLOGY LEVEL*

(1975 PRICES)

	TECH I	TECH II	TECH III	TECH IV
Variable Cost	334.17	480.08	1233.16	959.87
Labor	253.24	206.24	616.50	178.57
Animal	43.37	89.38	86.49	17.83
Machine	4.06	31.80	35.23	338.16
Purchase Input				
Seed	6.13	12.70	46.57	59.81
Fertilizer	1.11	101.76	319.77	228.93
Insecticide	.30	10.56	34.27	34.94
Fungicide	-	-	-	-
Herbicide	0	0	0	2.53
Energy & Repair	0	0	0	38.67
Other	14.96	10.37	41.00	21.39
Interest	10.96	17.14	53.30	39.01
Fix Cost	132.01	159.43	232.97	277.93
Land	130.43	151.86	229.20	186.91
Labor	0	0	0	28.63
Depreciation	1.58	7.56	3.76	62.38
Total Cost	466.18	639.52	1466.13	1237.80
Gross Income	584.35	518.94	1033.07	1188.28
Net Benefit	118.16	-120.60	-433.00	-49.50
Farmers' Income	221.94	-.70	-319.00	-
Rural Income	414.77	189.15	270.76	225.05
Yield (cwt.)	14.42	12.81	25.50	29.34
Labor Days	35.15	33.41	58.77	19.57

*All data are computed on per manzana basis.

All values are in Cordobas except where noted.

TABLE 3.6

INPUT/OUTPUT ANALYSIS FOR RICE BY TECHNOLOGY LEVEL*

(1975 PRICES)

	TECH I	TECH II	TECH III	TECH IV
Variable Cost	803.45	1111.98	1558.92	1903.59
Labor	648.71	575.43	520.05	261.29
Animal	47.09	108.13	115.24	5.89
Machine	0	7.03	52.28	451.30
Purchase Input				
Seed	63.25	91.36	127.47	203.81
Fertilizer	0	254.58	498.65	621.29
Insecticide	0	0	25.90	114.99
Fungicide	0	0	0	45.20
Herbicide	0	0	70.04	66.78
Energy & Repair	0	0	0	45.65
Other	8.59	30.74	77.41	8.42
Interest	35.79	44.68	71.84	78.68
Fix Cost	192.50	292.23	198.57	534.65
Land	188.33	291.25	178.85	259.02
Labor	0	0	16.20	36.07
Depreciation	995.95	1404.22	1757.50	2437.99
Gross Income	2027.28	1938.28	2316.42	3516.98
Net Income	1031.12	534.06	588.92	1366.00
Farmers'Income	1082.83	707.59	625.32	-
Rural Income	1726.92	1217.62	1225.50	303.25
Yield (cwt.)	27.02	25.84	30.88	46.89
Labor days	71.13	93.93	73.25	24.27

*All data are computed on per manzana basis.

All values are in Cordobas except where noted.

Upland Rice

Of the 60 upland rice farms included in the sample 16 fell into technology I, 18 in technology II, 10 in technology III and 16 in technology IV. Rice differed from the other three crops in that there was very little difference in yield between technologies I and III, 27.02 and 30.88 cwt per manzana, respectively (Table 3.6). Labor also varied little between technologies I and III but level II surprisingly used almost 30 percent more labor.

In spite of the small difference in yield between traditional cultivation and technology III, farmers using purchased inputs were able to earn a respectable return of 625 cordobas per manzana. There was no advantage for the traditional farmer to increase his use of purchased inputs though as he was earning almost twice as much as his neighbor who invested and risked more in his crop.

Technology Four

If the only objective in agricultural development were to increase production, the obvious choice would seem to be a shift from technology I to technology IV rather than technology III. For all crops except beans, yields nearly doubled. The problems with such a transformation, however, are evident in the data. Labor requirements decline significantly in both sorghum and rice and rural income declines for each of the four crops. Such

TABLE 3.7

ANALYSIS OF VARIANCE FOR YIELD, LABOR, AND NET INCOME BY TECHNOLOGY FOR CORN, SORGHUM, BEANS AND RICE

		COEFFICIENT OF VARIATION	F VALUE	PROBABILITY >F
Beans	Yield	51.66%	5.23	.002
	Labor	43.0%	.044	.997
	Income	101.75%	.484	.698
Corn	Yield	50.68%	56.37	.0001
	Labor	46.33%	4.42	.005
	Income	690.77%	4.57	.004
Rice	Yield	29.59%	23.37	.0001
	Labor	46.66%	6.17	.0014
	Income	85.35%	4.201	.0095
Sorghum	Yield	54.10%	14.31	.0001
	Labor	43.33%	7.139	.0004
	Income	-1126.06%	2.93	.037

a shift would further impoverish the poor and add to an already badly skewed income distribution in the country.

The difference in the means of selected variables noted between the different technology levels were further analyzed to see if they were statistically significant. The variables for which it was felt that statistical differences are necessary to justify the prediction of the model due to changes in technology are: labor days required per manzana, yield per manzana, and net income per manzana. The results of the test are presented in the analysis of variance (Table 3.7). There is a statistically significant difference between the values of the variables for most of the different technology levels.

Area by Technology and Crop

Having determined the yield, income, etc., per manzana for each crop by technology, the next step was the estimation of area in each crop by technology level. The National Census provides some assistance in this regard as it shows the percentage of all farms using fertilizer and insecticide:[37]

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37) These data are questioned by some persons knowledgeable about Nicaraguan agriculture, because they are available for each year, not only census years. They are considered low estimates of actual input use.

8% use fertilizer and insecticide

2.5% use fertilizer only

14% use insecticide only

These figures apply to all crops however, and do not define the percentage of area in each technology level for basic grains. A much higher percentage of farms producing export crops use modern inputs, therefore, only a very small percentage of basic grain farmers could be expected to be in technology II or III due to use of chemical inputs. The use of improved seed will result in more farmers being included in the higher technology levels, but this again, could only be a small percentage. The Ministry of Agriculture data indicate that a maximum of 16 percent of the corn area could be planted from the seed produced by the government and/or imported. The situation for the other grains is even worse. The addition of the seed data and the rate of chemical use provides the basis of one estimate of area by technology: a very low percentage of farmers use modern technology, and a very high percentage of the total area is planted by traditional farmers.

The UNASEC survey data provides additional assistance in estimating the area by technology. The percentage of farms and area in each technology was computed from the sample (Table 3.8) but due to biases in the sampling procedure, these percentages could not be expanded directly to the national levels. The sample farms were selected

TABLE 3.8

ESTIMATION OF AREA UNDER CULTIVATION ACCORDING TO TECHNOLOGY CLASSIFICATION

		TECH I	TECH II	TECH III	TECH IV
Corn:	% of Farms in Sample	40%	20%	23%	15%
	% Area in Sample	32%	15.6%	21%	29%
	* Estimated by author	60%	15%	15%	10%
Beans:	% Farms in Sample	37%	42%	17.7%	2.7%
	% Area in Sample	26%	45%	25%	4%
	* Estimated for model	67%	15%	15%	03%
Sorghum:					
	% of Farms in Sample	40%	19%	18%	22%
	% Area in Sample	29%	16%	14%	41%
	Estimated for Model	50%	15%	15%	20%
Rice:	% of Farms in Sample	27%	30%	17%	29%
	% of Manzanas in Sample	7%	5%	6%	81%
	Estimated for model	50%	20%	15%	15%

*Estimates were checked in an interview with Leonardo Green and Waldo Hooker of the Nicaraguan Ministry of Agriculture on February 15, 1976 to insure that they were a reasonable estimate of current conditions in Nicaragua.

in such a way that the different levels of technology in each region would be represented. The percentage of farms using purchased inputs in the sample therefore, is greater than the percentage of farms in any given area that use these inputs. The effect of this is thus, an overestimation of the area in technology III and underestimation of the area in technology I.

The true percentage of area in each technology level should lie somewhere between that estimated from census figures for purchased input use and the UNASEC sample data for percentage of area by technology. For the purpose of determining coefficients of area by technology in the model, estimates were made between the expected minimum and maximum (Table 3.8). These estimates were checked with personnel from the Nicaraguan Ministry of Agriculture and found acceptable.[38]

Growth in Area Under Cultivation

The second set of estimates or assumptions that are required in the model is the rate of growth in land area for each of the crops. The rates of growth in area for 1963 to 1975 are shown in Table 3.9. The 1971 to 1975 figures are probably the least reliable and an overestimation of the actual growth rate as 1971 data is from the

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38) Interviews with Leonardo Green and Waldo Hooker February 8, 1976.

TABLE 3.9

PERCENT CHANGE IN AREA PER YEAR FOR THE FOUR FOOD CROPS

	1963-71[1]	1971-75[3]	1974-75[2]	ESTIMATE 1975-80
Corn	1.73	4.85	6.5	3
Beans	3.35	6.08	-1.1	3
Sorghum	1.25	12.75	4.9	3
Rice	5.25	2.18	2.9	3
	Average		4.7	3%

1. National Census Reports
2. Banco Nacional de Nicaragua (BNN)
3. BNN Annual Reports and National Census Reports

Census reports and the 1975 figures are from the Central Bank reports. The estimated growth rate of three percent is the figure used in the simulation model in this study, but could be easily adjusted if one wished to assume a different growth rate for any or all of the crops.

Balance of Payments

The last set of relationships to be defined in the model is the relationship between foreign exchange costs and benefits and changing technology. The foreign exchange benefits are defined as the estimated world price times the change in output due to adoption of technology III on technology I farms. For this equation, the policy makers will have to make their best estimate of what the price will be over the range of time the model is to simulate. It may be more accurate to use two prices, one for the foreign exchange saved by substituting domestic production for what would have been imported and another lower price for the value of foreign exchange earned from exporting grain. But due to the range of error possible in estimating the world price, the attempt to estimate two prices probably would not provide any more realistic estimate of foreign exchange benefits so only one price is used in the model.

The foreign exchange costs of shifting technology is defined as the cost of importing all chemicals inputs and fuel requirements for increased mechanization and replacement of machinery used. For lack of any reliable data in the difference between what the farmer pays and what the foreign exchange costs are, the experiments with the model in this study are based on the assumption the foreign exchange costs equal one half the price the farmer pays.

These assumptions are sufficiently questionable that the predicted values for foreign exchange cost and benefit may be questioned, but the direction of the impact and the magnitude of the input/output ratios are considered sufficiently reliable to be valuable in an evaluation of the proposed programs.

Validation of the Model

The model once developed was tested for its validity against the 1971 National Agricultural Census reports. The labor requirement projected by the model was considered reasonably close to the reported labor requirements for all crops except beans. For beans, it was decided to accept the coefficients and equations of the model. The Census reports are thought to overestimate the requirements of labor in production of beans in that the labor requirements on UNASEC sampled farms were lower in all regions and size categories than the national average recorded by the Census.

The ability of the model to mimick the real world in terms of production, unfortunately was less reliable than its ability to project labor requirements. In the case of corn it overestimated National Census figures for production by approximately 20 percent. This is possibly partially due to the failure of the UNASEC survey to include those farms with the lowest yields. The technology I farmers had an average yield of 14.6 which was not sufficiently low to bring average yield for sample farms into line with the national yield of 15 hundredweight per manzana reported in the Census. To the extent that this is true, the model may overestimate yield and income for traditional farmers. It is also possible that the Census data may underestimate production due to the difficulty of accounting for home consumption or other data gathering problems in less developed countries. In any case, the projections of the model are still valuable in that they provide a realistic estimate of changes due to implementation of the proposed program. Also, the model if adjusted, to account for the error factor of 1971 is still helpful in determining whether or not domestic production will be sufficient to meet consumption requirements.

CHAPTER IV

APPLICATION OF THE MODEL FOR CORN

This Chapter presents the results of the simulation model experiment for corn for a period of five years beginning in 1975. The system's analysis of the corn production sector which has been reported in Chapter III forms the basis for the model. Prices are assumed constant in real terms over the time of the simulation runs and equal to those reported for 1975 except where noted. In those runs where a change in technology is indicated, the rate of change per year is equal to a shift of 10 percent of the total areas in corn production from traditional technology to technology III. It is assumed that the credit and technical assistance provided through the supervised credit program will be sufficiently successful as to make this shift in technology a reasonable expectation. The consumption figures differ from all others in that they represent the entire country, rather than only the six regions included in the production analysis. The growth in consumption is estimated at approximately 4.5 percent per annum with three percent due to growth in population[39] and 1.5 percent

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39) Population Reference Bureau, Inc., <u>1973 World Population Data Sheet</u>, (Washington, D.C. 1973)

due to increase in income.[40]

The analysis of the corn subsector and experiments with the model for this subsector are probably more important than the analysis of the other three grain crops combined. Corn is the most important crop accounting for 40 percent of the total land in cultivation, 334,000 manzanas in 1975. It is also the staple of the diet accounting for approximately one-third of the daily caloric intake. Increases in yield for this important crop seem realistically possible if one compares Nicaraguan yields with those of other countries. Neighboring El Salvador yields are almost double those of Nicaragua, and U. S. yields are nearly six times as great.[41] While yields in other countries were increasing, Nicaragua corn yields not only did not increase but have actually declined since the early 1950's.[42]

Production and Consumption

Aggregate production and consumption projections of the model for a period of five years are shown in Table 4.1.

