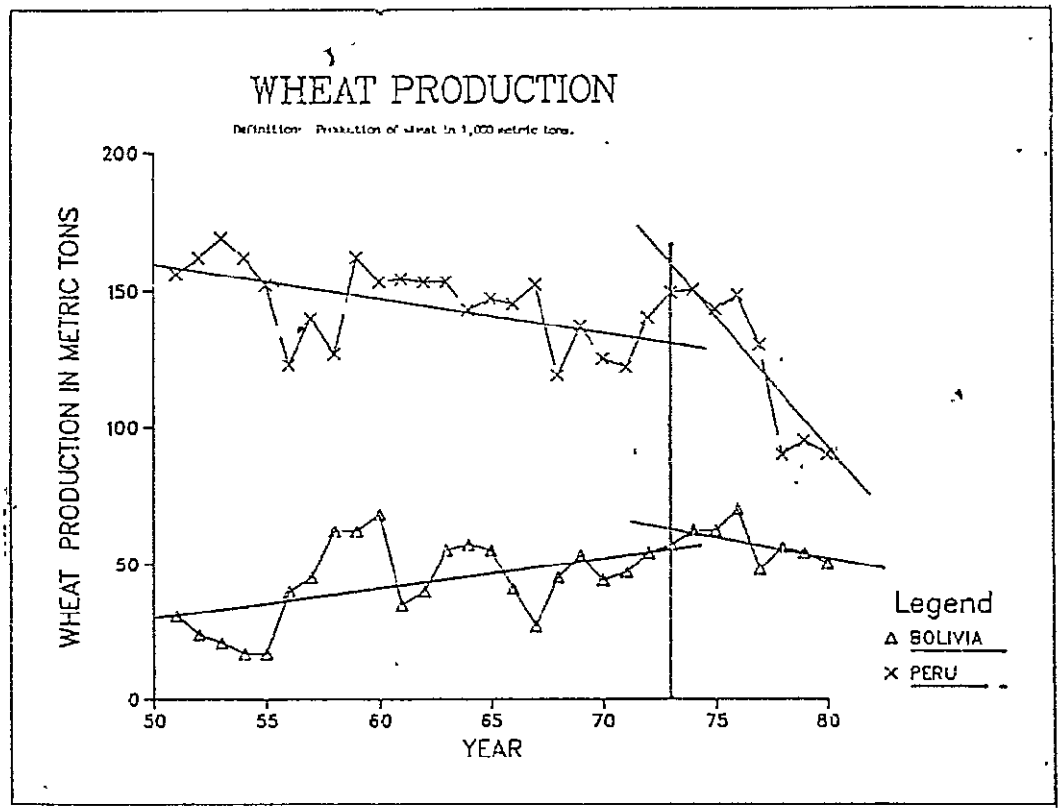
THE FEASIBILITY OF USING TIME SERIES DATA ANALYSES FOR THE EVALUATION OF A.I.D. AGRICULTURAL PRODUCTION PROJECTS



BY

KARL R. WHITE

DAVID W. BUSH

CIE TAYLOR

UTAH STATE UNIVERSITY

DECEMBER 1982

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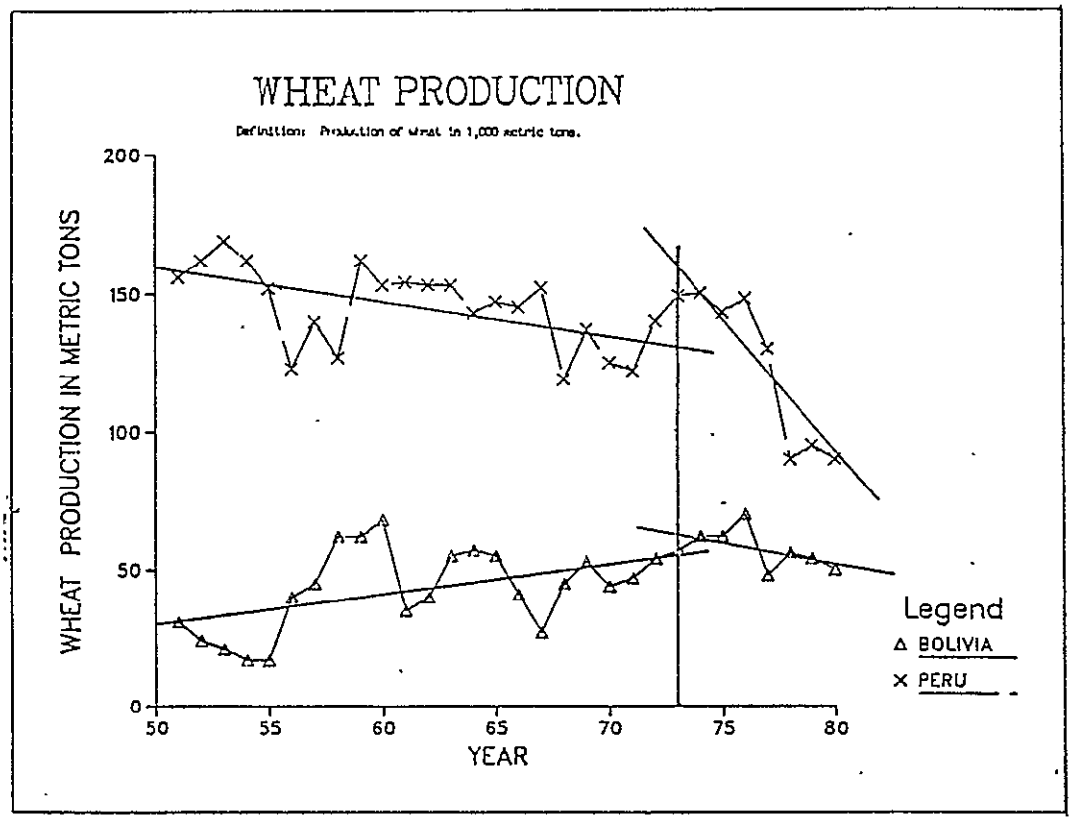

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EVALUATING THE IMPACT OF AID PROJECTS AIMED AT INCREASING FOOD YIELD

Abstract

This report summarizes the results of a time series analysis to evaluate the impact of the Bolivian Cereals Development Project. The study reported here was initiated because of a request by AID to use meta-analysis techniques to integrate the findings from various food yield projects funded by AID. However, preliminary work indicated that the available data from AID evaluation reports on food yield projects did not contain enough outcome data for a good meta-analysis. An alternative evaluation strategy (time series analysis using data from the Economic and Social Data Systems data base) was suggested as a means of gathering data about project impact. If it could be demonstrated that such an evaluation strategy yields useful outcome data, projects could use this strategy to collect outcome data, which over time would solve the problem which prevented a meta-analysis on existing projects.

A test of using the time series analysis strategy was conducted using the Bolivian Cereals Development Project. Data collected for Bolivia and a comparison country (Peru) suggested that the Bolivian Cereals Development Project had little, if any, impact on the production of wheat or other food yield associated variables. Alternative explanations for the pattern of data found were examined, and further analyses are suggested. It was concluded that a time series analysis evaluation strategy utilizing ESDS data is a viable and valuable technique which should be used more often with AID projects.

Rationale for Study

Each year the Agency for International Development (AID) spends hundreds of millions of dollars focused on increasing the food yield of developing countries. Each of the dozens and dozens of projects which are funded is required to do an evaluation of the effectiveness of their project. Unfortunately, the findings from each of these individual project evaluations have never been effectively summarized. One of the recommendations of the Agency's 1980 Evaluation Task Force was that the Agency find better ways of synthesizing the information provided by its individual project evaluations. The original purpose of this project was to use recently developed techniques referred to as "meta-analysis" to summarize and integrate the evaluation findings from approximately 160 projects which had focused primarily on increasing food yield.

Definition of Meta-Analysis

Briefly summarized, the meta-analytical approach requires the identification of a representative sample of evaluation studies on a given topic, converting the results or outcomes of the studies to a common metric, coding the various characteristics of studies that might have affected the results, and then using correlational and descriptive statistical techniques (both univariate and multivariate) to summarize study outcomes and to examine the covariation of study characteristics with outcome.

In the case of AID projects which have focused on increasing food yield, it was thought that most project evaluations would report the differences in yield between pre-project time periods and post-project time periods for the particular crop on which the project focused. For example, consider two hypothetical projects in different countries. Project A focuses on increasing wheat production in Country A located in South America. Project B focuses on increasing rice production in Country B in Africa. Suppose that in Country A, the average amount of wheat produced annually in the five years prior to the project was 100,000 metric tons. In the five years immediately following the project, the average amount of wheat produced annually was 125,000 metric tons. In this case, there was a 25% increase in yield associated with the project. In Country B, suppose that the average amount of rice produced annually in the country in the five years prior to the project was 40,000 metric tons, and in the five years after the project, the average amount of rice produced annually was 50,000 metric tons. Again, there was a 25% yield increase associated with the project. Even though the two projects were focusing on different crops, in different parts of the countries, and producing at different levels, both resulted in the same outcome, i.e., a 25% increase in yield.

If data such as these were available from a large subset of the 160 projects originally identified for the AID meta-analysis, then meta-analysis

techniques could be used to examine not only the average outcome of projects in terms of food yield, but also to examine whether various project characteristics covaried with or were associated with particular levels of outcome. For example, suppose 100 projects reported yield data as a part of their evaluation. Further suppose that 30 of these projects focused on increasing yield through better distribution of seed and fertilizer, 30 focused on the development and implementation of better crop varieties, and 40 focused on improved irrigation and farming methods. Results might show a 28% yield increase with "distribution of seed and fertilizer" projects, 7% increase with "improved crop variety" projects, and an 11% increase with "improved irrigation and farming methods" projects. These differences could be further stratified by type of crop (e.g., wheat, corn, sorghum, etc.), level of funding, region of the world, or numerous other variables. The results would provide AID decision makers with information about what type of projects are likely to be most successful in meeting the objective of increased food yield.

Obviously, these examples are overly simplistic, but the strategy of meta-analysis is portrayed. Meta-analysis attempts to convert outcomes of studies to a common metric (for AID agricultural production projects, percentage increase in yield) and then examines how those outcomes covary with various study characteristics. Data on outcome can be used from pre-post kinds of studies or from comparison types of studies, and study characteristics used to examine covariation with outcomes can include indices about the quality of the evaluation data as well as characteristics which describe the nature of the intervention.

Since its introduction in 1976, the techniques of meta-analysis have been used successfully with hundreds of topical areas and have been effective in making sense of and summarizing literature which previously was very confusing.

Given this successful track record, it seemed worthwhile to consider the application of meta-analytical techniques to AID's objective of achieving better synthesis from their individually conducted project evaluations.

Inadequacy of AID Evaluation Report Data to Support a Meta-Analysis

Unfortunately, upon closer examination, it became apparent that the data typically and, in fact, almost always collected in AID evaluation reports would not support a meta-analysis. The primary problem was that objective quantifiable outcome data were almost always lacking from AID evaluation reports. Furthermore, the information contained in project reports and evaluations describing the characteristics of the project was also very sparse. The paucity of objective evaluation data and information describing the project was also noted by Crawford and Barclay (1982) when they attempted to do a review of project evaluations of AID projects which had focused on agricultural research. As noted in their report:

> It was originally hoped the evaluations would provide insight into "activities or groups of activities that lead to project success". Unfortunately, the evaluations were not complete enough to permit this . . . As is shown below, the information obtained from the evaluations is primarily of a monitoring nature and, therefore, not readily applicable to the needs of policy analysis for future project design . . . Evaluations conducted during implementation rarely examined project impact--normally, they confine themselves to monitoring inputs and outputs . . . Unfortunately, it is impossible to make a more objective determination of the project's overall performance using only the data in the [written] evaluations . . . The absence of information on basic project characteristics makes a comparative analysis more difficult. (p. 39)

Recognizing these limitations, Crawford proceeded to attempt to identify those characteristics which were associated with successful projects and unsuccessful projects. To do this, he used the available evaluation documents and categorized each project as to whether it was:

(1) better than satisfactory project performance,

(2) satisfactory project performance, or

(3) less than satisfactory project performance.

In doing this, Crawford was appropriately aware of the limitations of categorizing outcomes in this manner, "the absence of standardized project performance indicators in AID's evaluation system means these ratings are based on subjective interpretations of the 'tone' of the evaluations and the degree of the criticism of the project." However, given the weaknesses of the existing data, there were no other alternatives. If we ignore the weaknesses in the data for the moment, there were some interesting covariates with project success. Among others, Crawford's report showed that projects which were categorized as "successful" according to the above scheme were associated with

(1) the presence of "on farm" testing,

(2) the use of multidisciplinary research teams,

(3) projects where research was adequately designed and implemented,

(4) projects where there were no major delays in construction,

(5) projects where host government support for the project was specifically noted, and

(6) projects where the participant training program was successful.

However, Crawford pointed out that conclusions based on these data must be viewed very cautiously. Indeed, the available data are so weak that one wonders whether any credence should be placed in the conclusions.

An Alternative Strategy for Collecting Project Outcome Evaluation Data

The approach used in the Crawford report is certainly in the spirit of meta-analysis. However, given our appraisal of the data available in AID agricultural project reports, in addition to the work done by Crawford, it was our conclusion that a true meta-analysis of those projects would not be a wise

expenditure of money. The most important and credible conclusion from Crawford's work (which was supported by our analysis of the data base) was the inadequacy of the outcome data in most AID project evaluations. These inadequacies are partly explained by the problem of doing large-scale evaluations on projects that aim at broad impact which will not result for several years after the project has completed, the lack of qualified people to conduct such evaluations in field-based settings, and the amount of money that such evaluations cost. However, these problems all assume that evaluation must be field based and must engage in new data collection. Based on our examination of the data, there appear to be some evaluation alternatives that should be considered. This report suggests one such alternative evaluation strategy that might be very feasible in conducting project evaluations of projects which have focused on increasing food yield. This evaluation strategy, if successful, would be very economical. If applied to AID agricultural production projects over several years, it could yield the type of data necessary to conduct a high quality meta-analysis or integrative review of food yield projects. In the remainder of this report, the general data evaluation approach is described and that strategy is applied to one such food yield project which was conducted in Bolivia from 1972 through 1976.

Time Series Analysis to Evaluate Project Impact

Although the project evaluation reports for AID projects which have focused on increasing food yield have contained very little information on crop production yields, a great deal of such data exists. One data source is the Economic and Social Data Base maintained by AID's Development Information Utilization Service. In addition to information on crop yield for major crops, a great deal of other information is maintained by the Economic and Social Data Services (ESDS) data bank. ESDS collects no data of their own but acts as a

clearinghouse for relevant data collected by other agencies including the U.S. Department of Agriculture, the International Monetary Fund, the World Bank, and host countries. For example, Figure 1 shows data taken from the ESDS about the level of wheat production in Bolivia in thousands of metric tons for the time period from 1951 through 1980. Other organizations such as the Food and Agricultural Organization of the United Nations and the Organisation for Economic Cooperation and Development also maintain data banks on other variables which are relevant to many of the food yield projects funded by AID. Using data from such data banks in a time series analysis, it may be possible to determine whether a particular project has impacted on food yield.

For example, suppose a project conducted for a one-year time period (1970) in Country A focused on increasing potato yield. If the project were successful, one would expect a time series of data on potato yield in that particular country to look something as what appears in Figure 2. As can be seen, there is a sharp increase in potato yield in 1971, the first year after the project's completion, and this increase continues for as long as data are available. If there were no such increase in potato yield, it would be evidence that the project had not been successful in terms of accomplishing its primary objective regardless of how well the project met its monitoring or enabling objectives such as training farmers, distributing seed, and improving varieties.

To be confident about conclusions that the project had been successful, however, one would also need to examine alternative explanations. For example, if independent of the project the government of Country A offered farmers substantial cash subsidies in 1970 to begin planting potatoes, it may have been the cash subsidies rather than the AID project which resulted in the increase. In addition, if farmers began planting potatoes but stopped planting wheat which, prior to that time had been the country's primary source of food, then

FIGURE 1

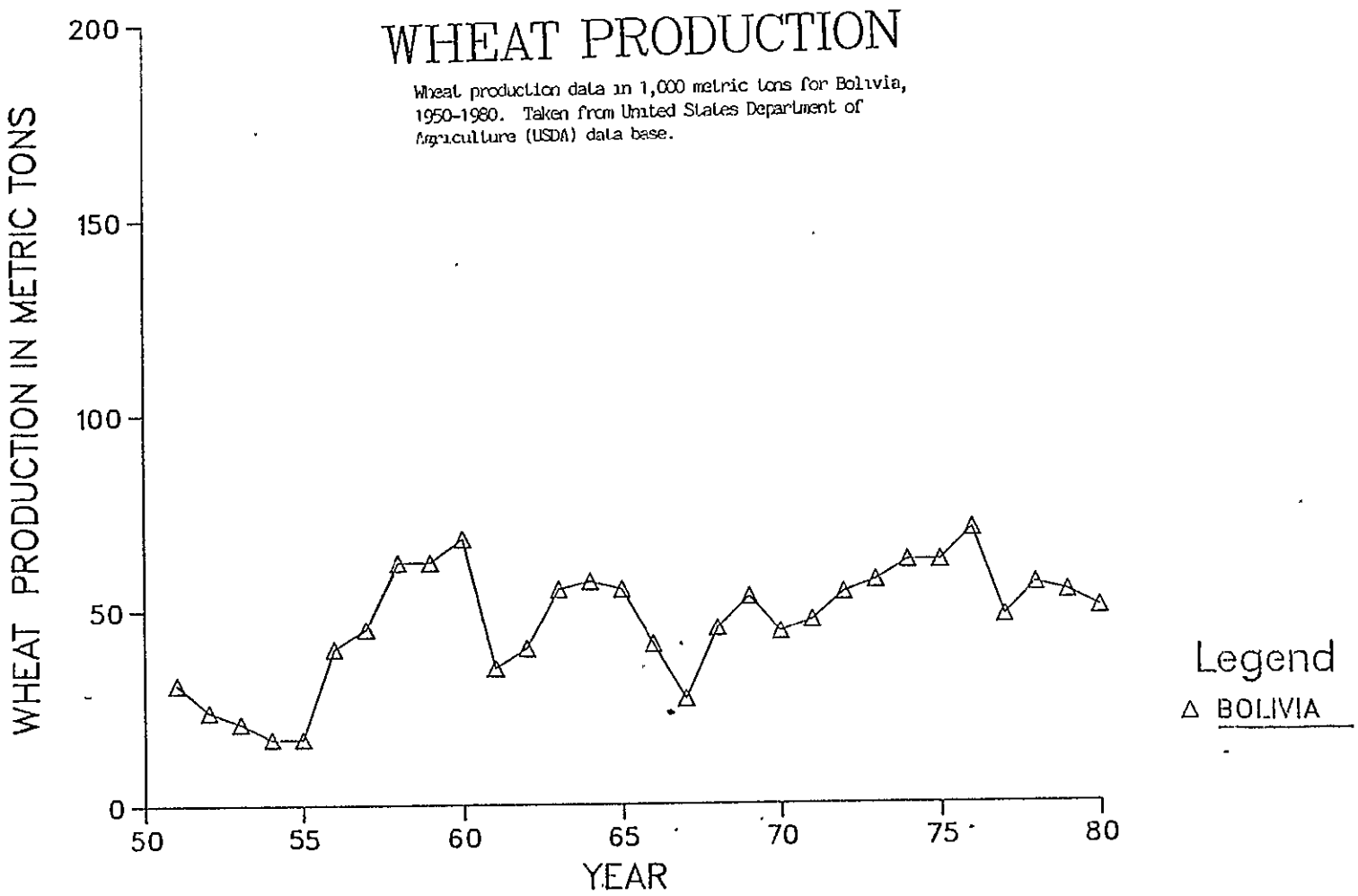
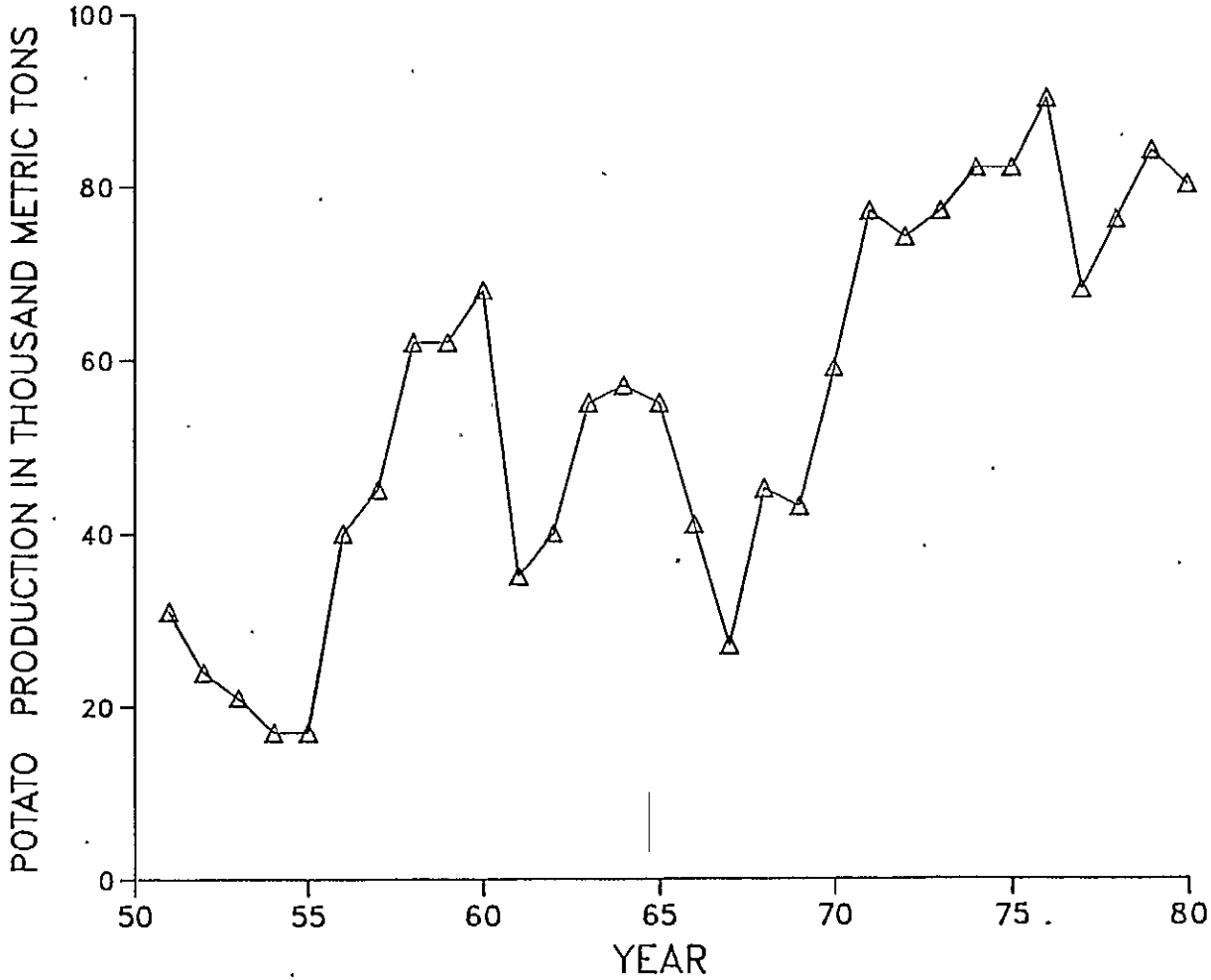

WHEAT PRODUCTION
Wheat production data in 1,000 metric tons for Bolivia, 1950-1980. Taken from United States Department of Agriculture (USDA) data base.
WHEAT PRODUCTION IN METRIC TONS
200
150
100
50
0
50
55
60
65
70
75
80
YEAR
Legend
BOLIVIA

FIGURE 2

HYPOTHETICAL PROJECT DATA FOR POTATO YIELD

Hypothetical data for a project conducted in 1970 to increase potato yield



total food yield in the country may have gone down even though potato yield increased. To do a thorough analysis, factors such as the following would need to be considered.