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40) Economic Research Service, USDA, The World Food Situation and Prospects to 1985, USDA Foreign Agriculture Economics Report No.98, pp.75-77. Income elasticity of demand in developing nations is reported to range between .3 and .5. The change in GNP in Latin America was approximately 4.0 percent in the early 1970's. If income continues to grow at this rate, the demand for food will increase by 1.2 percent to 2.0 percent per year. 1.5 percent is used in this study as a moderate projection of increase in consumption due to increase in income.

41) Food and Agriculture Organization Production Yearbook, Rome 1971, Vol. 25

42) Ibid, Production Yearbook, Various Years

Year 1 represents 1975 with Year 2 through 5 showing what changes could be expected for various assumptions or policies over that period of time. If the increase in production in the next five years is to come from a three percent yearly increase in land area only, then the present surplus of 53 thousand hundred weight of corn will be absorbed by the second year. By the fifth year, the deficit might be espected to reach 246.4 thousand hundred weight or almost five percent of the annual consumption requirement. If the area is assumed constant and additional increments of 10 percent of the area are planted under technology III every year, then production will increase approximately five percent per year. The current surplus may be expected to grow slowly reaching 136.3 thousand hundred weight by the end of the five years. These surpluses may fail to be realized though even if farmers shift technology and if climatic conditions are not similar to the year when the data were collected for this model. The surplus with a shift in technology would be at most 2.5 percent over estimated consumption and this would probably be insufficient to offset the shortages caused by even moderately unfavorable weather. If the area planted to corn continues to increase and the program is undertaken to bring about a concurrent shift in technology, then total production will increase by almost nine percent per year. This could lead to a surplus of 836 thousand hundred weight by the end of five

TABLE 4.1

CORN PRODUCTION AND CONSUMPTION

PROJECTIONS OF THE MODEL FOR FIVE YEARS

Year	Change in Total Production in 1000 cwt. due to: Change in Area only	% Change*	Change in Tech only	% Change	Change in Area & Tech	% Change
1	5566.7	-	5566.7	-	5566.7	-
2	5733.7	3.0	5891.9	5.8	6068.7	9.0
3	5905.8	3.0	6217.1	5.5	6595.7	8.7
4	6082.9	3.0	6542.3	5.2	7148.9	8.4
5	6265.4	3.0	6867.4	5.0	7729.4	8.1

Year	ESTIMATED CONSUMPTION	ESTIMATED SURPLUS (DEFICIT)[45] IN 1000 CWT. Change in Area only	Change in Tech only	Change in Area and Tech
1	4566.9	53.0	53.0	53
2	4772.4	(-13.9)	88.1	233.9
3	4987.2	(-85.9)	114.0	424.6
4	5211.6	(-163.3)	130.2	625.5
5	5446.1	(-246.4)	136.3	836.9

*The symbol % change represents "the annual percent change"

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[45] The Surplus (Deficit) is computed after adjusting the production estimate to account for the Caribbean Regions and error factors in the Central and Pacific Regions. See explanations in Chapter III, pp. 62-63, and Appendix B, Table B.1.

years. This surplus could be exported or larger portions could be diverted into animal feed for increased poultry and livestock production.

The recommendation of the model then for achieving an adequate domestic supply of corn in the short run is to implement a program to shift technology while encouraging a continued increase in area planted.

Employment

The effect of such a recommendation would also be favorable in terms of its impact on employment. Table 4.2 shows that the shift in technology would generate an increase in labor required by 1.8 percent per year. This increase plus an estimated three percent increase due to increased area planted would result in growth in employment of 4.8 percent per year. Such a growth rate would contribute to alleviating the employment problems that now exist and are likely to become worse in the future.

Income Effects

The income effect of changes in area and changes in technology are shown in Tables 4.3 and 4.4. The three income accounts are defined as:

1. Net Benefit[43] = Yield x the Government support price - all costs
2. Farmers' Income[44] = Gross Income - all costs except the labor supplied by the farmer and his family
3. Rural Income = Farmers' Income, plus wages paid for hired labor

TABLE 4.2

PROJECTED LABOR REQUIREMENTS FOR CORN PRODUCTION IN MAN YEARS

Year	If Area Changes	% Change	If Tech Changes	% Change	If Area and Tech Change	% Change
1	37917	-	37917	-	37916.5	*
2	39054	3.0	38605	1.8	39763.2	4.9*
3	40226	3.0	39264	1.8	41686.5	4.8
4	41432	3.0	39982	1.8	43689.5	4.8
5	42675	3.0	40671	1.7	45775.1	4.8

* Percentage changes may not sum due to rounding.

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43) All income changes are due entirely to the differences in income per manzana between the various technology levels and changes in income due to changes in the number of manzanas planted. Changes in supply are assumed to have no effect on price as prices are determined by Government support price levels.

44) Farmers' income is roughly equivalent to net cash income if one assumes that all small farmers pay for the cost of land through either cash or share rent.

TABLE 4.3

CHANGES IN PROJECTED INCOME FROM CORN PRODUCTION FOR FIVE YEARS IN C$1000 (1975 PRICES)

NET BENEFIT

Year	If Area Changes	% Change	If Tech Changes	% Change	If Area and Tech Change	% Change
1	23028	--	23028	--	23028	--
2	23718	3%	16469	-28.5	16962	-26%
3	24430	3%	9910	-39.8	10513	-38%
4	25163	3%	3350	-66.2	3660	-65%
5	25918	3%	-3209	-****	-3611	-199%

SMALL FARMERS' INCOME

Year	If Area Changes	% Change	If Tech Changes	% Change	If Area and Tech Change	% Change
1	39940	--	39940	--	39940	--
2	42238	3%	34619	-13.3	35657	-11%
3	42372	3%	29297	-15.4	31080	-13%
4	43644	3%	23975	-18.2	26197	-16%
5	44953	3%	18653	-22.2	20993	-20%

RURAL INCOME

Year	If Area Changes	% Change	If Tech Changes	% Change	If Area and Tech Change	% Change
1	127931	--	127931	--	127931	--
2	131769	3%	126767	-0.9	130570	2.1%
3	135722	3%	125683	-0.9	133252	2.1%
4	139793	3%	12440	-0.9	135978	2.0%
5	143987	3%	123276	-0.9	138747	2.0%

TABLE 4.4

CHANGES IN PROJECTED INCOME FROM CORN PRODUCTION FOR FIVE YEARS IN C$1000

(1975 PRICES EXCEPT FERTILIZER REDUCED BY 1/3)

	NET BENEFIT					
Year	If Area Changes	% Change	If Tech Changes	% Change	If Area & Tech Change	% Change
1	34556	-	34556	-	34556	-
2	35592	3	31115	-10.0	32049	-07.3
3	36660	3	27675	-11.1	29360	-08.4
4	37759	3	24235	-12.4	26481	-9.8
5	38892	3	20794	-14.2	23404	-11.6

	SMALL FARMERS' INCOME					
Year	If Area Changes	% Change	If Tech Changes	% Change	If Area & Tech Change	% Change
1	46939	-	46939	-	46939	-
2	48347	3	44736	-4.7	44078	-1.8
3	49798	3	42532	-4.9	45122	-2.1
4	51292	3	40329	-5.2	44068	-2.3
5	52830	3	38126	-5.5	42910	-2.6

	RURAL INCOME					
Year	If Area Changes	% Change	If Tech Changes	% Change	If Area & Tech Change	% Change
1	134930	3	134930	-	134930	-
2	138977	3	136884	1.4	140991	4.5
3	143147	3	138839	1.4	147295	4.5
4	147441	3	140794	1.4	153849	4.5
5	151864	3	142749	1.4	160665	4.4

Unfortunately, the shift in technology that had a favorable impact on both production and employment could have a negative effect on incomes of small farmers who are expected to work harder and risk more in the final implementation of the programs.

If 1975 input/output price ratios hold, aggregate "net income" from corn production will decline by 28 percent if 10 percent of the farms shift technology with no increase in area. As additional farms shift in succeeding years, the net income continues to decline. Even if area is increased simultaneously with a shift in technology the aggregate "net income" would decline by 26 percent the first year and continue to decline in succeeding years.

In order to examine more precisely the "income effect in the rural sector" as specified in the objectives of this study, two other measures of income were included in the model.

The effect on small farmers income is not as bad as the effect on "net income" as the small farmer does not actually pay for family labor. When unpaid labor is deleted from production cost, the returns to the farmer are greater than net income by the value of that labor. Even with this change in income accounting, the reduction in income per manzana for those shifting their technology has a significant negative effect on the incomes of small farmers as a whole. If technology is shifted on 10 percent of the area planted, small farmers income is reduced by 13.3 percent in the second year and continues to decline as more farmers shift. If area increases as technology changes, the total effect on small farmers incomes is still negative.

Rural income level - Small Farmers' Income plus paid labor - also declines as technology is shifted with the use of purchased inputs. The negative effect though is considerably less amounting to a decline of only 0.9 percent each year. If area continues to increase at the estimated rate of three percent, then the combined effect is an increase in rural income from corn production by 2.1 percent per year. There is however, little consolation though in this as returns per unit area, and per manday decline. Per capita income also declines as the population continues to grow at three percent.

As stated earlier, the above income effects were made assuming prices constant as reported in 1975. These prices were measured when fertilizer prices were at their peak and it is reported that fertilizer prices have since dropped by one-third from that level. Table 4.4 show the income effects if fertilizer prices are reduced and all other prices remain constant at the level of 1975. This change in prices has a positive effect on all income measurements, yet the effects of shifting to technology level III and the use of purchased inputs still has negative effects on income. Net benefit in this case declines by 10 to 14 percent if area increases concurrently with technology shifts. Farmers income declines by approximately five percent per year due to the shift in technology.

Rural income does increase though under the assumption of reduced fertilizer prices. If the technology employed changes while area is held constant, rural income should increase by approximately 1.4 percent per year. If area in production increases as the technology changes, then rural income should increase by 4.5 percent per year. This rate of growth should be sufficient to contribute to an increase in per capita income in rural areas as population grows at three percent. Unfortunately, with these input/ output prices the farmers who use the new technology would still suffer a loss in income and the program probably could not be sustained after the third or fourth year. Available cash (credit) and promises of higher incomes may get farmers into the program and keep them in the program for two or three years, but they would eventually realize that their debts were increasing faster than their incomes and be forced to revert to traditional agriculture.

Balance of Payments

The foreign exchange costs and benefits of shifting from traditional technology to level III are shown in Table 4.5. As was pointed out in Chapter III, these projections are not intended to show the exact cost to the last dollar or last one thousand dollars but only the magnitude and the

TABLE 4.5

BALANCE OF PAYMENTS EFFECT OF CHANGES IN TECHNOLOGY IN CORN PRODUCTION IN U.S. DOLLARS

YEAR	CHANGE IN PROD.* DUE TO CHANGE IN TECH	$ VALUE OF CHANGE IN PRODUCTION	$ VALUE OF CHANGE IN CHEMICAL ENERGY COST	NET BALANCE OF PAYMENTS EFFECT
1	-	-	-	-
2	334925	1346400	833941	512458
3	344975	1386801	858962	527838
4	355321	1428393	884729	543663
5	365983	1471253	911270	559982

YEAR	CHANGE IN PROD.* DUE TO CHANGE IN TECH	$ VALUE OF CHANGE IN PRODUCTION	$ VALUE OF CHANGE IN CHEMICAL ENERGY COST	NET BALANCE OF PAYMENTS EFFECT
1	-	-	-	-
2	334925	1346400	604481	741918
3	344975	1386801	622617	764183
4	355321	1428393	641295	787097
5	365983	1471253	660633	810719

* Changes in production are measured in hundredweight.

ratio of the net benefit to foreign exchange cost.

With 1975 prices, the ratio of net foreign exchange earnings (and/or savings) to foreign exchange cost of imported modern inputs is approximately .61. For every $100 spent for imported inputs the increased value of production is approximately $161. If the price assumption are valid a program to assist farmers in using these inputs would contribute approximately $500,000 to the national balance of payments position for every 30,000 manzanas (10 percent of Nicaruaguan corn area) brought into the program.

If one assumes the lower price for fertilizer, then this position is further improved. The ratio of net foreign exchange earnings to input costs is 1.22 or for every $100 spent for imported inputs the added value of production equals approximately $222. The program to assist farmers in using purchased inputs would contribute approximately $750,000 to the national balance of payments position for every 30,000 manzanas brought into the program. Thus the balance of payments effects as measured by the model provides further justification for shifting production technology on small farms with the use of imported chemical and energy inputs.