- average yield of the project targeted food
- average yield of total food
- amount of money expended by the country on agriculture
- amount of financial assistance coming into the country from outside sources for agriculture
- existence of droughts, severe weather conditions, or natural disasters
- political turmoil during the time period of the project
- production levels of other foods that were not targeted by the AID project

In addition to examining factors such as these within the targeted country, the analysis could be supplemented by examining similar variables in a "control" country. Statistical tests could also be computed to the time series data to determine whether changes which appear to occur at or near the time of the project are greater than would be expected by random variation.

Taken together, such analyses would provide valuable information about what impact, if any, AID projects are having on increasing food yield in developing countries. As noted above, if such data were collected for a substantial number of projects, these outcome data could be used in a meta-analysis study to then determine whether certain types of projects result in greater impact than other types of projects. Before a meta-analysis is possible, however, quantifiable outcome data about project impact need to be obtained.

A "Test" Example: Bolivia Cereals Development

To determine if the analysis strategy outlined above was practically as well as theoretically feasible, we conducted a test using a project conducted in Bolivia which focused on increasing wheat production in that country from 1972 through 1976. The procedures and findings of that analysis are described below.

Selecting an Appropriate Project

To identify countries where the time series analysis strategy might be feasible, computer-assisted searches were done using AID's DIS and PBAR data bases. The relation between PBAR and DIS is shown below in Figure 3.

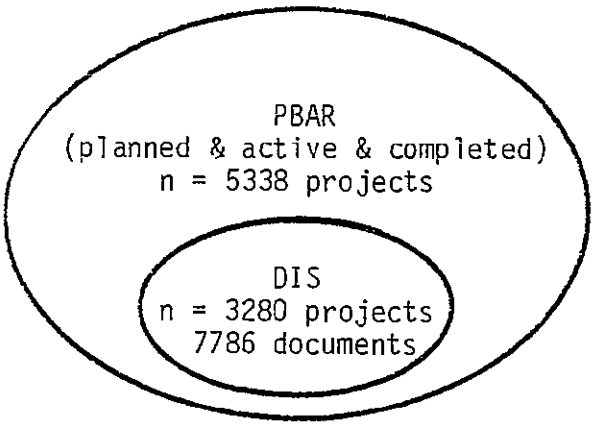


Figure 3. Relation between PBAR and DIS.

The descriptors used in each search and the number of projects identified are shown in Table 1. As can be seen, 944 (17.6%) of all projects listed in AID's PBAR system were coded with the "agriculture" technical code. Information about these 944 projects was examined to determine whether a substantial number of projects existed for which the time series analysis techniques would be appropriate. The following criteria were used to determine appropriateness.

- The project must focus on food production as opposed to improving seed varieties, alternative irrigation systems, etc.

Table 1

Descriptors Used and Results of Searching AID Data Bases for Agricultural Production Projects

Data Base		Descriptors	Yield	Obtained[c]
DIS	1.	GRAIN or FOOD or VEGETABLE PRODUCTION or GRAIN	n = 147[a]	C, T, A
DIS	2.	AGRICULTURAL PRODUCTION but not (1)	n = 259[a]	C, T, A
DIS	3.	AGRICULTURAL PRODUCTION contained as text in PURPOSE statement	n = 43	C
DIS	4.	AGRICULTURAL PRODUCTION contained as text in GOAL statement	n = 43	C
DIS	5.	AGRICULTURAL PRODUCTION contained as text in OUTPUT statement	n = 103	C
DIS	6.	AGRICULTURAL PRODUCTION contained as text in SUMMARY statement	n = 11	C
DIS	7.	AGRICULTUR* contained as text in SUMMARY statement	n = 365	C
DIS	8.	AGRICULTURE contained as text in SUMMARY statement	n = 67	C
PBAR	9.	"000" (AGRICULTURE) as a TECHNICAL code	n = 944[b]	C, T
PBAR	10.	"120" BETTER PRODUCTION METHODS as a PURPOSE code	n = 147	C, T
PBAR	11.	"140" MULTI-ELEMENT FOOD PRODUCTION as a PURPOSE code	n = 93	C, T

[a]These two counts are unduplicated.

[b]This represents a total unduplicated count, although most of projects identified in other searches are included in this count.

[c]C = count of # of projects, T = title and project number of project, A = abstract of project.

- The project should focus on a limited number of major crops.
- Projects should be capable of "saturation impact", i.e., should be fairly large and involve most of the country.
- Projects should take place in a relatively small country which is close to an "appropriate" comparison country.
- Project must focus on a crop which is reported in the USDA and/or FAO data base.
- The project should be of less than six years' duration and should end before 1978.
- Projects funded for larger amounts were preferred.

Using these criteria, 86 projects were identified as possible projects. These 86 projects were then narrowed to 14 projects which are summarized in Table 2. From these 14 projects, project #5110364, Cereals Development, which took place in Bolivia from 1972 through 1976 was selected as a test case for the analysis strategy.

Project Description: Bolivia Cereals Development

The following description of the project has been adapted from the description appearing in the DIS data base.

> Bolivia produces approximately 25% of the wheat it consumes. Consequently, grain must be imported for food and there is a loss of potential income in the rural sector. The purpose of the project was to upgrade agricultural techniques and improve wheat varieties in order to increase domestic production, thus achieving the goal to reduce Bolivian dependence on foreign wheat sources.
>
> The strategies involved a technical advisory team to provide improved wheat varieties for domestic Bolivian production, enhance technical capacity for applied seed, soil, and fertilizer research, and to train extension workers in improved wheat production practices. The project objectives included developing new gene pools for future breeding, adapting wheat varieties for various areas identified, introducing winter wheat, establishing a seed processing plant and seed laboratory, planting improved

Table 2

AID Impact Analysis:
Best Potential Comparisons

ORDER	PROJECT NO.	PROJECT TITLE	COUNTRY	PROJECT DESCRIPTION	CROPS	POSSIBLE COMP. COUNTRY	BEGIN/END	BUDGET	FAO/USDA
1	5110364	Cereals Development	Bolivia	Upgrade agricultural technology and improve wheat varieties to increase domestic production	Wheat	Peru	72/76	10947	X / X
2	3830039	Agricultural Inputs	Sri Lanka	Provide fertilizer to small/ mod. farmers in Sri Lanka to increase rice production	Rice	Bangladesh	75/76	7217	X / X
3	4890703	Rice Production	Korea	Loan to finance rice farmers to increase rice production	Rice	Japan	73/75	24150	X / X
4	6080058	Cereals Production	Morocco	Improve capacity to achieve/ sustain higher production	Wheat	Tunisia	68/76	1603	X / X
5	3860379	Rice Research	India	Establish all-India rice improvement project	Rice	Burma/Thailand	67/73	578	X / X
6	3880015	Agricultural Input II	Bangladesh	Loan to purchase wheat, seed/ fertilizer to increase crop	Wheat	Sri Lanka	75/78	7217	X / X
7	4920259	Small Farmers Income/ Production	Philippines	Increase capacity of government agencies to assist farmers	Rice	Indonesia	75/76	1083	X / X
8	2630027	Rice Research	Egypt	Provide new information to product/process rice	Rice	Ethiopia/Libya	77/81	19900	X / X
9	5270149	Soy/Corn Production	Peru	Establish soybean and corn production in highlands	Soybean Corn	Bolivia	79/81	2249	X / X
10	3060165	Agricultural Credit	Afghanistan	Loan to buy seeds/fertilizer to increase agricultural prod.	Wheat Sugar beets	Pakistan	77/80	5000	X / X
11	5200232	Food Production and Nutrition Improvement	Guatemala	Improve ability to assist in crop production/improve seed	Corn Bean Sorghum	Honduras	75/81	1662	X / X
12	6830201	Cereals Production	Niger	Produce/distribute to feed Niger's population--even bad weather	Cereals	Mali	74/81	16104	X / X
13	6640205	Agricultural Production	Tunisia	Change agricultural production 7.6% per year	All	Morocco	70/70	1616	X / X
14	3910327	Seed Potato Production	Pakistan	Increase supply	Potatoes	Afghanistan	68/77	27	X / X

varieties of wheat, improving in-country milling capacity to meet domestic and imported wheat needs, training of extension agents to teach wheat production practices, and establishment of a soil testing agency to guide fertilization.

During the project, the Bolivian Ministry of Rural Affairs and Agriculture assisted in devising a comprehensive program to increase wheat production. Over 4,000 wheat varieties and lines were tested, a seed processing plant and seed laboratory were established, and new varieties were planted and average yield increased by 30%. Training abroad was provided for 8 technicians and 38 were supported for in-country thesis and research programs; 29 agricultural development courses were conducted (including over 1,100 students), and 32 extension workers were trained. In-country milling capacity was increased and markets were found for mill by-products.

Description of Target and Comparison Countries

To better estimate the impact of the Bolivian Cereals Development project, Peru was chosen as a comparison country and data for both countries were examined. Brief descriptions of each country are given below to establish a context in which the data can be interpreted. A map showing the location of the two countries is shown in Figure 4.

Description of Bolivia: Target Country

Bolivia is a landlocked country in the heart of South America with Brazil to the east, Peru and Chile on the west, and Argentina and Paraguay on the south. More than 80% of the population lives on the plateau which contains the capital city of La Paz. Bolivia contains an area of approximately 424,162 square miles, approximately equal to the size of California and Texas combined. The estimated population in 1980 was 5,580,000 with a per capita income in 1977 of $730.