Summary

The increased use of purchased inputs will have the hypothesized effect on three of the four aspects of the economy under consideration. If the simulation model and the assumptions contained therein are valid, then a shift from traditional production practices to technology III as defined in Chapter III will:

1. increase production of corn
2. increase labor required in the production process
3. improve the balance of payments situation of Nicaragua

Unfortunately, such a shift will result in lower incomes for the small farmers who were the intended beneficiaries from such a change. Even if fertilizer prices are reduced by one-third of the reported price in 1975, the small farmers income is still lower if they use modern inputs than if they followed traditional technology. Given this situation, the policy makers seem to have three options. The first and probably least desirable is to do nothing and face increasing domestic food shortages. The second option is to control input/output price ratios for corn production so that small farmers can increase their production and income by using more purchased inputs. And the third option is to invest in research to identify a better package of technology that can be offered to the farmers. The second option can provide much quicker results as it can be implemented faster than the third option. The third option, research, takes longer to achieve results but will probably be required in the long run as land area under cultivation cannot be expected to increase indefinitely.

CHAPTER V

APPLICATION OF THE MODEL FOR BEANS

This Chapter presents the result of the simulation model experiments for bean production in Nicaragua for a period of five years beginning with 1975 as the base year. The production and consumption estimates are presented first and then followed by employment, income, and balance of payment estimates. In those table where a change in technology is indicated, the change is an annual transfer from level I technology to level III technology for 10 percent of the total area in bean production. This shift represents the expected results of credit and technical assistance provided through a supervised credit program. Where a change in area is indicated, it represents an increase in area planted of three percent per year.

Beans are planted on 37 percent of all farms in Nicaragua, second only to corn. As a food crop they are an important source of protein in the daily diet. Immediate increases in production of this crop are important as Nicaraguan production was 146,000 hundred weight or 14 percent short of the amount consumed in 1975. It is hoped that the necessary increases in production can be achieved at least partially through increased yields. More intensive production methods along with new varieties are considered by some to be able to triple production.[45]

Production and Consumption

The aggregate production and consumption estimates[46] for a period of five years beginning in 1975 are shown in Table 5.1. If there is no change in technology and area planted increases at the rate of three percent, then consumption will continue to lead production and the current deficit will increase. If there is no change in area and farmers do shift technology, production does increase, but the rate of increased production is insufficient to keep up with consumption much less overcome the current deficit.

If area increases as farmers shift technology, the rate of increase in production is approximately 6.8 percent per year. With this rate of increase, the gap between consumption and production begins to narrow but there is still a deficit at the end of the five-year simulation period. If the Government of Nicaragua hopes to overcome the deficit between production and consumption in the short run, area planted will have to increase at a faster rate and/or production per manzana will have to increase faster than was possible in the model. Area in cultivation, however, cannot

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45) Swenson, Walter, "Cost of Production Analysis of Major Food Crops in Nicaragua. (Unpublished Master's Thesis University of Missouri-Columbia, 1974), p.76.

46) Consumption estimates are computed for beans in the same manner they were computed for corn. See Chapter IV, p.

TABLE 5.1

BEAN PRODUCTION AND CONSUMPTION PROJECTIONS OF THE MODEL FOR FIVE YEARS

	Change in Total Production in 1000 cwt. due to:					
Year	Change in Area only	% Change	Change in Tech only	% Change	Change in Area & Tech	% Change
1	625.2	-	625.2	-	625.2	-
2	643.2	3.0	648.5	3.7	668.0	6.8
3	663.3	3.0	671.9	3.6	712.8	6.7
4	683.2	3.0	695.2	3.5	759.7	6.6
5	703.6	3.0	718.5	3.4	808.7	6.5

		ESTIMATED SURPLUS (DEFICIT) IN 1000 CWT.*		
Year	ESTIMATED CONSUMPTION	Change in Area only	Change in Tech only	Change in Area & Tech
1	1136.0	(-149.7)	(-149.7)	(-149.7)
2	1187.1	(-171.3)	(-173.5)	(-143.1)
3	1240.6	(-194.2)	(-199.7)	(-136.3)
4	1296.4	(-218.6)	(-228.2)	(-129.1)
5	1354.7	(-244.6)	(-259.2)	(-121.7)

* The Surplus (Deficit) is computed after adjusting the production estimate to account for the Caribbean Regions and error factors in the Central and Pacific Regions. See explanations in Chapter III, pp. 62-63 and Appendix B, Table B. 1.

continue to increase indefinitely. Only through increases in yield will the effective demand be met. It is apparent from these projections that researchers must continue to develop the technology that will provide increasing yields if shortages of this basic commodity are to be avoided.

Employment

Due to the fact that there was no statistically significant difference between the amount of labor used under the different technology levels, the projected effects of changing technology on employment can not be considered statistically significant.[47] For purposes of comparison with other crops though, Table 5.2 shows the simulated employment levels under various conditions.

TABLE 5.2

PROJECTED LABOR REQUIREMENTS FOR BEAN PRODUCTION IN MAN YEARS

Year	If Area Changes	% Change	If Tech Changes	% Change	If Area and Tech Change	% Change
1	9435.2	-	9435	-	9435.2	-
2	9718.2	3.0	9492	.6	9776.3	3.6
3	10009.8	3.0	9548	.6	10129.3	3.6
4	10310.1	3.0	9604	.6	10494.8	3.6
5	10619.4	3.0	9661	.6	10873.0	3.6

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[47] The statistical test are noted in Chapter III, Table 3.2

Income Effects

The income effects of changes in area and technology are shown in Tables 5.3 and 5.4. Table 5.3 shows the expected incomes from bean production assuming 1975 prices constant for the five-year period. Changes in either area or technology will contribute positively to net incomes from bean production. If only area changes, income changes are directly proportioned to changes in area. If only technology changes, then the net benefit from bean production increases at a rate of 1.4 percent per year.

Small farmers' income and rural income also increase as farmers shift from traditional technology to level III technology with increased use of purchased inputs. The rate of change in these two income measures is only slightly different than the rate of change in net income for bean production. This was not unexpected for bean production as there is little, if any, change in labor requirements between the different technologies and labor costs are the primary difference between net income and rural income.

The results in Table 5.4 with fertilizer prices reduced by 33 percent from 1975 price levels are very similar to the results noted above. Net income is three percent higher in the initial year and grows at a faster rate. With reduced fertilizer prices, income grows approximately 2.5 percent per year due to technology shifts as opposed to a growth rate of 1.4 percent at 1975 prices. At the end of

TABLE 5.3

CHANGES IN PROJECTED INCOME FROM BEAN PRODUCTION FOR FIVE YEARS IN C$1000 (1975 PRICES)

	NET BENEFIT					
Year	If Area Changes	% Change	If Tech Changes	% Change	If Area and Tech Change	% Change
1	42586.1	-	42586.1	-	42586.1	-
2	43683.7	3.0	43182.5	1.4	44477.9	4.4
3	45179.6	3.0	43778.8	1.4	46444.9	4.4
4	46535.0	3.0	44375.2	1.4	48489.9	4.4
5	47931.0	3.0	44971.5	1.3	50615.8	4.4

	FARMERS' INCOME					
Year	If Area Changes	% Change	If Tech Changes	% Change	If Area and Tech Change	% Change
1	46512.0	-	46512.0	-	46512.0	-
2	47907.4	3.0	46986.4	1.0	48396.0	4.1
3	49344.6	3.0	47460.8	1.0	50351.1	5.0
4	50824.9	3.0	47935.2	1.0	52380.0	4.0
5	5235.0	3.0	48409.5	1.0	54485.3	4.0

	RURAL INCOME					
Year	If Area Changes	% Change	If Tech Changes	% Change	If Area and Tech Change	% Change
1	67966.1	-	67966.1	-	67966.1	-
2	70005.0	3.0	68940.8	1.4	71009.0	4.5
3	72105.1	3.0	69915.5	1.4	74173.3	4.5
4	74268.2	3.0	70890.2	1.4	77463.5	4.4
5	76496.3	3.0	71864.8	1.4	80884.4	4.4

TABLE 5.4

CHANGES IN PROJECTED INCOME FROM BEAN PRODUCTION FOR FIVE YEARS IN C$1000 (1975 PRICES EXCEPT FERTILIZER REDUCED BY 1/3)

	NET BENEFIT					
Year	If Area Changes	% Change	If Tech Changes	% Change	If Area and Tech Change	% Change
1	43830.2	-	43830.2	-	43830.2	-
2	45145.1	3.0	44904.6	2.5	46251.8	5.5
3	46499.4	3.0	45979.1	2.4	48779.2	5.5
4	47894.4	3.0	47053.6	2.3	51416.6	5.4
5	49331.2	3.0	42128.0	2.3	54168.4	5.4

	SMALL FARMERS' INCOME					
Year	If Area Changes	% Change	If Tech Changes	% Change	If Area and Tech Change	% Change
1	47594.9	-	47594.9	-	47594.9	-
2	49022.8	3.0	48547.2	2.0	50003.6	5.1
3	50493.4	3.0	49499.5	2.0	52513.9	5.0
4	52008.2	3.0	50451.7	1.9	55129.9	5.0
5	53568.5	3.0	51404.0	1.9	57855.5	4.9

	RURAL INCOME					
Year	If Area Changes	% Change	If Tech Changes	% Change	If Area and Tech Change	% Change
1	69049.0	-	69049.0	-	69049.0	-
2	71120.4	3.0	70501.6	2.1	72616.6	5.2
3	73254.0	3.0	71954.1	2.1	76336.1	5.1
4	75451.6	3.0	73406.7	2.0	80213.4	5.1
5	77715.1	3.0	74859.3	2.0	84254.7	5.0

five years, net income is seven percent greater with lower fertilizer prices. The fertilizer price effect on rural incomes is not as great since reduction in fertilizer prices has little effect on labor earnings.

It is fortunate though that the income effects of changing technology in bean production are different from those found in corn production. Whereas, changing technology in corn was good for the country (increased production) and bad for the farmer (lower incomes), changing technology in bean production is good for both the country and the farmers who shift technology.

Balance of Payments

The simulated foreign exchange costs and benefits of changing technology are shown in Table 5.5. The actual dollar amounts shown in the table are only a rough estimate. These estimates are based on the assumptions that foreign exchange costs equal one-half of the farmers' costs for chemicals and petroleum-based energy and foreign exchange benefits equal the increase in production times an assumed price of $16.57 per hundred weight.

If the above assumptions are reasonably valid, then shifting technology has a positive balance of payments effect under 1975 price conditions. The ratio of net foreign exchange earnings to foreign exchange cost is approximately 2.0 or for every $100 dollars spent for imported inputs the foreign exchange value of increased production is approximately $300 leaving a net of $200. Under these conditions every 10 percent of the bean land that is converted from traditional to modern technology would contribute an increment of almost $250,000 to the countries' balance of payments position.

If one assumes that fertilizer prices have declined by one-third from their peak in 1975, then the net balance of payments effect of changing technology is further improved. The ratio of net earnings to cost is 3.2 to one or for every additional $100 of inputs imported and used, output would increase by approximately $420. A change in technology on 10 percent of the bean land would add nearly $320,000 to the countries balance of payments position.

Summary

A program to increase the use of purchased inputs would have the hypothesized effect on three of the four output variables being considered. If the assumption contained in the model are valid than a shift in technology will:

1. increase production
2. increase small farmers' incomes and rural income
3. improve the balance of payments position of Nicaragua

TABLE 5.5

BALANCE OF PAYMENTS EFFECT OF CHANGES IN TECHNOLOGY IN BEAN PRODUCTION IN U.S. DOLLARS

1975 PRICES				
YEAR	CHANGE IN PROD. DUE TO CHANGE IN TECH	$ VALUE OF CHANGE IN PRODUCTION	$ VALUE OF CHANGE IN CHEMICAL ENERGY COST	NET BALANCE OF PAYMENTS EFFECT
1	-	-	-	-
2	24037.04	398293.80	129626.60	268667.10
3	24757.99	410240.00	133515.50	276724.50
4	25500.70	422546.80	137520.60	285026.10
5	26265.82	435224.80	141646.30	293578.50

FERTILIZER PRICES REDUCED BY 1/3				
YEAR	CHANGE IN PROD. DUE TO CHANGE IN TECH	$ VALUE OF CHANGE IN PRODUCTION	$ VALUE OF CHANGE IN CHEMICAL ENERGY COST	NET BALANCE OF PAYMENTS EFFECT
1	-	-	-	-
2	24037.04	398293.80	94452.19	303841.60
3	24757.99	410240.00	97285.50	312954.50
4	25500.70	422546.80	100203.80	322342.90
5	26265.82	435224.80	103210.10	332014.70

The hypothesized increase in labor will not be achieved by adoption of more modern technology but neither will there be a reduction in labor required per manzana caused by the change in technology.

Given the price ratios included in the model, it is reasonable to conclude that implementation of the proposed program will have the significant and positive effects desired. In addition to changing the technology used though, it is recommended that farmers be encouraged to increase the area planted to beans at a rate faster than the three percent rate hypothesized in the model. This is one way in the absence of markedly improved varieties that the country can achieve self-sufficiency in this important source of protein. Small farmers and rural laborers would also gain more from an increase in area planted to beans as the amount of labor required and the farmers' income per manzana from bean production are greater than they are for corn.

CHAPTER VI

APPLICATION OF THE MODEL FOR GRAIN SORGHUM

This Chapter presents the results of the simulation model experiments for grain sorghum production in Nicaragua. Year 1 represents 1975, the base year. The simulated effects on production of changing area planted and technology are presented first. Following the production estimates are employment, income, and balance of payments projections. In those tables where a change in technology is indicated, the change is an annual shift from level I technology to level III technology for 10 percent of the total area in bean production each year. This shift represents the expected results of additional credit and technical assistance provided through a supervised credit program. Where a change in area is indicated it represents an increase in area planted of three percent per year.

Grain sorghum, while an important for Nicaraguan agriculture and small farmers in many ways, is only a secondary crop. It is planted only about 15 percent of the farms in Nicaragua and accounts for a total area of 83,000 manzanas. It is used as both a feed grain and food grain. As a food grain, it is consumed only as a last resort as rice or corn is preferred. The strengths of grain sorghum are primarily found in its agronomic characteristics. Even if yields and value are both low, the ability of grain sorghum to withstand a wide-range of adverse climatic conditions allows the farmer to produce some crop when he could not have produced anything else. It is the hope of the government that production can be increased to meet a growing demand and to provide an increased source of income for small farmers.

Production Estimates

Given the various technologies identified in the sector analysis of Nicaraguan agriculture, there exist the potential for significant increases in production of grain sorghum. Table 6.1 shows the production possibilities projected by the model. With production increases of three percent per year due to increase in area only, the deficit of 110,000 hundredweight of 1975 will increase to 214,000 hundredweight by the end of five years. If area and technology both change simultaneously, however, production will increase by approximately nine percent per year. With this rate of increase in production, and consumption increasing at the rate of 4.5 percent[48] annually, consumption can be completely supplied by domestic production in four years.

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48) Consumption for grain sorghum is computed in the same manner as corn. See Chapter IV p. 65.

TABLE 6.1

GRAIN SORGHUM PRODUCTION AND CONSUMPTION PROJECTIONS OF THE MODEL FOR FIVE YEARS

	Change in Total Production in 1000 cwt. due to:					
Year	Change in Area only	% Change	Change in Tech only	% Change	Change in Area & Tech	% Change
1	1119.4	-	1119.4	-	1119.4	-
2	1153.0	3.0	1185.3	5.9	1220.9	9.1
3	1187.6	3.0	1251.2	5.6	1327.4	8.7
4	1223.2	3.0	1317.1	5.3	1439.2	8.4
5	1257.9	3.0	1383.0	5.0	1556.6	8.2

		ESTIMATED SURPLUS (DEFICIT) IN 1000 CWT.*		
Year	ESTIMATED CONSUMPTION	Change in Area only	Change in Tech only	Change in Area and Tech
1	1344.0	(-110.7)	(-110.7)	(-110.7)
2	1404.5	(-134.2)	(-113.2)	(-74.5)
3	1467.7	(-159.3)	(-118.5)	(-36.3)
4	1535.7	(-186.1)	(-126.5)	39.6
5	1602.7	(-214.7)	(-137.6)	46.3

* The Surplus (Deficit) is computed after adjusting the production estimate to account for the Caribbean Regions and error factors in the Central and Pacific Regions. See explanations in Chapter III, pp. 62-63, and Appendix B, Table B. 1.

Employment

The effects of changes in technology and/or area in sorghum production are shown in Table 6.2. The labor required per manzana for technology III has already been shown to be 67 percent greater than the labor requirement for traditional technology (Table 3. 5). In terms of total labor required this translates into a growth in employment of 6.7 percent in year two with 10 percent of the farms shifting from level I to level III technology. In succeeding year the rate of growth declines slightly. If both area and technology changes are effected simultaneously, then the labor requirement increases in the average by over nine percent per year. If this rate of increase in employment could be generated without having negative effects on other variables, changing technology in sorghum production would definitely be advantageous.

TABLE 6.2

PROJECTED LABOR REQUIREMENTS FOR GRAIN SORGHUM PRODUCTION IN MAN YEARS

Year	If Area Changes	% Change	If Tech Changes	% Change	If Area and Tech Change	% Change
1	8077.4	-	8077	-	8077.4	-
2	8319.8	3.0	8618	6.7	8876.2	9.9
3	8569.4	3.0	9258	6.3	9715.6	9.5
4	8826.4	3.0	9698	5.9	10597.4	9.1
5	9091.2	3.0	10238	5.6	11523.4	8.7

Income Effects

Unfortunately, under 1975 input/output price conditions the only small farmers who had positive net benefit from sorghum production were those who followed traditional practices (Table 3.5). The aggregate net benefit from sorghum production estimated by the model is negative in the base year and continues to get worse as area increases or more farms are shifted to a higher technology level (Table 6.3). The small farmers' income account was small but positive in the base year and become negative in the succeeding years. This is because the income of traditional farmers was positive and sufficient to offset the losses of farmers with more intensive use of purchased inputs. As more farmers change technology, the aggregate income of small farmers declines and becomes negative in the third year. Rural income is positive for all three of the technology levels available to small farmers but one-third lower for technology III as compared to technology I. The effect of a national program to shift from level I to level III technology would reduce rural income by 4.5 to 5.2 percent per year in spite of the increased labor requirement noted earlier. Shifting technology is therefore unacceptable if 1975 price ratios remain constant.

The effect of changes in technology on income if fertilizer prices were reduced by one-third is shown in Table 6.4. The reduction in fertilizer costs reduces the

TABLE 6.3

CHANGES IN PROJECTED INCOME FROM GRAIN SORGHUM PRODUCTION FOR FIVE YEARS IN C$1000

(1975 PRICES)

	NET BENEFIT					
Year	If Area Changes	% Change	If Tech Changes	% Change	If Area and Tech Change	% Change
1	-2013.6	--	-2013.6	--	-2013.6	--
2	-2074.0	3.0	-5291.1	162.8	-5449.9	170.7
3	-2136.1	3.0	-8568.7	61.9	-9090.5	66.8
4	-2200.3	3.0	-11846.3	38.3	-12944.8	42.4
5	-2266.3	3.0	-15123.9	27.7	-17022.0	31.5

	FARMERS' INCOME					
Year	If Area Changes	% Change	If Tech Changes	% Change	If Area and Tech Change	% Change
1	3747.3	--	3747.3	--	3747.3	--
2	3850.7	3.0	530.5	-85.8	546.4	-85.4
3	3975.5	3.0	-2686.3	-606.4	-2849.9	621.6
4	4094.8	3.0	-5903.1	119.7	-6450.5	126.3
5	4217.6	3.0	-9119.9	54.5	-10264.5	59.1

	RURAL INCOME					
Year	If Area Changes	% Change	If Tech Changes	% Change	If Area and Tech Change	% Change
1	19111.6	--	19111.6	--	19111.6	--
2	19684.9	3.0	18225.2	-4.5	18802.8	-1.6
3	20275.5	3.0	17398.8	-4.7	18458.4	-1.8
4	20883.7	3.0	16542.4	-4.9	18076.4	-2.1
5	21510.2	3.0	15686.1	-5.2	17654.8	-2.3

TABLE 6.4

CHANGES IN PROJECTED INCOME FROM GRAIN SORGHUM PRODUCTION FOR FIVE YEARS IN C$1000

(1975 PRICES EXCEPT FERTILIZER REDUCED BY 1/3)

	NET BENEFIT					
Year	If Area Changes	% Change	If Tech Changes	% Change	If Area and Tech Change	% Change
1	136.7	--	136.7	--	136.7	--
2	140.8	3.0	-2515.6	-****	-2591.5	-****
3	150.0	3.0	-5168.0	105.4	-5482.6	111.6
4	149.3	3.0	-7820.2	51.3	-8545.3	55.9
5	153.8	3.0	-10472.5	33.9	-11786.8	37.9

	SMALL FARMERS' INCOME					
Year	If Area Changes	% Change	If Tech Changes	% Change	If Area and Tech Change	% Change
1	4999.1	--	4999.1	--	4999.1	--
2	5249.1	3.0	2497.6	-51.8	2479.8	-50.4
3	5303.5	3.0	-183.9	-107.6	-195.1	-107.9
4	5462.3	3.0	-2775.4	-***	-3032.8	-1454.2
5	5626.5	3.0	-5367.0	-***	-6040.4	-99.2

	RURAL INCOME					
Year	If Area Changes	% Change	If Tech Changes	% Change	If Area and Tech Change	% Change
1	20363.3	-	20363.3	-	20363.3	-
2	20974.2	3.0	20132.3	-1.1	20736.2	1.8
3	21603.6	3.0	19901.2	-1.1	21113.2	1.8
4	22251.6	3.0	19670.1	-1.2	21494.0	1.8
5	22919.1	3.0	19439.0	-1.2	21878.7	1.8

loss for technology III net incomes and small farmers' income accounts. Yet both remain negative. Rural income for technology III is increased but still lower than rural income from technology I production. The negative effect of changing technology under these price conditions is not as great as it was for 1975 prices but the effect on small farmers' incomes is still disastrous.

Balance of Payments

The simulated foreign exchange costs and benefits of changing technology are shown in Table 6.5. The actual dollar amounts shown in the table are only a rough estimate. These estimates are based on the assumption that the foreign exchange costs of higher technology equal one-half of the farmers' costs for chemicals and mechanization and foreign exchange benefits equal the increase in production times an assumed price of $3.62 per hundredweight.

If the above assumption are reasonably valid, then shifting technology has a positive effect on Nicaragua's balance of payments position. Under 1975 price conditions, the ratio of net foreign exchange earnings to foreign exchange costs is approximately .58. For every $100 spent for imported inputs the foreign exchange value of increased production is approximately $158 leaving a net of $58. If one assumes that 10 percent of the sorghum land will be converted to technology III then sorghum production will contri-

TABLE 6.5

BALANCE OF PAYMENTS EFFECT OF CHANGES IN TECHNOLOGY IN GRAIN SORGHUM PRODUCTION IN U.S. DOLLARS

1975 PRICES

YEAR	CHANGE IN PROD. DUE TO CHANGE IN TECH	$ VALUE OF CHANGE IN PRODUCTION	$ VALUE OF CHANGE IN CHEMICAL ENERGY COST	NET BALANCE OF PAYMENTS EFFECT
1	--	--	--	--
2	67865.81	245674.10	155231.50	90442.63
3	69901.38	253042.90	159888.30	93154.56
4	71998.50	260634.50	164685.00	95949.50
5	74156.81	268447.60	169624.30	98823.25

FERTILIZER PRICES REDUCED BY 1/3

YEAR	CHANGE IN PROD. DUE TO CHANGE IN TECH	$ VALUE OF CHANGE IN PRODUCTION	$ VALUE OF CHANGE IN CHEMICAL ENERGY COST	NET BALANCE OF PAYMENTS EFFECT
1	--	--	--	--
2	67865.81	245674.10	109227.80	136446.30
3	69901.38	253042.90	112504.60	140538.30
4	71998.50	260634.50	115879.50	144754.90
5	74156.81	268447.60	119354.30	149093.20

bute an additional $90,000 to the balance of payments position each year.

If one assumes that fertilizer prices have declined by one-third from their peak in 1975, then the net balance of payments effect of changing technology is further improved. The ratio of net earnings to costs in this case is 1.25. Under these price conditions shifting 10 percent of the sorghum land from technology I to technology III every year will contribute an additional $130,000 to $140,000 to the Nicaraguan balance of payments position.

Summary

A program to increase the use of purchased inputs would have the hypothesized effect on three of the four output variables being considered. If the assumptions of the model are valid then the shift in technology specified will:

1. increase production
2. increase labor employed in sorghum production
3. improve the balance of payments position of Nicaragua

The effect on net income and small farmers' income will not only be negative but will result in actual deficits for small farmers. This is true whether one assumes the 1975 price ratios or the more favorable price ratios that would exist if fertilizer prices are significantly reduced. Given this situation, it seems unlikely that production, labor, or incomes can be affected by changes in technology.

Given the technology available and price ratios that are likely to prevail, it would be a disservice to anyone to finance small farmers for more intensive production of grain sorghum via the use of purchased inputs. The only role available for sorghum production, and possibly a very good one, is as an alternate crop under tradition cultivation. For the subsistence farmer, it will probably remain in his best interest to produce sorghum when no other crop is reasonably feasible.

CHAPTER VII

APPLICATION OF THE MODEL FOR UPLAND RICE

Upland rice is the least important of the four grain crops to small farmers. It was planted on only 5.9 percent of the farms accounting for a total area of only 19,000 manzanas in 1971. Rice is becoming an important food grain though as area planted and yields increase, especially for paddy rice. Consumption and exportation of rice has increased as production has increased.