The chief topographical feature is the great central plateau which covers 65,000 square miles and runs over 500 miles in length. Over 70% of the labor force is in agriculture, the principal products being potatoes, corn, rice, sugar cane, bananas, barley, and maize. The major industries (employing 10% of the population) are in refining petroleum and processing food, tin, textiles, and

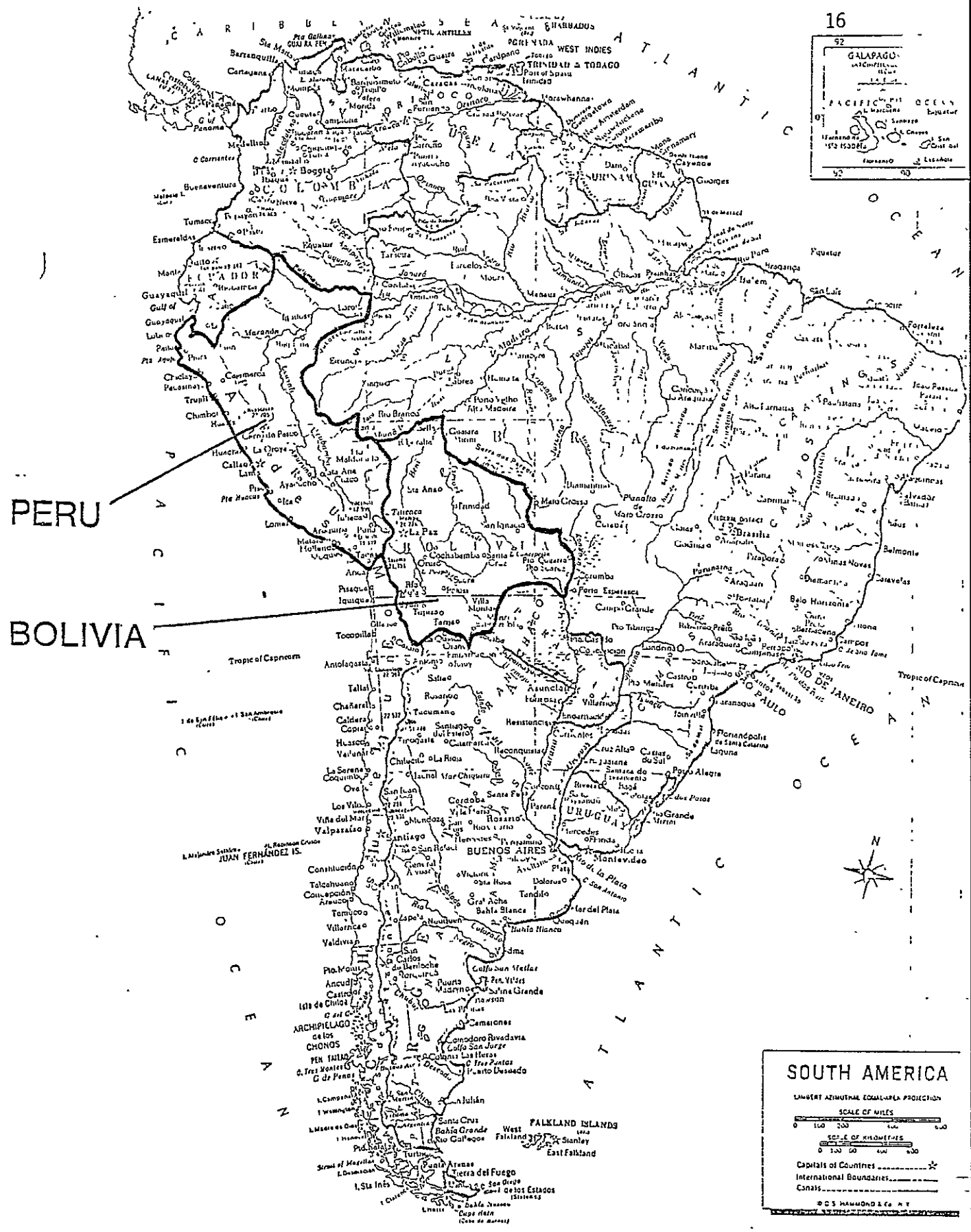


Figure 4. Map showing location of target (Bolivia) and comparison (Peru) countries.

clothing. The major exports are tin, petroleum, natural gas, lead, zinc, silver, and other minerals. The economy has deteriorated since 1977 with lack of petroleum reserves and a large external debt. The position worsened in 1981 when world tin prices remained low. The inflation rate in 1980 was just below 50%.

When General Luis Garcia Meza Tejada seized power on July 17, 1980, it was the 189th coup in Bolivia's 155 years of independence. Since the year 1825, Bolivia has had more than 60 revolutions, 70 Presidents, and 11 constitutions. In 1970, Col. Hugo Banzer Suarez seized the presidency and eliminated all elections, labor unions, and nationalized much of the industry in the country. Due to strikes and public pressure, the first elections in 11 years were authorized in July 1977 by Col. Suarez. However, since that time, a number of coups and countercoups have taken place, and the current president of Bolivia is General Celso Torrelio Villa who took office September 4, 1981.

Description of Peru: Comparison Country

Peru, the third largest country in South America, lies on the western coastline of the Pacific Ocean with Colombia and Ecuador to the north, Brazil and Bolivia to the east, and Chile to the south. Peru is divided by the Andes Mountains into three sharply differentiated zones. To the west is the coastline, much of which is arid, extending 50 to 100 miles inland. The mountain areas, with peaks over 20,000 feet, lofty plateaus, and deep valleys, lies centrally. Beyond the mountains to the east is the heavily forested slope leading to the Amazonian plains. Peru is 15% larger than Bolivia (approximately 496,222 square miles), not quite as large as the state of Alaska. The population in 1980 was approximately 17,770,000 with per capita income in 1977 of $748.

Approximately 43% of the labor force is involved in agriculture, the principal products being corn, sugar, cotton, coffee, and wool. Peru is normally the world's largest exporter of fish meal. However, in 1972 the industry was crippled by the disappearance of anchovies from the offshore waters. In 1974 the anchovies returned, restoring partially the industry to the country. Natural resources include minerals and metals, petroleum and timber, and fish. Major exports are copper, fish products, cotton, sugar, coffee, lead, silver, zinc, and wool.

Peru's government was headed through the 60's by Fernando Belaunde Terry. However, on October 3, 1968, Belaunde was overthrown by Gen. Juan Velasco Alvarado. Over the next six years, Velasco made sweeping changes in the country, nationalizing oil, mining, fish meal, and banking industries as well as establishing cooperatives from the larger private farms. The World Bank granted Peru $470 million in credits in 1973, ending an international financial boycott in which the U.S. had participated. Food shortages, escalating foreign debt, and strikes led to another coup in August, 1976 and a slowdown of socialist programs. Finally, labor protest culminated in a general strike in July, 1977. At that time, major student and leftist demonstrations took place and 50% to 100% increases in prices were ordered in 1978. Finally, after 12 years of military rule, Peru returned to democratic leadership under the former President Terry in July, 1980. Other factors that should be considered besides the major land reform, the political instability, and the major crisis in the fishing industry was a major earthquake which occurred in 1970 killing over 50,000 people.

Data Analysis

Figures 5 through 8 show the time series of data from 1950-1980 from the Economic and Social Data Systems data bank for both Bolivia (the target country) and Peru (the comparison country) for the following variables:

- wheat production in 1,000 metric tons
- barley production in 1,000 metric tons
- corn production in 1,000 metric tons
- rice production in 1,000 metric tons

Each graph is divided into a pre-project period (1950-1972) and a post-project period (1973-1980) by a heavy black line. The data points for each variable have been "fitted" with a "line of best fit" or a "regression line" which shows the mean level of production and the trend in production for each variable in both time periods for each country. If the project were having its hoped for impact, one would expect a substantial shift in level and/or trend (or slope) for wheat in Bolivia, but not for Peru or for the other crops. Shifts in Peru or in the other crops would suggest that some other factors besides the project were affecting crop production. As can be seen in Figures 5-8, wheat dropped slightly in Bolivia, corn and rice decreased slightly or stayed the same, and barley dropped substantially following the initiation of the project. In Peru, there were dramatic drops in wheat, corn, and rice with a fairly sizeable increase in barley production in the years following the project.

It is important to examine not only the average difference in level between the pre- and post-intervention time but also the slope of the line of best fit or regression line. As can be seen in the Bolivian wheat data, total wheat production from 1950 through 1972 was on an increasing trend. The line of best fit from 1973 through 1980 starts out a bit higher but with a reversal trend. This downward trend suggests that the project has not improved the wheat production in Bolivia. The downward trends for the other non-project related crops may indicate that there are other factors contributing to decreased grain productivity. If that is the case, however,

FIGURE 5

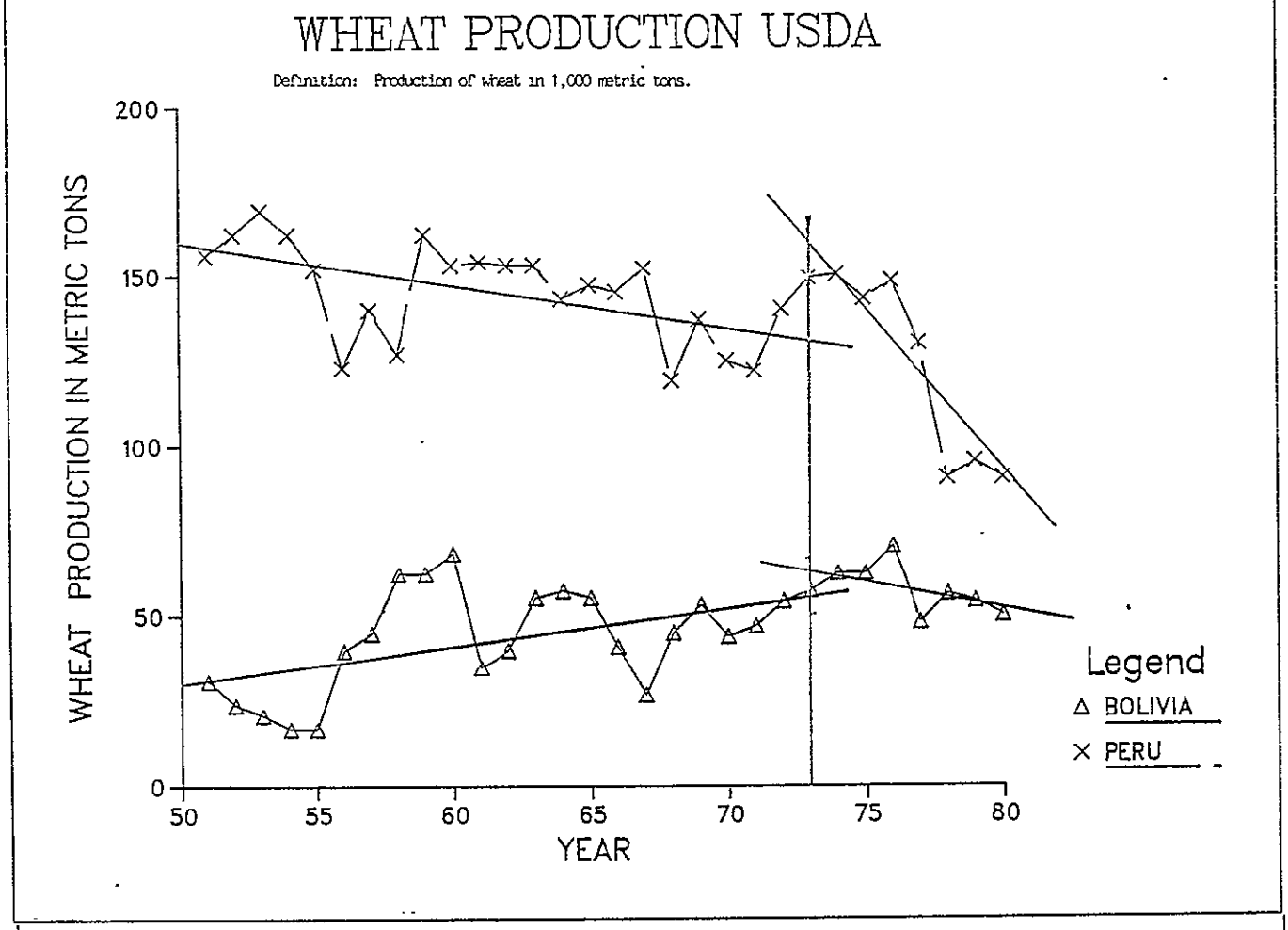


FIGURE 6

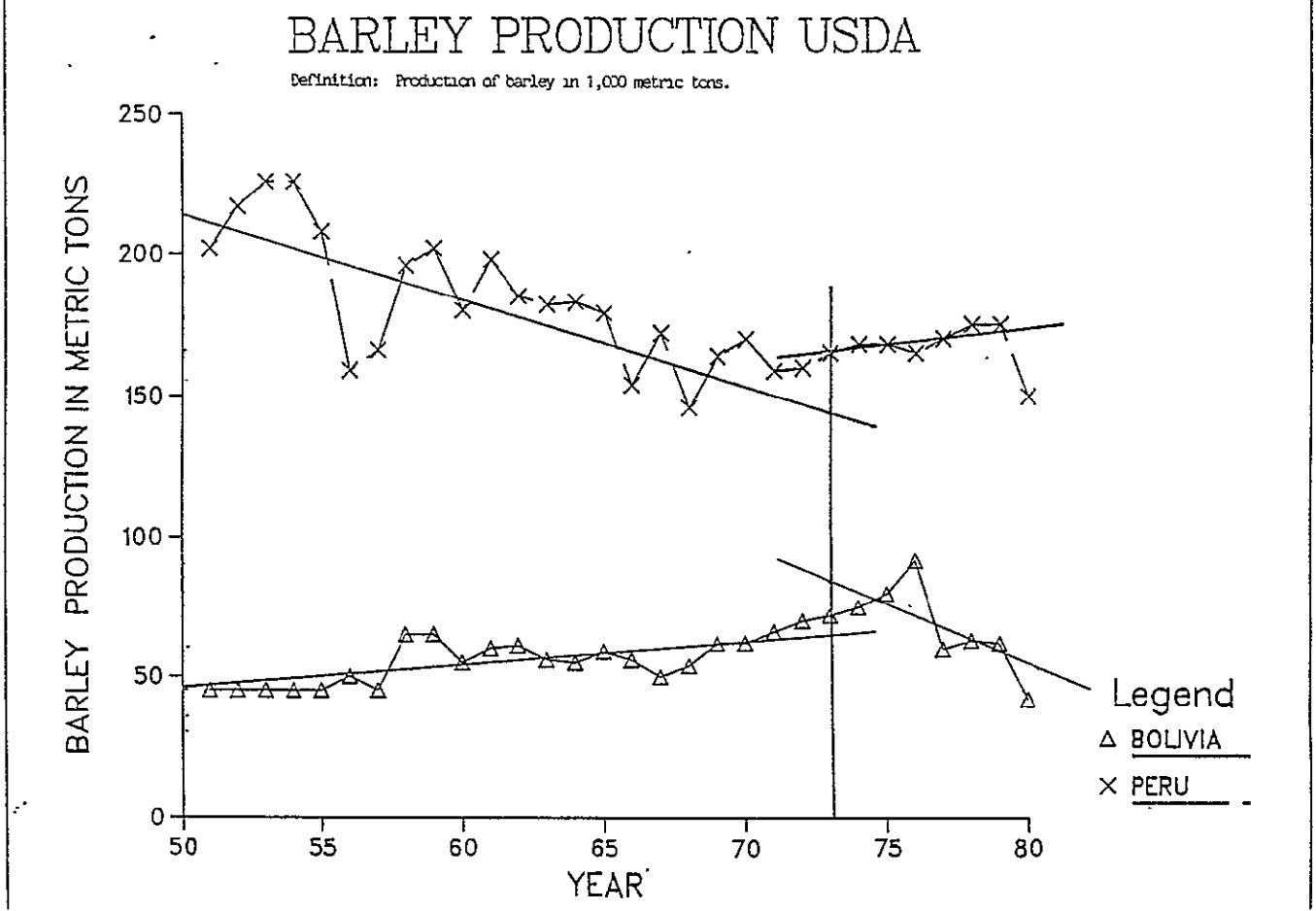


FIGURE 7

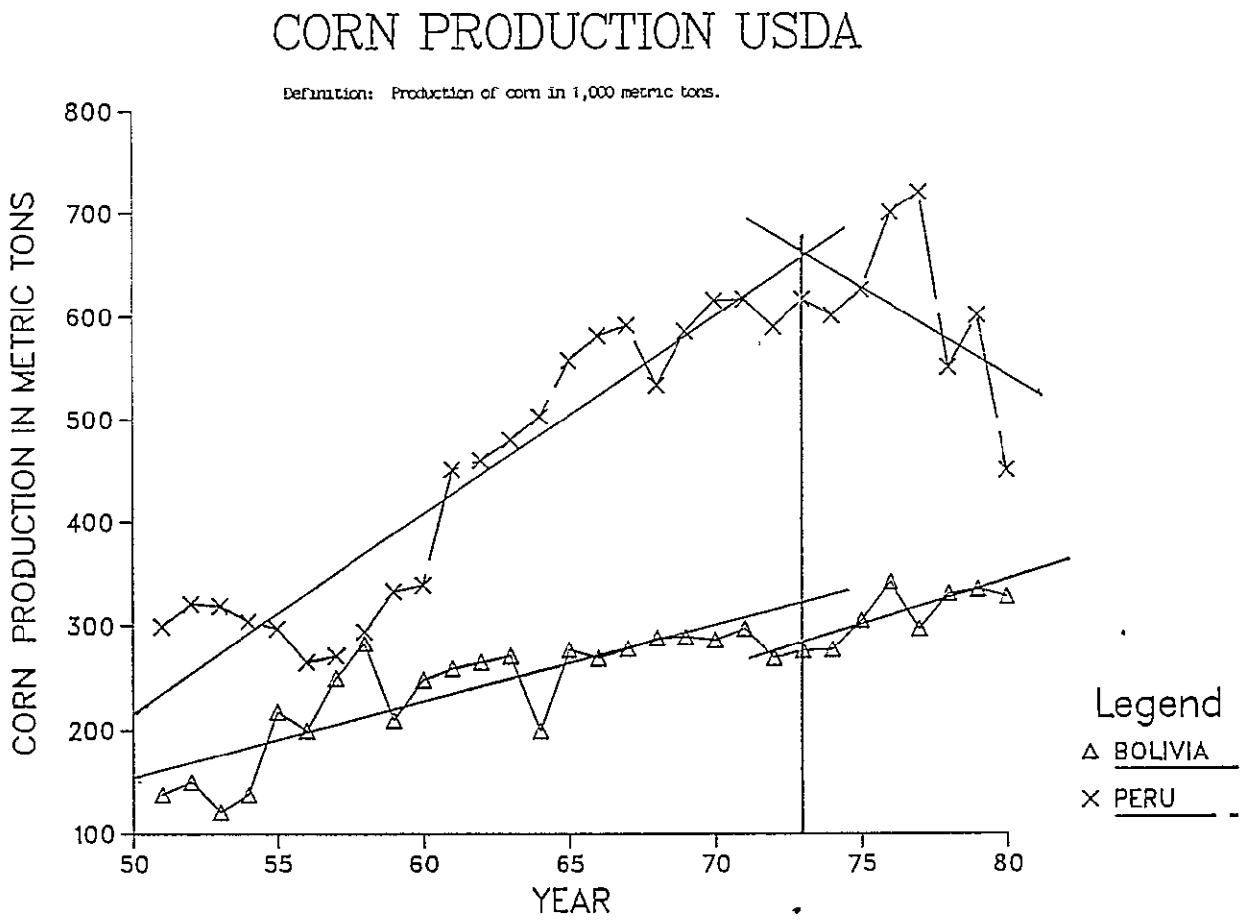
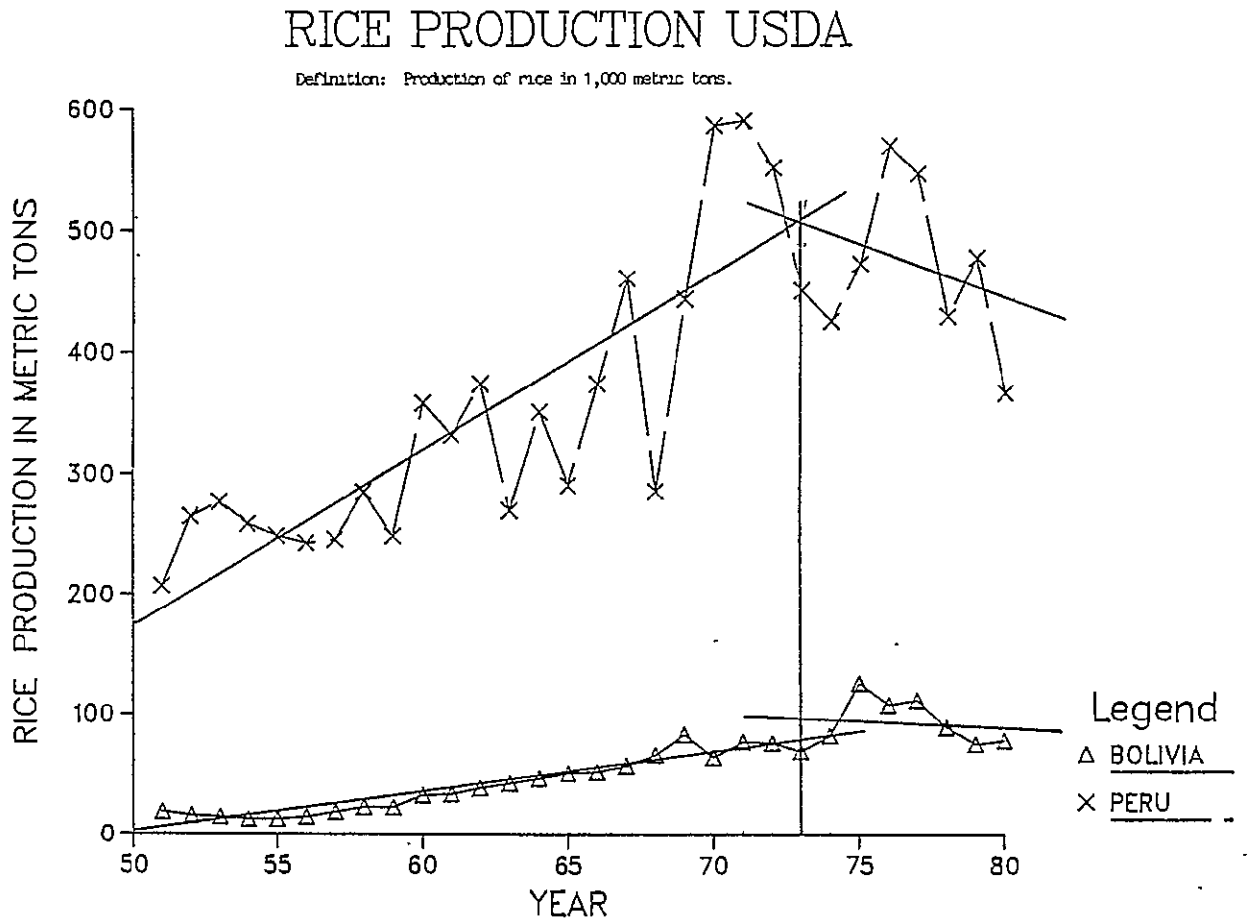


FIGURE 8



the project was not powerful enough to overcome these other factors since the downward slope of wheat is no less severe than for the other crops.