Most of the increase has had little effect on small farmers as paddy rice production is concentrated on a few large farms. About 97 percent of all paddy rice was produced on farms larger than 100 manzanas. Production of paddy rice will probably continue to be concentrated on large farms as the cost of land development and other forms of capital investment required are considered beyond the reach of the small farmer. The one advantage the small farmers have gained from the increase in production is a relatively high support price level that is maintained partially through the political influence of large rice farmers.

As the focus of this study is on small farmers and not food production in general, the sector on rice production refers only to upland rice. This chapter presents the results of the simulation model experiments for upland rice production. Year one data are estimates of the conditions prevailing in 1975 and serve as a base year for comparison with various changes in area and technology that might be induced. In the tables where a change in technology is indicated, the change is an annual transfer from level I technology to level III technology for 10 percent of the total area in upland rice production. This shift represents the expected results of credit and technical assistance provided through a supervised credit program. Where a change in area is indicated, it represents an increase in area planted of three percent per year.

Production and Consumption

In this Chapter on rice, there is no attempt made to compare production with expected consumption over the range of years the model simulates, because upland rice provides only a relatively small portion of the total rice supply. Only the changes in total production of upland rice are considered.

The effect of shifting a greater percentage of total area each year to higher technology will be to increase production each year in increments of approximately 8,500 cwt of rough rice (Table 7.1). This would represent an increase in production of only 1.2 percent due to changes in technology. If one assumes that the area planted also increases as farmers shift technology, the production will increase at a rate of approximately 4.3 percent per year. This is a relatively slow rate of increase in comparison to the other three crops studied where increases of 6.8-9.3 percent per year were expected. Thus, changing technology will have a small but positive effect on total production.

TABLE 7.1

UPLAND RICE PRODUCTION
PROJECTIONS OF THE MODEL FOR FIVE YEARS

Year	Change in Total Production in 1000 cwt. due to: Change in Area only	% Change	Change in Tech only	% Change	Change in Area & Tech	% Change
1	627.8	-	627.8	-	627.8	-
2	646.7	3.0	635.8	1.3	659.9	4.3
3	666.1	3.0	643.8	1.3	683.0	4.3
4	686.1	3.0	651.8	1.2	712.2	4.3
5	706.7	3.0	659.8	1.2	742.6	4.3

Employment

The contribution of changing technology in rice production to relieving unemployment problems is also positive but small (Table 7.2). If area remains constant and farmers are induced to shift to a higher technology, employment in rice production may be expected to increase at a rate of only 0.3 percent per year. If an additional 40 percent of the area is planted to technology III instead of technology I after a period of four years, it would probably generate only 65 to 70 additional manyears of employment in the fifth year.

TABLE 7.2

PROJECTED LABOR REQUIREMENTS FOR UPLAND RICE PRODUCTION IN MAN YEARS

Year	If Area Changes	% Change	If Tech Changes	% Change	If Area and Tech Change	% Change
1	5489.4	-	5489	-	5489.4	-
2	5654.1	3.0	5506	.3	5651.5	3.3
3	5823.7	3.0	5523	.3	5859.5	3.3
4	5998.4	3.0	5540	.3	6053.7	3.3
5	6178.3	3.0	5557	.3	6254.3	3.3

Income Effects

The effects of changes in area and/or technology on net benefits are shown in Table 7.3. Farmers' incomes, and rural income accounts for rice are defined the same as they are for the other grain crops where:

1. Net Benefit = Yield x Government support price (Gross Income) - all costs
2. Farmers' Income= Gross Income - all costs except labor supplied by the farmer and his family
3. Rural Income = Farmers' Income, plus wages paid for hired labor

In all income accounts the price of rice is held constant at C$145.00 per cwt which was the official price in 1975. Changes in supply are assumed to have no effect on this price as it is an administered price set by the national government.

If one assumes 1975 input/output prices constant over the time period of the simulation run, then changes in technology with no change in area will have a negative effect on net income, small farmers' income, and rural income (Table 7.3). Net benefit declines by 4.8 percent between the base year and year two and continues to decline through the fifth year. The small farmers' income is the worst affected by changes in technology as this account declines by 5.9 percent between year one and year two and continues to decline over the five-year period. The percentage decline in rural income is only 3.8 percent but the amount of decrease is almost the same as small farmers' incomes. Rural laborers retain their income at almost the same level as mandays of labor and wages remain constant. The reduction in farmers' income noted above has sufficient negative effect on rural income to cause a reduction of 3.8 percent in the first year and a continuing decline throughout the period simulated.

This decline in income does not mean that farmers are losing money. On the contrary, the farmers in technology III have a net income of over C$588 per manzana. The negative effect is caused by the fact that the increase in production costs for purchased inputs is much higher than the increased value of the added production.

If one prefers to reject the assumption that 1975 prices will be maintained throughout the five-year range of the simulation model and assume lower input costs by reducing the price of fertilizer by one-third, the results are shown in Table 7.4. Changing technology with no change in area planted still has a negative effect on net income from rice production. If planted area increases at an annual rate of three percent at the same time farmers shift from technology I to III then the effects of these two changes are opposite and nearly equal. With a change in both area and technology Table 7.4 shows a change in net income of 0.1 percent to -0.2 percent.

The more favorable price ratio is also insufficient to make it profitable in terms of small farmers' income or rural income to induce a shift in technology. If technology changes, small farmers' incomes decline by 3.6 percent to 4.1 percent per year. Rural income likewise declines by 2.5 percent to 2.7 percent per year.

From this analysis, it seems one must reject the hypothesis that increased use of purchased inputs in rice production will increase the income of small farmers. The only way that technology III could ever compete with technology I would be if the inputs were practically given to the farmers. An unlikely occurrence.

TABLE 7.3

CHANGES IN PROJECTED INCOME FROM UPLAND RICE PRODUCTION FOR FIVE YEARS IN C$100 (1975 PRICES)

	NET BENEFIT					
Year	If Area Changes	% Change	If Tech Changes	% Change	If Are and Tech Change	% Change
1	18944.9	-	18944.9	-	18944.9	-
2	19513.2	3.0	18029.9	-4.8	18570.8	-2.0
3	20098.6	3.0	17115.0	-5.1	18157.2	-2.2
4	20701.6	3.0	16200.0	-5.3	17702.2	-2.5
5	21322.6	3.0	15285.1	-5.6	17203.4	-2.8

	FARMERS' INCOME					
Year	If Area Changes	% Change	If Tech Changes	% Change	If Area and Tech Change	% Change
1	16071.3	-	16071.3	-	16071.3	-
2	16553.5	3.0	15124.7	-5.9	15578.4	-3.1
3	17050.1	3.0	14178.1	-6.3	15041.5	-3.4
4	17561.6	3.0	13231.4	-6.7	14458.3	-3.9
5	18088.4	3.0	12284.8	-7.2	13826.6	-4.4

	RURAL INCOME					
Year	If Area Changes	% Change	If Tech Changes	% Change	If Area and Tech Change	% Change
1	27649.3	-	27649.3	-	27649.3	-
2	28478.7	3.0	26611.8	-3.8	27410.1	-0.9
3	29333.1	3.0	25574.3	-3.9	27131.8	-1.0
4	30213.1	3.0	24536.8	-4.1	26812.0	-1.2
5	31119.4	3.0	23499.3	-4.2	26448.7	-1.4

TABLE 7.4

CHANGES IN PROJECTED INCOME FROM UPLAND RICE PRODUCTION FOR FIVE YEARS IN C$100

(1975 PRICES EXCEPT FERTILIZER REDUCED BY 1/3)

	NET BENEFIT					
Year	If Area Changes	% Change	If Tech Changes	% Change	If Area and Tech Change	% Change
1	20430.3	-	20430.3	-	20430.3	-
2	21043.2	3.0	19849.7	-2.8	20445.2	0.1
3	21674.5	3.0	19269.1	-2.9	20442.5	0.0
4	22324.8	3.0	18688.4	-3.0	20321.3	-0.1
5	22994.5	3.0	18107.	-3.1	20380.5	-0.2

	SMALL FARMERS' INCOME					
Year	If Area Changes	% Change	If Tech Changes	% Change	If Area and Tech Change	% Change
1	16920.5	-	16920.5	-	16920.5	-
2	17428.1	3.0	16308.2	-3.6	16797.4	-0.7
3	17950.0	3.0	15696.9	-3.8	16651.7	-0.9
4	18489.4	3.0	15083.6	-3.9	16482.2	-1.0
5	19044.1	3.0	14471.2	-4.1	16287.5	-1.2

	RURAL INCOME					
Year	If Area Changes	% Change	If Tech Changes	% Change	If Area and Tech Change	% Change
1	28498.4	-	28498.4	-	28498.4	-
2	29353,3	3.0	27795.2	-2.5	28629.1	+0.5
3	30233.9	3.0	27092.1	-2.5	28742.0	+0.4
4	31140.9	3.0	26388.9	-2.6	28835.8	+0.3
5	32075.1	3.0	25685.8	-2.7	28909.5	+0.3

Balance of Payments

The foreign exchange costs and benefits of shifting from traditional technology to level III technology are shown in Table 7.5. The actual dollar amounts shown in the table are not intended to be exact as was pointed out in Chapter III but are rough estimates of what might be expected. These estimates are based on the assumption that foreign exchange costs equal one-half of the farmers' costs (converted to U.S. dollar) for chemicals and petroleum-based energy. Foreign exchange benefits equal the increase in production times a price of U.S.$7.00 per cwt.

If the above assumption are reasonably valid, then shifting technology has a negative effect on the balance of payment position. The ratio of net foreign exchange earnings to foreign exchange cost for imported inputs is approximately -.3 percent. For every $100 spent for imported purchased inputs for upland rice production the increased value of production is approximately $63 leaving a deficit of $37. Every additional 10 percent of the land that purchased inputs are applied to at the technology III level cost the country of Nicaragua $35,000 dollars in foreign exchange.

If one were willing to accept the assumption that fertilizer prices in the model should be lower than those reported in January 1975 by one-third then the effect of changing technology on the balance of payments is improved. The ratio of foreign exchange earnings to cost under these

TABLE 7.5

BALANCE OF PAYMENTS EFFECT OF CHANGES IN TECHNOLOGY IN UPLAND RICE PRODUCTION IN U.S. DOLLARS

1975 PRICES

YEAR	CHANGE IN PROD. DUE TO CHANGE IN TECH	$ VALUE OF CHANGE IN PRODUCTION	$ VALUE OF CHANGE IN CHEMICAL ENERGY COST	NET BALANCE OF PAYMENTS EFFECT
1	-	-	-	-
2	8226.07	55937.28	91049.50	-35112.22
3	8472.73	57614.59	93780.81	-36166.22
4	8727.02	59343.73	96594.19	-37250.45
5	8989.05	61125.57	99492.19	-38365.62

FERTILIZER PRICES REDUCED BY 1/3

YEAR	CHANGE IN PROD. DUE TO CHANGE IN TECH	$ VALUE OF CHANGE IN PRODUCTION	$ VALUE OF CHANGE IN CHEMICAL ENERGY COST	NET BALANCE OF PAYMENTS EFFECT
1	-	-	-	-
2	8226.07	55937.28	66452.88	-10515.60
3	8472.73	57614.59	68446.38	-10831.78
4	8727.02	59343.73	70449.63	-11155.89
5	8989.02	61125.57	72614.75	-11489.18

price conditions is -.16, or for every $100 spent for inputs the added value of production is approximately $84 leaving a deficit of $16. Every additional 10 percent of the total riceland that purchased inputs are applied to at the technology III level cost the country an addition of $11,000 in balance of payments deficit.

In the case of rice production, the effect of shifting technology on the balance of payments position of Nicaragua serves as one more argument for traditional technology in upland rice production.

Summary

The increased use of purchased inputs can not be considered to have a significant positive effect on any of the four aspects of the economy under consideration. The effect of shifting technology did have a positive effect on production and employment, yet in both cases the projected effect was so small that it would be essentially unnoticeable.

The effect of changing technology on income was negative for all income accounts and both sets of prices. This does not mean, however, that small farmers should not grow upland rice. The potential income from upland rice production by using traditional or technology I practices was as high or higher than the potential income from any other crop.

The balance of payments effects of changing technology in rice production were negative for both price assumptions. This may seem striking in light of the fact that rice is an export crop in Nicaragua but one must remember that this analysis applies only to upland rice. Paddy rice may look and taste the same but the technology and costs and returns are markedly different. What is true or false for upland rice may be the opposite for paddy rice.

In conclusion, it seems that a farmer who has sufficient rainfall can make a reasonably good income per manzana from upland rice production if he follows a level I technology and support prices remain at their high levels of 1975. This will be good not only for the farmer but also for the rural labor force as rice requires as much as, or more labor than any other crop. Providing credit and assistance in using purchased inputs on upland rice would be a disservice to all involved unless an alternate technology or method of production is discovered.