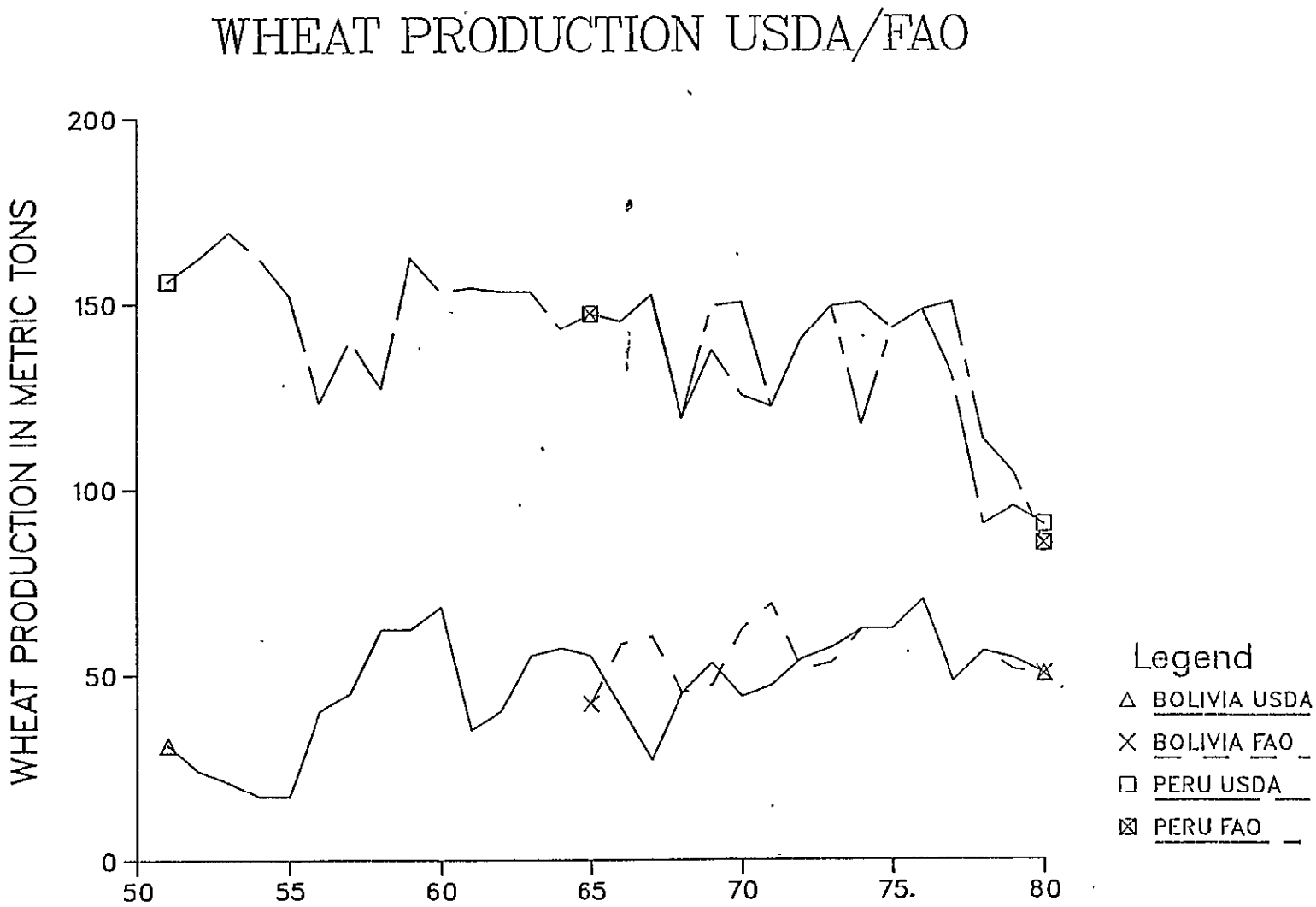
Further information is gained by examining the same crop data for Peru. In Peru, there was a dramatic downward shift in the period from 1973 to 1980 for wheat and somewhat less severe shifts for corn and rice. Because the downward shift in Bolivian wheat was less severe, these data suggest that the project may have lessened the negative impact of whatever is contributing to this dramatic downward shift in Peru.

Data on various crops are also collected by the United Nations Food and Agricultural Organization (FAO). To check the reliability of the ESDS data (which are obtained from the United States Department of Agriculture--USDA), data for wheat production were graphed simultaneously for the two data sources. The results are shown in Figure 9. As can be seen, FAO data were only available since 1965 for wheat. With a few minor exceptions, there were no differences between the two data bases. Consequently, only USDA data were used in the remaining analyses.

Figures 10 through 18 contain time series data for both Bolivia and Peru for other variables that might be affected by the project. Again, lines of best fit are drawn for the periods before 1973, and from 1973 through 1980. Also, as before, it is important to examine both shifts in level as well as shifts in slope or trend of these regression lines. The following variables are included:

- total supply of calories per capita per day
- supply of calories from cereals per capita per day
- supply of calories from vegetable products per capita per day
- total supply of protein per capita per day
- supply of protein from cereals per capita per day

FIGURE 9


WHEAT PRODUCTION USDA/FAO
WHEAT PRODUCTION IN METRIC TONS
200
150
100
50
0
50
55
60
65
70
75.
80
Legend
BOLIVIA USDA
BOLIVIA FAO
PERU USDA
PERU FAO

- supply of protein from vegetable products per capita per day
- index of food production per capita (production level of 1969-1971 = 100)
- index of total agricultural production (production level 1952-1956 = 100)
- infant mortality rate

None of the data contained in these graphs[a] suggests there has been a substantial positive impact from the project. In part, that is understandable because each of the variables are further removed from the project objectives. On the other hand, the data in these graphs do tend to corroborate the evidence from Figures 5-8 suggesting little or no impact. For example, Figure 10 shows substantial increases in the total amount of calories available in Bolivia and a slight decline in Peru. Figures 11 and 12 show that the amount of calories available from cereal products increases dramatically in Bolivia as does the amount of calories available from vegetable products. The fact that available calories from both cereals and vegetable products (which were not targeted by the project) increased similarly suggests that this increase may not have been due to the project.

As shown in Figures 13-15, the total amount of protein available and protein available from cereals and vegetables in Bolivia all increase substantially. However, the protein available from cereals represents less than 2% of the total amount of protein available to Bolivians. Also, the simultaneous increase of protein from vegetables at almost exactly the same rate suggests a cause other than the project. It is also interesting to note that per capita supplies of both protein and calories are substantially higher for Peru than for Bolivia (although Peruvian supplies are trending downward).

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[a]It is important to note that graphs in Figures 10-17 are based on far fewer data points (12 or 13 points as compared to 30 or more in most earlier graphs). Hence, the stability of these graphs is much less well established.

FIGURE 10

TOTAL CALORIES

Definition: Energy equivalent of net food supplies available in country per capita per day in terms of calories at the retail level and allowing 10% for waste at household level. Available supplies comprise domestic production, imports less exports, and changes in stock. Net supplies exclude animal feed, seeds, quantities used in food processing and losses. (FAO data)

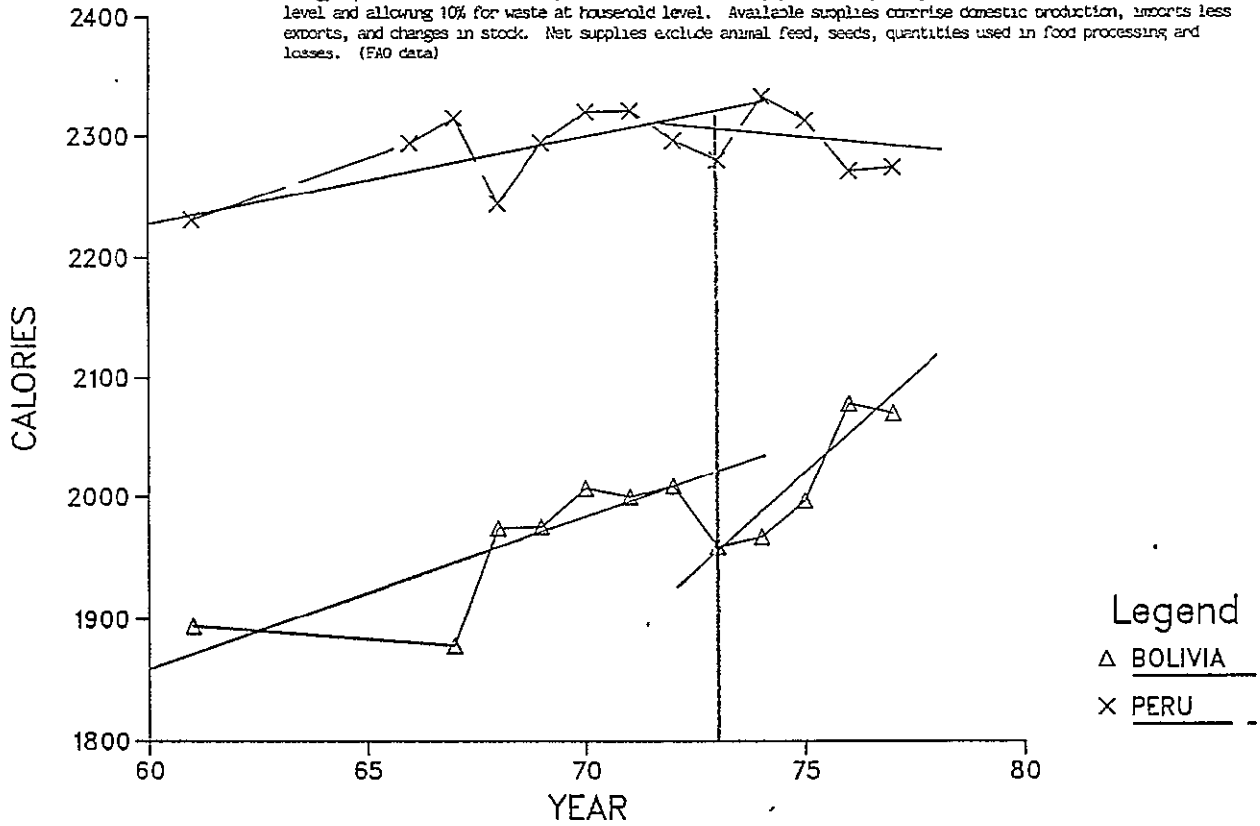


FIGURE 11

SUPPLY OF CALORIES FROM CEREALS

Definition: Energy equivalent of net food supplies from cereals available in country per capita per day in terms of calories at the retail level and allowing 10% for waste at household level. Available supplies comprise domestic production, imports less exports and changes in stock. Net supplies exclude animal feed, seed, quantities used in food processing and losses.