CHAPTER VIII

SUMMARY AND CONCLUSION

This study was concerned with the potential effects of changing technology and increasing the use of purchased inputs in the production of basic grains in Nicaragua. The effects were measured by a simulation model developed specifically for this study. The crops considered were corn, beans, grain sorghum, and upland rice. This concluding Chapter will summarize some important features of the method, the sources of information included in the model, and the simulated result for each crop. An evaluation of the projections of the model is presented with policy alternatives that should be considered in an agricultural development program for Nicaragua. The Chapter is concluded with recommendations for improvement in the simulation model and recommendations for further research.

Summary

The objective of this study was to examine the possible impacts of changing technology and increasing the use of purchased inputs in the production of basic food grains by small farmers. A simple simulation model that used available production and price data was used to project the results of changing technology. The impact was measured in terms of the effect of changing technology for each grain on: 1) Total production of each of the basic grains, 2) Income in the rural sector, 3) Employment in agriculture, and 4) The balance of payments position of Nicaragua.

The simulation model was chosen because of its ability to examine the effects of any given policy or program on a number of objectives. This approach was seen as a non-optimizing, flexible method in which relevant data and relationships could be incorporated without creating severe computational problems. The model used in this study is relatively simple in comparison to other simulation models used in agricultural development policy analysis. It is deterministic in nature and leaves stochastic considerations up to the users of the model. It does, however, allow the user of the model to examine the possible effects of a given policy before that policy is implemented. What the model lacks in sophistication hopefully is compensated by clarity of the assumptions involved and the minimal cost of using such a model to evaluate available data.

The data used in the construction of this model was derived from four sources. The national agricultural survey conducted by UNASEC provided the data that were used to disaggregate the farms into four technology levels for each crop. The input/output ratios were then computed from these data for each level of technology. The input/

output price ratios were based on data collected by Philip Warnken and the UNASEC staff in January of 1975. These prices were adjusted in some of the computer runs to reflect a 33 percent reduction in fertilizer prices since January 1975. The National Agricultural Census data were used to determine the total area in each crop by technology level and as a check on the model to insure that it could mimick the real world in estimating production and employment figures for the basic grains. The Annual Reports of the Central Bank of Nicaragua were used to estimate consumption levels of the four grains and the rate of increase in land for each of the four crops.

The system's analysis of the basic grains sector relies heavily on <u>An Analysis of Agricultural Production in Nicaragua</u> by Philip Warnken and Walter Swenson and detailed studies of costs and returns for each of the crops by Robert Finley.[49] The systems synthesis and model formulation were based on the assumption that annual shifts from technology level I to technology level III on 10 percent of the area in production for each crop could be induced by a supervised credit program. It was further assumed that the farmers new to technology III would have

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49) Robert F. Finley, "Analysis of Maize (Bean, Upland Rice, and Grain Sorghum) Production in Nicaragua: A Detailed Study of Costs and Returns." (Unpublished report for USAID/Nicaragua, 1974).

similar input/output ratios to those farms in technology III when the UNASEC survey was conducted.

The model was tested by comparing generated output for total employment and production with historical data from the Census and Central Bank reports. The employment data of the model were found to be similar to historical data. There was considerable difference, however, between the total production estimates of the model and historical data. In order to compare expected production with consumption over the time the model simulated, the production data were adjusted in the model to account for the discrepancy between Census data and the extrapolations from the UNASEC data. This adjustment allows for a rough estimation of possible surpluses or shortages for the four basic grains. If the model were to be used in an actual policy making situations however, the production data should be reexamined and the formulas for estimating production should be recomputed to improve the accuracy of the model.

In the input/output analysis of each crop by technology, yields were found to be significantly greater for technology level III than technology level I (Table 8.1). The labor requirement per manzana is also greater for technology III than technology I but the difference is relatively small for beans and upland rice. The number of mandays labor used per manzana under technology III was greatest for rice followed by sorghum, beans, and

TABLE 8.1

YIELDS PER MANZANA FOR THE FOUR BASIC GRAINS BY TECHNOLOGY IN HUNDREDWEIGHT

	TECH I	TECH II	TECH III	TECH IV
Corn	14.68	16.62	26.16	44.28
Beans	9.89	13.19	14.08	16.93
Grain Sorghum	14.42	12.81	25.50	29.34
Upland Rice	27.02	25.84	30.88	46.89

TABLE 8.2

LABOR REQUIREMENTS* PER MANZANA FOR THE FOUR BASIC GRAINS BY TECHNOLOGY

	TECH I	TECH II	TECH III	TECH IV
Corn	32.81	40.21	39.13	32.17
Beans	43.51	44.24	46.14	44.53
Grain Sorghum	35.15	33.41	58.77	19.57
Upland Rice	17.13	93.93	73.25	24.27

* Labor requirement measured in 8-hour mandays.

corn (Table 8.2).

For the corn, sorghum, and rice, both farmers' income and rural income per manzana is lower under technology level III than level I (Table 8.3). Only in bean production, however, was farmers' income and rural income greater under technology level III than level I given 1975 input/output price ratios. The greatest income per manzana was generated by upland rice under traditional technology. The lowest income per manzana was from the production of grain sorghum under technology level III. Following technology level III in sorghum production, resulted in an actual loss of C$319 per manzana for the farmer and contributed only C$270 per manzana to rural income (Table 8.3 and Table 8.4).

If fertilizer prices are reduced by 33 percent, the income levels for technology III all increase with no change in income for technology I as no fertilizers are used. But, except for beans again, the income per manzana is greater for technology level I than technology level III.

Simulation Results

The model having been synthesized, checked, adjusted, and validated, was run to simulate a period of five years beginning with 1975 as a base year. It was run for three different sets of assumptions using 1975 price data. In the first run area was changed and technology remained constant. This provided an estimate of what would happen

TABLE 8.3

SMALL FARMERS' INCOME PER MANZANA FOR THE FOUR BASIC GRAINS BY TECHNOLOGY*

	TECH I	TECH II	TECH III
Corn	232.10 (232.10)**	-32.56 (22.06)	44.21 (154.31)
Beans	820.53 (820.53)	996.54 (1040.36)	905.70 (991.54)
Grain Sorghum	221.94 (221.94)	-0.70 (32.88)	-319.00 (203.48)
Upland Rice	1082.83 (1082.83)	707.59 (791.60)	625.32 (830.35)

* Income measured in Cordobas US$1 = C$7.00

** Number in parenthesis are income per manzana if fertilizer prices are reduced by 33 percent from January 1975 levels.

TABLE 8.4

RURAL INCOME PER MANZANA FOR THE FOUR BASIC GRAINS BY TECHNOLOGY*

	TECH I	TECH II	TECH III	TECH IV
Corn	684.19	313.97	443.10	475.78
	(889.19)**	(368.59)	(553.20)	(475.78)
Beans	1183.00	1393.00	1158.00	500.77
	(1183.00)	(1436.82)	(1243.84)	(500.77)
Grain Sorghum	414.77	189.15	270.76	225.05
	(414.73)	(222.73)	(376.28)	(225.05)
Upland Rice	1726.92	7212.62	1225.50	303.25
	(1726.92)	(1301.63)	(1387.08)	(305.25)

* Income measured in Cordobas; C$1.00 = US$7.00

** Numbers in parenthesis are income per manzana if fertilizer prices are reduced by 1/3 from January 1975 levels.

if current programs and policies in Nicaragua remain constant. In the second run technology changed and area remained constant to examine the effects of changing technology isolated from any change in area. In the third run area in production, increased each year and technology was changed. The model was then run for each of the sets of assumptions above with fertilizer prices reduced by 33 percent from 1975 levels. These prices were used in the model because fertilizer prices on the world market have declined. This type of price change in the model is also useful in examining the possible effects of price controls or subsidizing inputs on the incomes of those farmers who would use the same inputs at either price.

The effects of changing technology on total production of each of the crops is shown on Table 8.5. As was hypothesized, changing technology will increase total production. Corn and grain sorghum output increase by almost six percent per year due to change in technology only. Bean and rice production increase at a slower rate. The amount of labor required in the production of basic grains also increase for all four crops as was hypothesized but the rate of increase due to change in technology for beans and rice is very small; .6 and .3 percent, respectively.

The effect of changing technology on small farmers' income and rural income is mixed. Only in the case of

TABLE 8.5

PROJECTED RATE OF GROWTH* IN PRODUCTION, EMPLOYMENT, SMALL FARMERS' INCOME, AND RURAL INCOME FOR THE FOUR BASIC GRAIN CROPS WITH CHANGE IN AREA AND/OR TECHNOLOGY CHANGES

	Change Area only	Change Tech only	Change Area & Tech
Corn:			
Production	3.0	5.8	8.8
Employment	3.0	1.8	4.8
Farmers' Income	3.0	-13.0(-4.7)**	-11.0(-1.8)
Rural Income	3.0	-0.9(1.4)	2.1(4.5)
Beans:			
Production	3.0	3.7	6.8
Employment	3.0	.6	3.6
Farmers' Income	3.0(3.0)	1.0(2.0)	4.0(5.1)
Rural Income	3.0(3.0)	1.4(2.1)	4.5(5.2)
Grain Sorghum:			
Production	3.0	5.9	9.0
Employment	3.0	6.7	9.8
Farmers' Income	3.0(3.0)	-85.0(-51)	-82.0(-50)
Rural Income	3.0(3.0)	-4.5(-1.1)	-1.6(1.8)
Upland Rice:			
Production	3.0	1.3	4.3
Employment	3.0	.3	3.3
Farmers' Income	3.0(3.0)	-5.9(-3.6)	-3.0(-0.7)
Rural Income	3.0(3.0)	-3.8(-2.5)	-0.9(.5)

* Rate of change expressed as a percent of the base year.

** Figures not in parenthesis indicate rate of growth in income accounts if 1975 price ratios are constant for the simulation period. Numbers in parenthesis are rates of growth if fertilizer prices are reduced by 1/3.

beans did both income accounts increase due to changing technology under both price conditions included in the model. In the case of corn, changing technology has a negative effect on both small farmers' income and rural income accounts under 1975 price conditions. If fertilizer prices are reduced though, changing technology has a negative effect on small farmers' income but a positive effect on rural income. Based on the model and available prices, the hypothesized positive effect on income cannot be shown.

In grain sorghum, the effect of changing technology on income is clearly negative. The drastic decline in income of 50 to 85 percent exaggerates the magnitude of the effect because the aggregate income in the base year was very low. This results in a very large percentage change in following years. In the case of rice, the effect of changing technology is also negative. Even with the more favorable price conditions, farmers' income and rural income decline by 3.6 and 2.5 percent, respectively, due to changing technology. The hypothesized increase in income due to changing technology cannot be shown.

The balance of payments position of Nicaragua is improved by shifting technology in the production of corn, beans, and grain sorghum (Table 8.6). The actual amount of foreign exchange earned from shifting techno-

TABLE 8.6

RATIO* OF NET FOREIGN EXCHANGE EARNINGS TO FOREIGN EXCHANGE COST FOR IMPORTED PURCHASED INPUTS IF TECHNOLOGY CHANGES FROM LEVEL I TO LEVEL III

	1975 Prices	1975 Prices Except Fertilizer Reduced by 1/3
Corn	.61	1.22
Beans	2.0	3.2
Grain Sorghum	.58	1.25
Upland Rice	-.30	-.16

* This Ration= (FEBENE - FECOST)/ FECOST

FEBENE = The foreign exchange value of added production due to change in technology.

FECOST = The foreign exbhange costs of the additional imported inputs used in the higher technology level.

For further explanation see pages 74,75.

logy may differ from the model projection due to changes in input and output prices but the ratios shown in Table 8.6 are felt to reasonably approximate the effect. Some costs may have been left out of the model but the chemical and energy cost were near their peak when these computations were made. On the other hand, the returns are computed from very conservative price estimates for grain: corn \$2.25 per bushel, grain sorghum \$3.60 per cwt, rice \$6.80 per cwt, and beans \$16.57 per cwt. Only in the case of upland rice is the balance of payments effect of changing technology negative. Changing fertilizer prices within the range specified would effect only the magnitude of the ratio. For no crop is the balance of payment ratio so close to zero that changing prices would change the sign.

Evaluation of the Model and its Projections

The model has shown that only some of the effects of changing technology are positive as hypothesized. Others are negative indicating detrimental effects in some areas if farmers are induced to transfer from technology level I to technology level III. From the projection of the model, it is clearly to the advantage of all to shift technology in bean production. In the case of corn, it would also seem to be in the best interest of all to shift technology if the government can influence the input and/or output prices sufficiently to guarantee the farmers an income under technology level III commensurate with his increased costs if he shifts technology. The positive effects on employment, production, and the balance of payments seem sufficiently strong to justify such a program.

In the case of both upland rice and grain sorghum, given the four technology levels available, it seems best to stick with traditional production of these two crops. This is not to say that development cannot be induced in the production of these grains. Further agronomic research was called for in Warnken's analysis of the agricultural situation of Nicaragua and this model supports that recommendation. Only through more intensive research can the new packages of technology be discovered that will enable small farmers to increase their production and incomes.

To the extent that this model shows these positive and negative effects it seems that this type of model could be very helpful to policy makers in small countries who are trying to develop the basic grain production sector. This model should be even more helpful if adapted and run on computing facilities within the country. The people working in and thoroughly knowledgeable about a given country's agriculture would be in a better position to determine the appropriate data set to use when there are conflicts. More relevant alternative packages of assumptions could be used for different computer runs for comparison purposes.

In no case, however, can such a model as this one be expected to determine alone whether any given policy or program should be implemented. It is deterministic and rigid in its input/output assumptions. Variations in climate and prices are not contained in the model but may occur in the real world. It is assumed that inputs can be made available, that credit and technical assistance can be provided. It is assumed that government has the ability to maintain the price levels that it sets. In real life judgements have to be made concerning these assumptions. The cost of meeting these constraints have to be further weighed against the benefits of the program identified in the simulation model.

If all of the above considerations were to be included in the model, the complexity of the model and costs of collecting data, building, and running the model would be multiplied. Whether or not these costs could be justified by what would be considered more reliable projections remains open to question. Assumptions still would have to be made and good policy and programs would still require judgement on the part of the policy makers. The simulation model might best be viewed in the same way as any other tool: Its value lies in its ability to aid one in accomplishing a task at minimum cost, not in its own internal complexity or sophistication.

Recommendations for Further Study

The results of this study suggest three areas in which further research is needed to evaluate the effects of changing technology on economic variables that are of interest to policy makers in less developed countries.

If this model were to be used in actual policy making situations in Nicaragua, it would be helpful to have more direct access to the various data sources on yields and area in production to improve the accuracy of the model in predicting total production. More accurate price data could improve the estimation of the balance of payments effects. The actual goals of the proposed credit and technical assistance program in terms of number of farmers and area to be affected should be used in the model instead of an arbitrary rate of technological change as was used in this study.

In other countries where the use of simulation models is being considered the whole range of complexity in the modeling process should be considered. Relatively simple models such as the one used in this study may not be worthwhile in some areas capable of more sophisticated models. Attempting to use more sophisticated models may lead to erroneous conclusions if the data base in the model is weak and assumptions are hidden in the sophisticated computer program. The collection of sufficient data and the construction of complex models to mimick reality may cost more than the information the model generates is worth. The use of the appropriate models, however, can provide valuable information in policy and program considerations.

The technology used by small farmers must continue to improve if the increasing demand for food is to be met and the rural population in developing countries are to have a better standard of living. Different levels of technology are employed by different farmers in almost all LDC's today. More research is needed to identify the technology used by the best small farmers and the information needs to be made available to more farmers. Agricultural researchers must continue to seek to identify packages of technology that will increase both production and rural income under changing prices and condition of trade.

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APPENDIX A

THE COMPUTER PROGRAM AND DEFINITIONS OF VARIABLES USED IN THE PROGRAM.

SIMULATION MODEL

(The Model below uses 1975 prices except fertilizer reduced by 1/3, and area and the technology change)[1]

```
C   Dimension Statements

     INTEGER I
     REAL MZTOMA, MZTOFR, MZTOSO, MZTOAR, MA1, MA2, MA3, MA4
     REAL PM(10), LM(10), IM(10), FM(10), AM(10), RM(10), CM(10), EM(10)
     REAL PM(10),LMC(10), IMC(10),FMC(10),AMC(10),CMC(10), RMC(10)
    1EMC(10)
     REAL PF(10),LF(10),IF(10),FF(10),AF(10),CF(10),EF(10)
     REAL PFC(10),LFC(10),IFC(10),FFC(10),AFC(10),RFC(10),CFC(10),
    1EFC(10)
     REAL PS(10),LS(10),IS(10),FS(10),AS(10),RS(10),CS(10),ES(10)
     REAL PSC(10),LSC(10),ISC(10),FSC(10),ASC(10),RSC(10),CSC(10),
    1ESC(10)
     REAL PA(10),LA(10),IA(10),FA(10),AA(10),RA(10),CA(10),EA(10)
     REAL PAC(10),LAC(10),IAC(10),FAC(10),AAC(10),RAC(10),CAC(10),
    1EAC(10)
     REAL DPMT(10),DCMT(10),DEMT(10),BMBENE(10),BMCOST(10),BMNET(10)
     REAL DPFT(10),DCFT(10),DEFT(10),BFBENE(10),BFCOST(10),BFNET(10)
     REAL DPST(10),DCST(10),DEST(10),BSBENE(10),BSCOST(10),BSNET(10)
     REAL DPAT(10),DCAT(10),DEAT(10),BABENE(10),BACOST(10),BANET(10)
     REAL CONSM(10),CONSF(10),CONSS(10)
     T=1
```

```
C    Initialize area for each crop and Compute Consumption

         MZTOMA=283252.
         CONSM(1)=4566900
         CONSS(I)=1344000
         CONSF(T)=1136000
         DO 15 I=2,5
         CONSM(I)=CONSM(I-1)*1.045
         CONSF(I)=CONSF(I-1)*1.045
         CONSS(I)=CONSS(I-1)*1.045
      15 CONTINUE
         MZTOFR=55697.
         MZTOSO=59467.
         MZTOAR=20691.

C    Compute area in each technology level for each crop

      10 MA1=MZTOMA*.60
         MA2=MZTOMA*.15
         MA3=MZTOMA*.15
         MA4=MZTOMA*.10
         FRI=MZTOFR*.67
         FR2=MZTOFR*.15
         FR3=MZTOFR*.15
         FR4=MZTOFR*.03
         SO1=MZTOSO*.50
         SO2=MZTOSO*.15
         SO3=MZTOSO*.15
         SO4=MZTOSO*.20
```

```
      AR1=MZTOAR*.50
      AR2=MZTOAR*.20
      AR3=MZTOAR*.15
      AR4=MZTOAR*.15
       GOTO77
   20 MA1=MZTOMA*.50
      MA2=MZTOMA*.15
      MA3=MZTOMA*.25
      MA4=MZTOMA*.10
      FR1=MZTOFR*.57
      FR2=MZTOFR*.15
      FR3=MZTOFR*.25
      FR4=MZTOFR*.03
      SO1=MZTOSO*.40
      SO2=MZTOSO*.15
      SO3=MZTOSO*.25
      SO4=MZTOSO*.20
      AR1=MZTOAR*.40
      AR2=MZTOAR*.20
      AR3=MZTOAR*.25
      AR4=MZTOAR*.15
       GOTO77
   30 MA1=MZTOMA*.40
      MA2=MZTOMA*.15
      MA3=MZTOMA*.35
      MA4=MZTOMA*.10
      FR1=MZTOFR*.47
      FR2=MZTOFR*.15
      FR3=MZTOFR*.35
      FR4=MZTOFR*.03
      SO1=MZTOSO*.30
      SO2=MZTOSO*.15
      SO3=MZTOSO*.35
      SO4=MZTOSO*.20
```

```
      AR1=MZTOAR*.30
      AR2=MZTOAR*.20
      AR3=MZTOAR*.35
      AR4=MZTOAR*.15
      GOTO77
40    MA1=MZTOMA*.30
      MA2=MZTOMA*.15
      MA3=MZTOMA*.45
      MA4=MZTOMA*.10
      FR1=MZTOFR*.37
      FR2=MZTOFR*.15
      FR3=MZTOFR*.45
      FR4=MZTOFR*.03
      SO1=MZTOSO*.20
      SO2=MZTOSO*.15
      SO3=MZTOSO*.45
      SO4=MZTOSO*.20
      AR1=MZTOAR*.20
      AR2=MZTOAR*.20
      AR3=MZTOAR*.45
      AR4=MZTOAR*.15
      GOTO77
50    MA1=MZTOMA*.20
      MA2=MZTOMA*.15
      MA3=MZTOMA*.55
      MA4=MZTOMA*.10
      FR1=MZTOFR*.27
      FR2=MZTOFR*.15
      FR3=MZTOFR*.55
      FR4=MZTOFR*.03
      SO1=MZTOSO*.10
      SO2=MZTOSO*.15
      SO3=MZTOSO*.55
      SO4=MZTOSO*.20
```

```
      AR1=MZTOAR*.10
      AR2=MZTOAR*.20
      AR3=MZTOAR*.55
      AR4=MZTOAR*.15

C     Computer Production, Labor, Incomes, and Chemical Cost of each crop

   77 PM(T)=MA1*14.68+MA2*16.62+MA3*26.16+MA4*44.28
      LM(T)=(MA1*32.81+MA2*40.21+MA3*39.13+MA4*32.17)/260
      IM(I)=MA1*149.47+MA2*(-130.50)+MA3*(-82.10)+MA4*235.07
     1+MA2*54.62*MA3*110.11+MA4*159.88
      FM(T)=MA1*232.10+MA2*(-32.56)+MA3*44.21+MA4*0.0
     1+MA2+54.62+MA3*110.1
      AM(T)=MA1*232.10+MA2*(-32.56)+MA3*44.21+MA4*475.78
     1+MA2*54.62+MA3*110.11+MA4*159.88
      RM(T)=MA1*484.19+MA2*313.97+MA3*443.10+MA4*475.78
     1+MA2*54.62+MA3*110.1
      CM(T)=MA1*.05+MA2*172.80+MA3*378.28+MA4*475.78
     1-MA2*54.62-MA3*110.11-MA4*159.88
      EM(T)=MA1*0.0+MA2*10.67+MA3*21.95+MA4*71.73
      PF(T)=FR1*9.89+FR2*13.19+FR3*14.08+FR4*16.93
      LF(T)=(FR1*43.51+FR2*44.24+FR3*46.14+FR4*44.53)/260
      IF(T)=FR1*714.69+FR2*882.96+FR3*821.76+FR4*1001.8
     1+FR2*43.82+FR3*85.84+FR4*96.26
      FF(T)=FR1*820.53+FR2*996.54+FR3*905.70
     1+FR2*43.82+FR3*85.8
      AF(T)=FR1*820.53+FR2*996.54+FR3*905.70+FR4*1192.7
     1+FR2*43.82+FR3*85.84+FR4*96.26
      RF(T)FR1*1183.+FR2*1393.+FR3*1358.+FR4*500.77
     1+FR2*43.82+FR3*85.8
      CF(T)=FR1*.30+FR2*143.95+FR3*303.61+FR4*332.01
     1-FR2*43.82-FR3*85.84-FR4*96.26
      EF(T)=FR1*0.0+FR2*7.77+FR3*13.03+FR4*62.0
      PS(T)=SO1*14.42+SO2*12.81+SO3*25.50+SO4*29.34
      LS(T)=(SO1*35.15+SO2*33.41+SO3*58.77+SO4*19.57)/260.
```

```
      IS(T)=SO1*118.16+SO2*(-120.6)+SO3*(-433.)+SO4*(-49.5)
     1+SO1*.37+SO2*33.58+SO3*105.52+SO4*75.54
      FS(T)=SO1*221.94+SO2*(-.7)+SO3*(-319.)
     1+SO1*.37+SO2*33.58+SO3*105.52
      AS(T)=SO1*221.94+SO2*(-.7)+SO3*(-319.)+SO4*118.71
     1+SO1*.37+SO2*33.58+SO3*105.52+SO4*75.54
      RS(T)=SO1*414.77+SO2*189.15+SO3*270.76+SO4*225.05
     1+SO1*.37+SO2*33.58+SO3*105.52
      CS(T)=SO1*1.42+SO2*112.35+SO3*354.05+SO4*266.41
     1-SO1*.37-SO2*33.58-SO3*105.52-SO4*75.54
      ES(T)=SO1*1.58+SO2*.756+SO3*3.76+SO4*101.05
      PA(T)=AR1*27.02+AR2*25.84+AR3*30.88+AR4*46.89
      LA(T)=(AR1*71.13+AR2*93.93+AR3*73.25+AR4*24.27)/260.
      IA(T)=      AR2*534.06+AR3*588.92+AR4*1366.+AR1*1031.12
     1+AR2*84.10+AR3*161.58+AR4*205.03
      FA(T)=AR1*1082.83+AR2*707.59+AR3*625.32
     1+AR2*84.01+AR3*161.58
      AA(T)=AR1*1082.83+AR2*707.59+AR3+625.32+AR4*1366.
     1+AR2*84.01+AR3*161.58+AR4*205.03
      RA(T)=AR1*1726.92+AR2*1217.62+AR3*1225.5+AR4*303.25
     1+AR2*84.01+AR3*161.58
      CA(T)=AR1*0.0+AR2*254.58+AR3*594.61+AR4*848.27
     1-AR2*84.01-AR3*161.58-AR4*205.03
      EA(T)=AR1*0.0+AR2*.98+AR3*3.51+AR4*285.20

C     Compute adjusted production estimate and compare to consumption

      APM=PM(T)-PM(T)*.26+9.3*.19*MZTOMA
      APS=PS(T)-PS(T)*.12+10.7*.39*MZTOSO
      APF=PF(T)+PF(T)*.17+7.5*.61*MZTOFR
      CPMNET=APM-CONSM(T)
      CPFNET=APF-CONSF(T)
      CPSNET=APS-CONSS(T)
```

```
      CREDM=MA3*810.
      CREDF=FR3*850.
      CREDS=SO3*1010.
      CREDA=AR3*1358.
      CREDT=CREDM+CREDF+CREDS+CREDA
      WRITE(6,90)
      WRITE(6,92) T,MA1,MA2,MA3,MA4,CREDM
      WRITE(6,92) T,FR1,FR2,FR3,FR4,CREDF
      WRITE(6,92) T,SO1,SO2,SO3,SO4,CREDS
      WRITE(6,92) T,AR1,AR2,AR3,AR4,CREDA
92    FORMAT('0',15,5F15.0)
      WRITE(6,93)CREDT
93    FORMAT(' ',F90.0)
      WRITE(6,94) APM,CONSM(T),CPMNET
      WRITE(6,94) APS,CONSS(T),CPSNET
      WRITE(6,94) APF,CONSF(T),CPFNET
94    FORMAT('0',3F20.0)
      T=T+1

C     Compute new area for year T+1

      MZTOMA=MZTOMA*1.03
      MZTOFR=MZTOFR*1.03
      MZTOSO=MZTOSO*1.03
      MZTOAR=MZTOAR*1.03
       GOTO(  10,20,30,40,50,99),T

C     Compute annual percent change in each output variable

99    PMC(1)=0
      D0 66 T=2,5
      PFC(T)=(PF(T)-PF(T-1)/PF(T-1)
      LFC(T)=(LF(T)-LF(T-1)/LF(T-1)
```

```
      IFC(T)=(IF(T)-IF(T-1))/IF(T-1)
      FFC(T)=(FF(T)-FF(T-1))/FF(T-1)
      AFC(T)=(AF(T)-AF(T-1))/AF(T-1)
      RFC(T)=(RF(T)-RF(T-1))/RF(T-1)
      CFC(T)=(CF(T)-CF(T-1))/CF(T-1)
      EFC(T)=(EF(T)-EF(T-1))/EF(T-1)
      PAC(T)=(PA(T)-PA(T-1))/PA(T-1)
      LAC(T)=(LA(T)-LA(T-1))/LA(T-1)
      IAC(T)=(IA(T)-IA(T-1))/IA(T-1)
      FAC(T)=(FA(T)-FA(T-1))/FA(T-1)
      AAC(T)=(AA(T)-AA(T-1))/AA(T-1)
      RAC(T)=(RA(T)-RA(T-1))/RA(T-1)
      CAC(T)=(CA(T)-CA(T-1))/CA(T-1)
      EAC(T)=(EA(T)-EA(T-1))/EA(T-1)
      PSC(T)=(PS(T)-PS(T-1))/PS(T-1)
      LSC(T)=(LS(T)-LS(T-1))/LS(T-1)
      ISC(T)=(IS(T)-IS(T-1))/IS(T-1)
      FSC(T)=(FS(T)-FS(T-1))/FS(T-1)
      ASC(T)=(AS(T)-AS(T-1))/AS(T-1)
      RSC(T)=(RS(T)-RS(T-1))/RS(T-1)
      CSC(T)=(CS(T)-CS(T-1))/CS(T-1)
      ESC(T)=(ES(T)-ES(T-1))/ES(T-1)
      PMC(T)=(PM(T)-PM(T-1))/PM(T-1)
      LMC(T)=(LM(T)-LM(T-1))/LM(T-1)
      IMC(T)=(IM(T)-IM(T-1))/IM(T-1)
      FMC(T)=(FM(T)-FM(T-1))/FM(T-1)
      AMC(T)=(AM(T)-AM(T-1))/AM(T-1)
      RMC(T)=(RM(T)-RM(T-1))/RM(T-1)
      CMC(T)=(CM(T)-CM(T-1))/CM(T-1)
66    EMC(T)=(EM(T)-EM(T-1))/EM(T-1)
```

```
C     Compute balance of payments effect

      DO 55 T=2,5
      DPMT(T)=PM(T-1)*PMC(T)-PM(T-1)*.03
      DCMT(T)=CM(T-1)*CMC(T)-CM(T-1)*.03
      DEMT(T)=EM(T-1)*EMC(T)-EM(T-1)*.03
      BMBENE(T)=DPMT(T)*4.02
      BMCOST(T)=(DCMT(T)+DEMT(T))/2/7
      BMNET(T)=BMBENE(T)-BMCOST(T)
      DPFT(T)=PF(T-1)*PFC(T)-PF(T-1)*.03
      DCFT(T)=CF(T-1)*CFC(T)-CF(T-1)*.03
      DEFT(T)=EF(T-1)*EFC(T)-EF(T-1)*.03
      BFBENE(T)=DPFT(T)*16.57
      BFCOST(T)=(DCFT(T)+DEFT(T))/2/7
      BFNET(T)=BFBENE(T)-BFCOST(T)
      DPST(T)=PS(T-1)*PSC(T)-PS(T-1)*.03
      DCST(T)=CS(T-1)*CSC(T)-CS(T-1)*.03
      DEST(T)=ES(T-1)*ESC(T)-ES(T-1)*.03
      BSBENE(T)=DPST(T)*3.62
      BSCOST(T)=(DCST(T)+DEST(T))/2/7
      BSNET(T)=BSBENE(T)-BSCOST(T)
      DPAT(T)=PA(T-1)*PAC(T)-PA(T-1)*.03
      DCAT(T)=CA(T-1)*CAC(T)-CA(T-1)*.03
      DEAT(T)=EA(T-1)*EAC(t)-EA(T-1)*.03
      BEBENE(T)=DPAT(T)*6.80
      BACOST(T)=(DCAT(T)+DEAT(T))/2/7
 55   BANET(T)=BABENE(T)-BACOST(T)

C     Print statements

      WRITE(6,90)
      DO 88 T=1,5
```

```
235   88   WRITE(6,89) T,PM(T),PMC(T),LM(T),LMC(T),IM(T),IMC(T),FM(T),FMC(T),
          1AM(T),AMC(T),RM(T),RMC(T),CM(T),CMC(T),EM(T),EMC(T)
236        DO 44 T=2,5
237   44   WRITE(6,91) T,DPMT(T),BMBENE(T),DCMT(T),DEMT(T),BMCOST(T),BMNET(T)
238        WRITE(6,90)
239        DO 87 T=1,5
240   87   WRITE(6,89)  T,PF(T),PFC(T),LF(T),LFC(T),IF(T),IFC(T),FF(T),FFC(T)
          1,AF(T),AFC(T),RF(T),RFC(T),CF(T),CFC(T),EF(T),EFC(T)
241        DO 45 T=2,5
242   45   WRITE(6,91) T,DPFT(T),BFBENE(T),DCFT(T),DEFT(T),BFCOST(T),BFNET(T)
243        WRITE(6,90)
244        DO 86 T=1,5
245   86   WRITE(6,89)  T,PS(T),PSC(T),LS(T),LSC(T),IS(T),ISC(T),FS(T),FSC(T)
          1,AS(T),ASC(T),RS(T),RSC(T),CS(T),CSC(T),ES(T),ESC(T)
246        DO 46 T=2,5
247   46   WRITE(6,91) T,DPST(T),BSBENE(T),DCST(T),DEST(T),BSCOST(T),BSNET(T)
248        WRITE(6,90)
249        DO 85 T=1,5
250   85   WRITE(6,89)  T,PA(T),PAC(T),LA(T),LAC(T),IA(T),IAC(T),FA(T),FAC(T)
          1,AA(T),AAC(T),RA(T),RAC(T),CA(T),CAC(T),EA(T),EAC(T)
251        DO 47 T=2,5
252   47   WRITE(6,91) T,DPAT(T),BABENE(T),DCAT(T),DEAT(T),BACOST(T),BANET(T)
253   91   FORMAT('0',12,6F16.2)
254   90   FORMAT('1')
255    89  FORMAT('0',I1,F9.0,F6.3,F9.0,F6.3, F10.0,F6,3,F10.0,F6.3,F10.0,
          1F6.3,F11.0,F6.3,F10.0,F6.3,F9.0,F6.3)
256        STOP
257        END
```