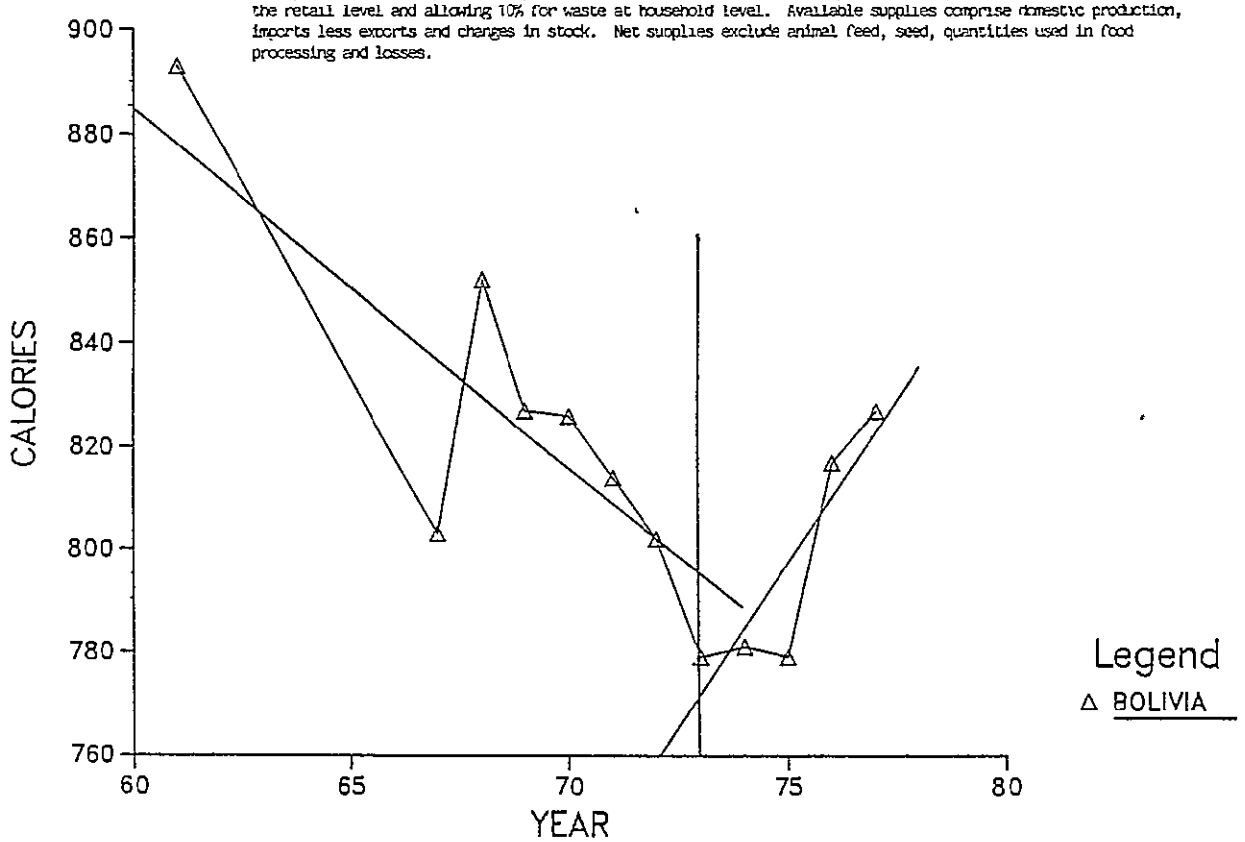


FIGURE 12

SUPPLY OF CALORIE VEGETABLE PRODUCTION

Definition: Energy equivalent of net food supplies from vegetables available in country per capita per day in terms of calories at the retail level and allowing 10% for waste at household level. Available supplies comprise domestic production, imports less exports and changes in stock. Net supplies exclude animal feed, seeds, quantities used in food processing and losses.

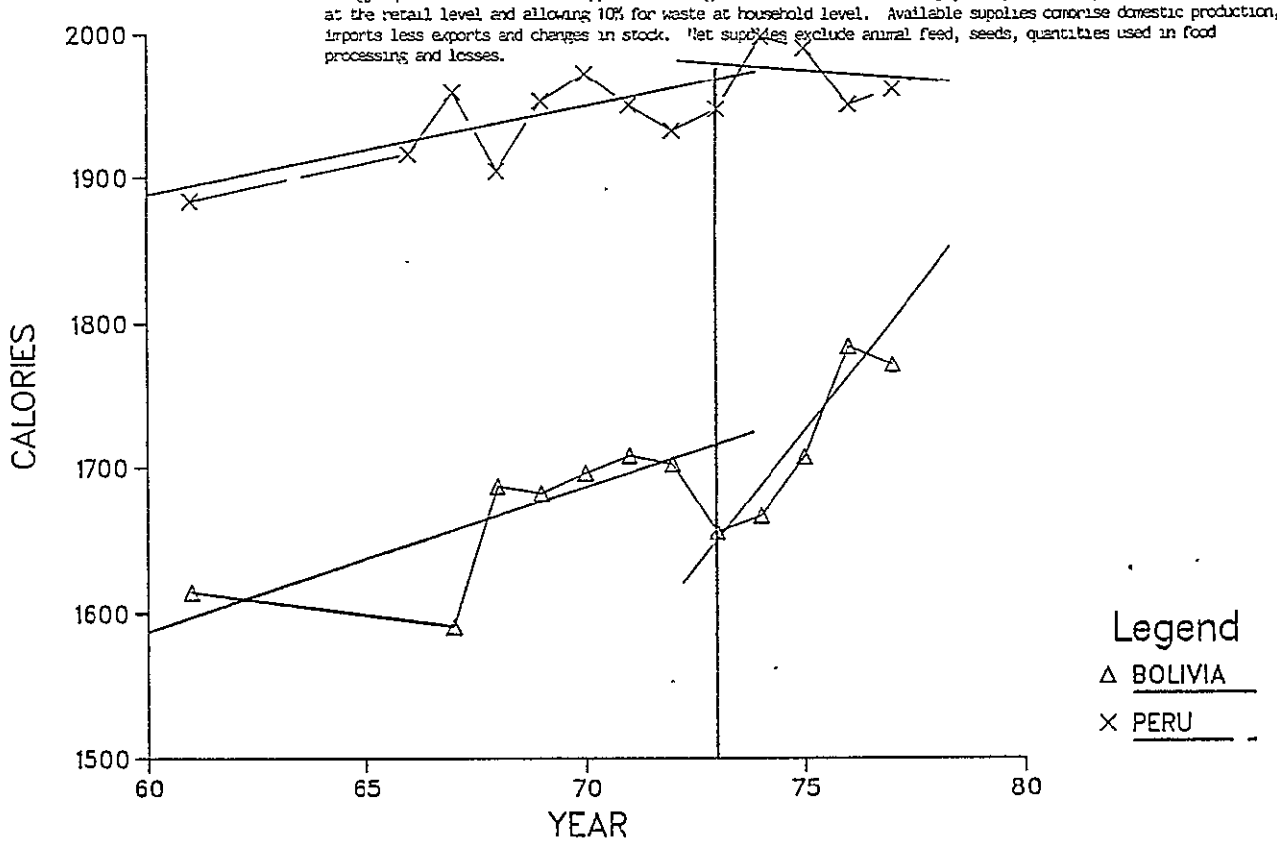


FIGURE 13

TOTAL SUPPLY OF PROTEIN

Definition: Protein content of per capita net supply of food per day. Requirements for all countries est. by USDA provide for minimum allowance of 60 grams of total protein per day and 20 grams of animal and pulse protein of which 10 grams should be animal protein. These standards are lower than the average for the world, proposed by FAO in the Third World food survey.

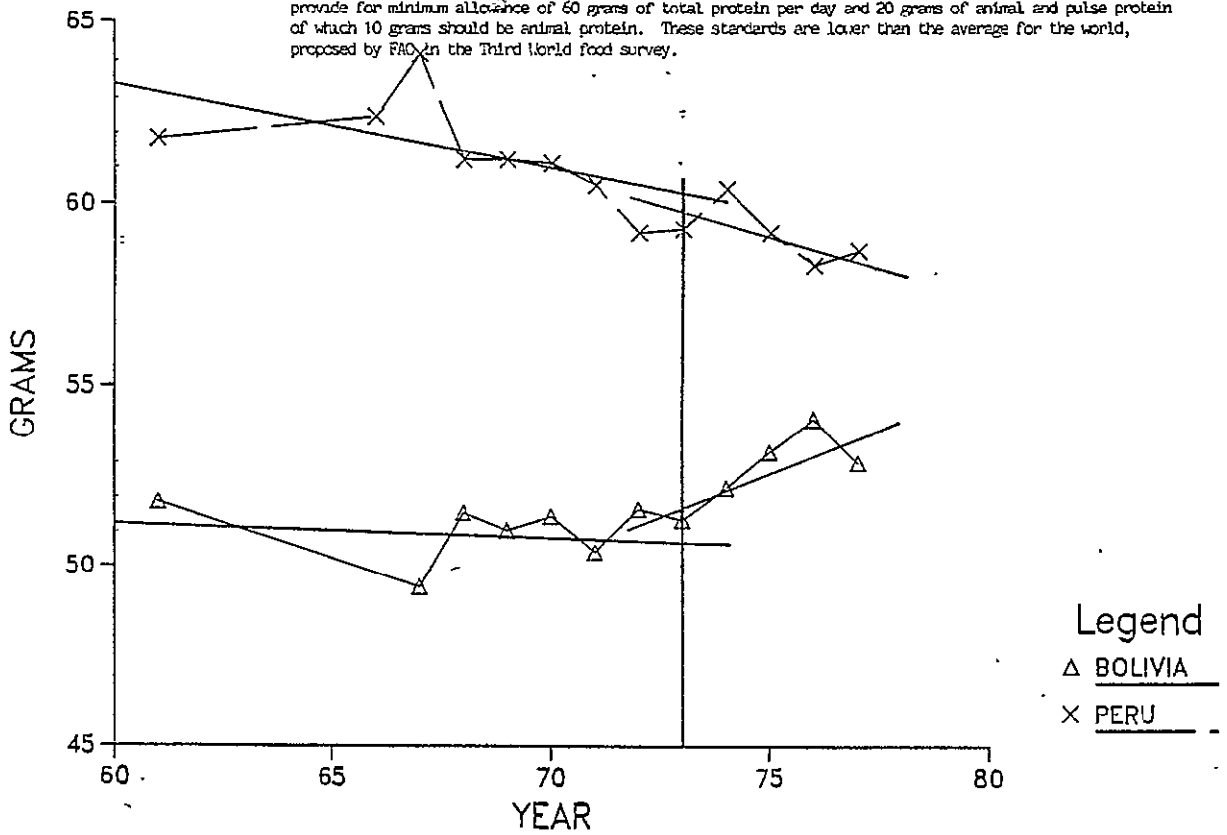


FIGURE 14

SUPPLY OF PROTEIN FROM CEREALS

Definition: Protein content of per capita net supply of food derived from pulses per day. Requirements for all countries est. by USDA provide for minimum allowance of 60 grams of total protein per day and 20 grams of animal and pulse protein, of which 10 grams should be animal protein. These standards are lower than the average for the world

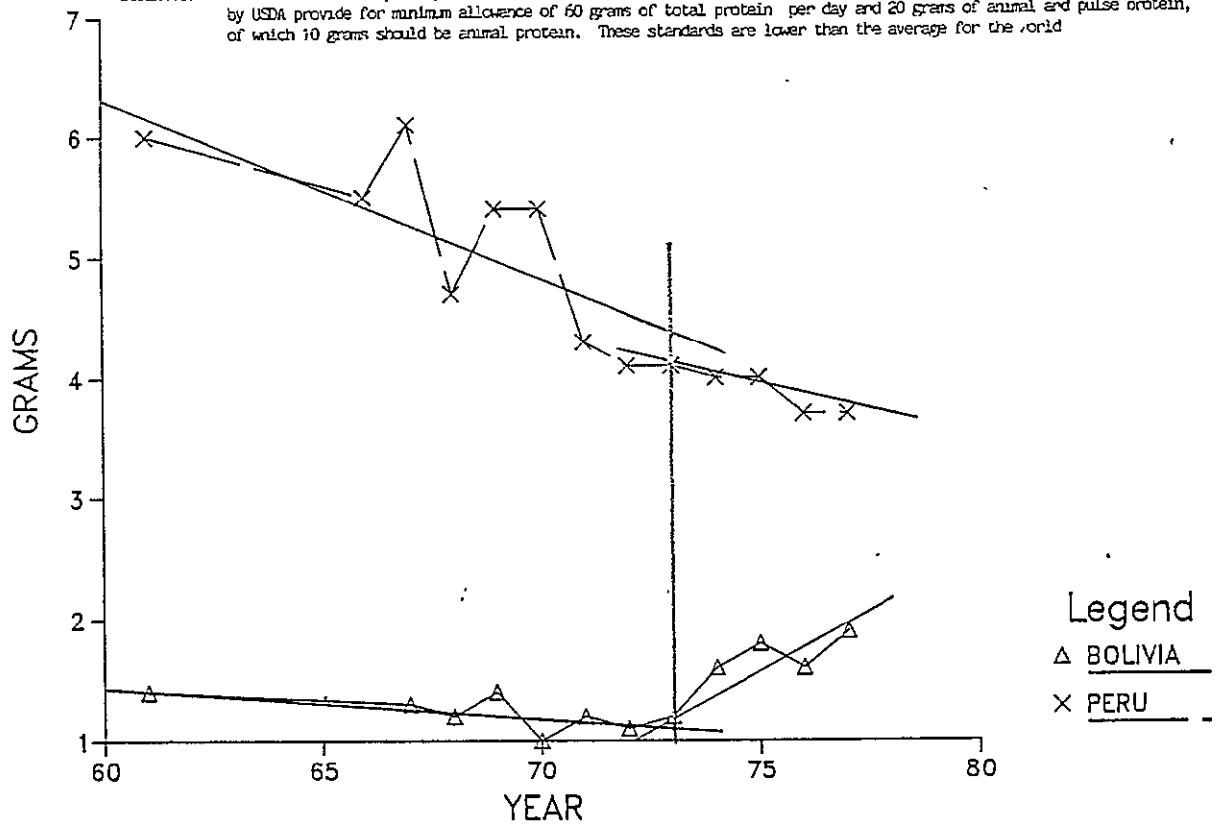


FIGURE 15

SUPPLY OF PROTEIN IN VEGETABLE PRODUCTS

Definition: Protein content of per capita net supply of food derived from vegetables per day. Requirements for all countries est. by USDA provide for minimum allowance of 60 grams of total protein per day and 20 grams of animal and pulse protein, of which 10 grams should be animal protein. These standards are lower than the average for the world.