---

[1] a) In order to hold technology constant change statement 173 to read GOTO (10,10,10,10,10,99),T

b) In order to hold area constant remove statement 169 to 172

c) In order to compute value for 1975 prices remove continuations from statements 116-199, 123-127, 131-135, and 139-143

DEFINITION OF VARIABLES USED IN THE COMPUTER PROGRAM

MZTOMA = Total area in 6 major regions in Corn Production

MZTOSO = Total area in 6 major regions in Sorghum Production

MSTOFR = Total area in 6 major regions in Bean Production

MZTOAR = Total area in 6 major regions in Rice Production

MA1, (MA2, MA3, MA4) = Area in Manzanas in Corn Production under respective levels of technology

FRI, (FR2, FR3, FR4) = Area in Manzanas in Bean Production under respective levels of technology

SO1, (SO2, SO3, SO4) = Area in Manzanas in Sorghum Production under respective levels of technology

AR1, (AR2, AR3, AR4) = Area in Manzanas in Rice Production under respective levels of technology

CONSM(T) = Annual Domestic Consumption of Corn

CONSF(T) = Annual Domestic Consumption of Beans

CONSS(T) = Annual Domestic Consumption of Sorghum

PM(T)* = Total Production of Corn in Given Time Period

LM(T) = Total Manyears of Labur Utilized in Corn Production

TM(T) = Total Net Benefit of all Corn Farms

FM(T) = Return to Small Corn Farmers (Small Farmers' Income)

RM(T) = Net Returns to Small Farmers and Rural Laborers (Rural Income)

CM(T) = Total Cost of Chemicals (Fertilizer, Insecticide, Herbicide, etc.) for Corn Production

EM(T) = Total Cost of Energy (Electric, Fuel, Repairs, and Depreciation) for Corn Production

PMC(T) = Percent Change in Corn Production

LMC(T) = Percent Change in Labor in Corn Production

IMC(T) = Percent Change in Net Benefit from Corn Production

FMC(T) = Percent Change in Small Farmers' Income from Corn Production

RMC(T) = Percent Change in Rural Income from Corn Production

CMC(T) = Percent Change in Chemical Cost from Corn Production

EMC(T) = Percent Change in Energy Cost from Corn Production

APM = Adjusted Production of Corn (Production of Corn in the Central and Pacific Regions adjusted for differences between UNASEC data and Central Bank data; and estimated production in Caribbean Region)

CPMNET = The difference between Consumption and Production in each year

CREDM = Credit requirement in Cordobas to finance changes in technology

DPMT = Change in Corn Production due to change in technology

DCMT = Change in Chemical Cost for Corn due to change in technology

DFMT = Change in Energy Cost for Corn due to change in technology

BMBENE = Foreign Exchange Benefit due to change in technology ($Value of added Production)

BMCOST = Foreign Exchange Cost due to change in technology

BMNET = Foreign Exchange Benefit - Foreign Exchange Cost

t = TIME PERIOD (1-5)

*The underlined letter denotes the particular crop
M is used to denote Corn (Maiz)
F is substituted to denote Beans (Frivoles)
S is substituted to denote Sorghum
A is substituted to denote Rice (Arroz)
(e.g., PM = Production of Corn, PS = Production of Sorghum, etc.)

APPENDIX B

ADJUSTED PRODUCTION ESTIMATES TO ACCOUNT FOR THE CARIBBEAN REGION AND DISCREPANCIES BETWEEN PROJECTIONS BASED ON UNASEC DATA AND NICARAGUA CENTRAL BANK DATA

TABLE B.1

ADJUSTED CORN PRODUCTION PROJECTION OF THE MODEL FOR FIVE YEARS

	TOTAL CHANGE IN PRODUCTION IN 1000 CWT DUE TO:		
Year	Change in Area only	Change in Tech only	Change in Area and Technology
1	4620.0	4620.0	4620.0
2	4758.5	4860.5	5006.3
3	4901.2	5101.2	5471.8
4	5048.3	5341.8	5837.1
5	5199.7	5582.4	6283.0

TABLE B.2

ADJUSTED BEAN PRODUCTION PROJECTION OF THE MODEL FOR FIVE YEARS

	TOTAL CHANGE IN PRODUCTION IN 1000 CWT DUE TO:		
Year	Change in Area only	Change in Tech only	Change in Area and Technology
1	986.3	986.3	986.3
2	1015.9	1013.6	1044.0
3	1046.3	1040.9	1104.3
4	1077.7	1068.2	1167.2
5	1110.1	1095.5	1233.0

TABLE B.3

ADJUSTED GRAIN SORGHUM PRODUCTION PROJECTION OF THE MODEL FOR FIVE YEARS

	TOTAL CHANGE IN PRODUCTION IN 1000 CWT DUE TO:		
Year	Change in Area only	Change in Tech only	Change in Area and Technology
1	1233.3	1233.3	1233.3
2	1270.3	1291.2	1330.0
3	1308.4	1349.2	1432.4
4	1347.6	1407.2	1537.7
5	1388.0	1465.2	1649.1