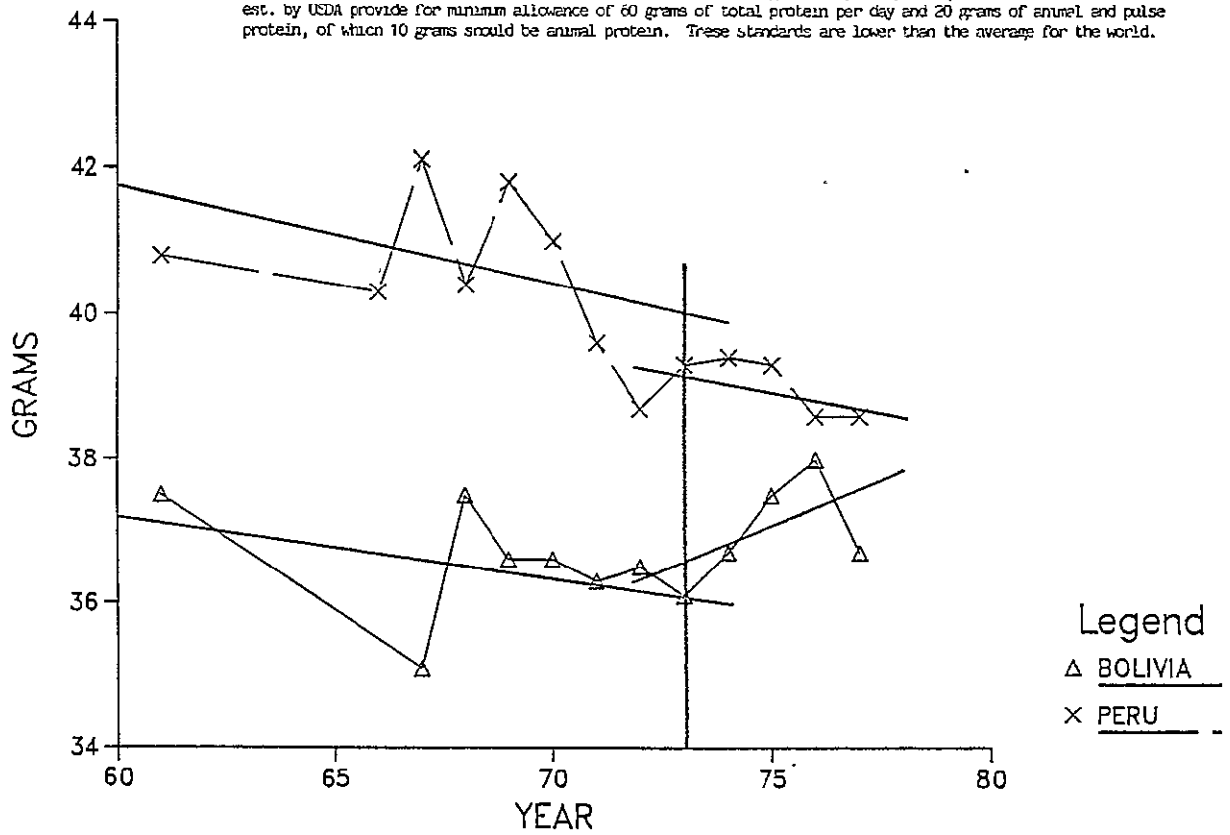


FIGURE 16

INDEX OF FOOD PRODUCTION PER CAPITA

Definition: Per capita annual production of all food commodities. Production excludes seed and feed and is on calendar year basis. Commodities cover primary goods (e.g., sugar cane instead of sugar) which are edible and contain nutrients (e.g., coffee and tea are excluded).

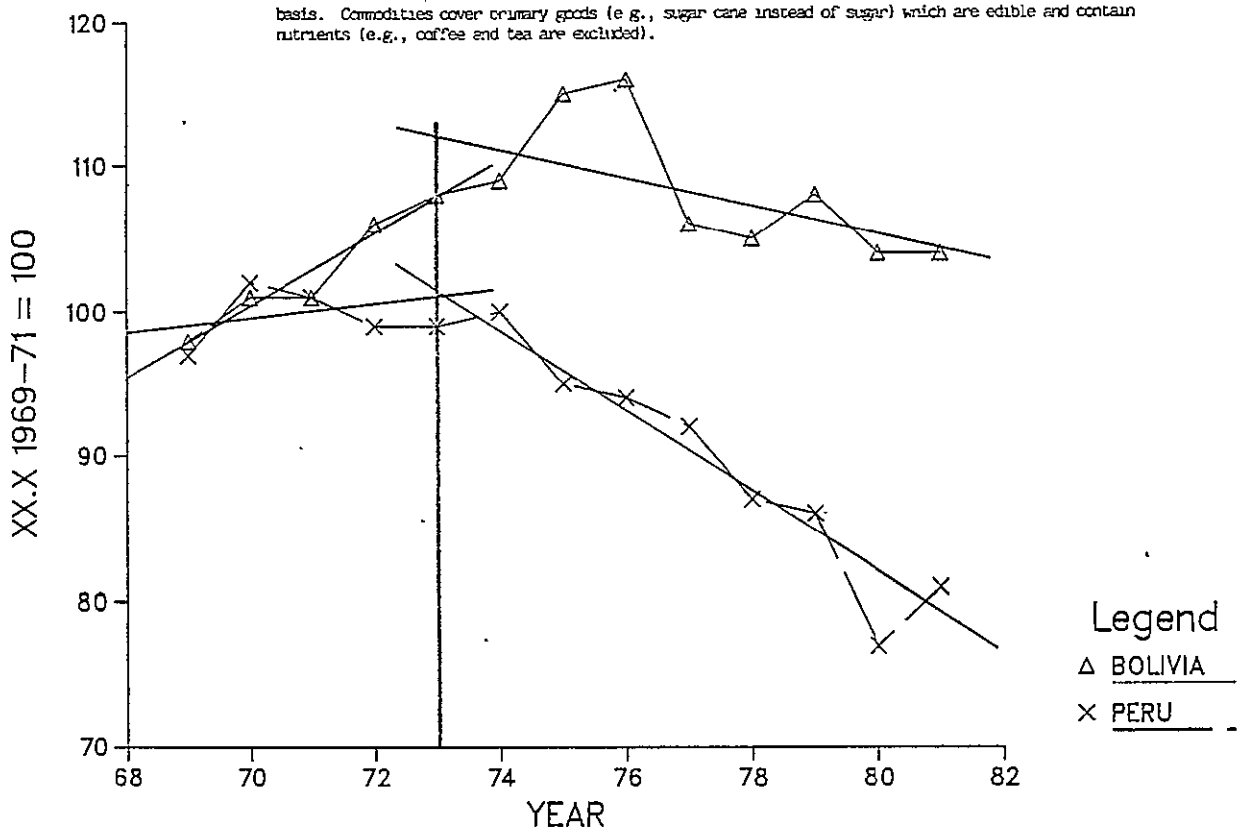


FIGURE 17

INDEX OF TOTAL AGRICULTURAL PRODUCTION

Definition: The relative level of the aggregate volume of agricultural production with the base period 1952-56=100.

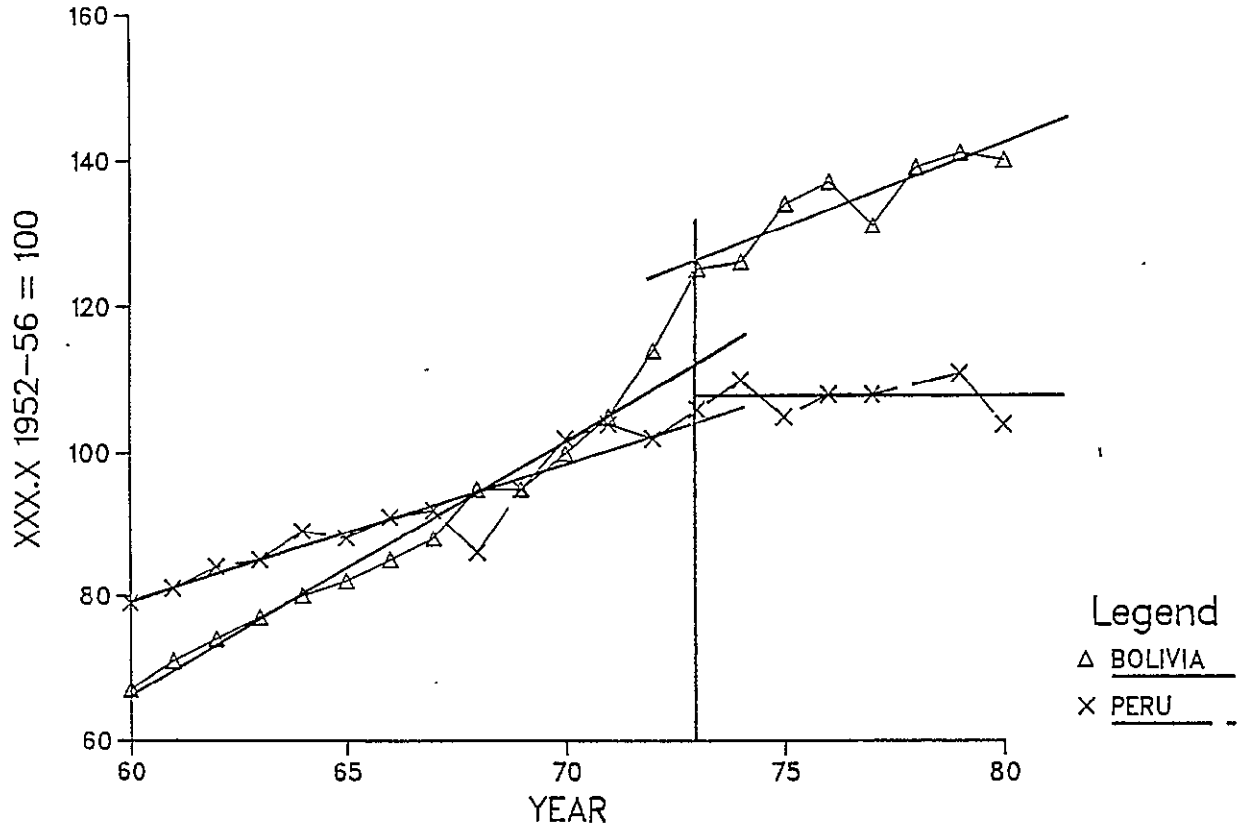
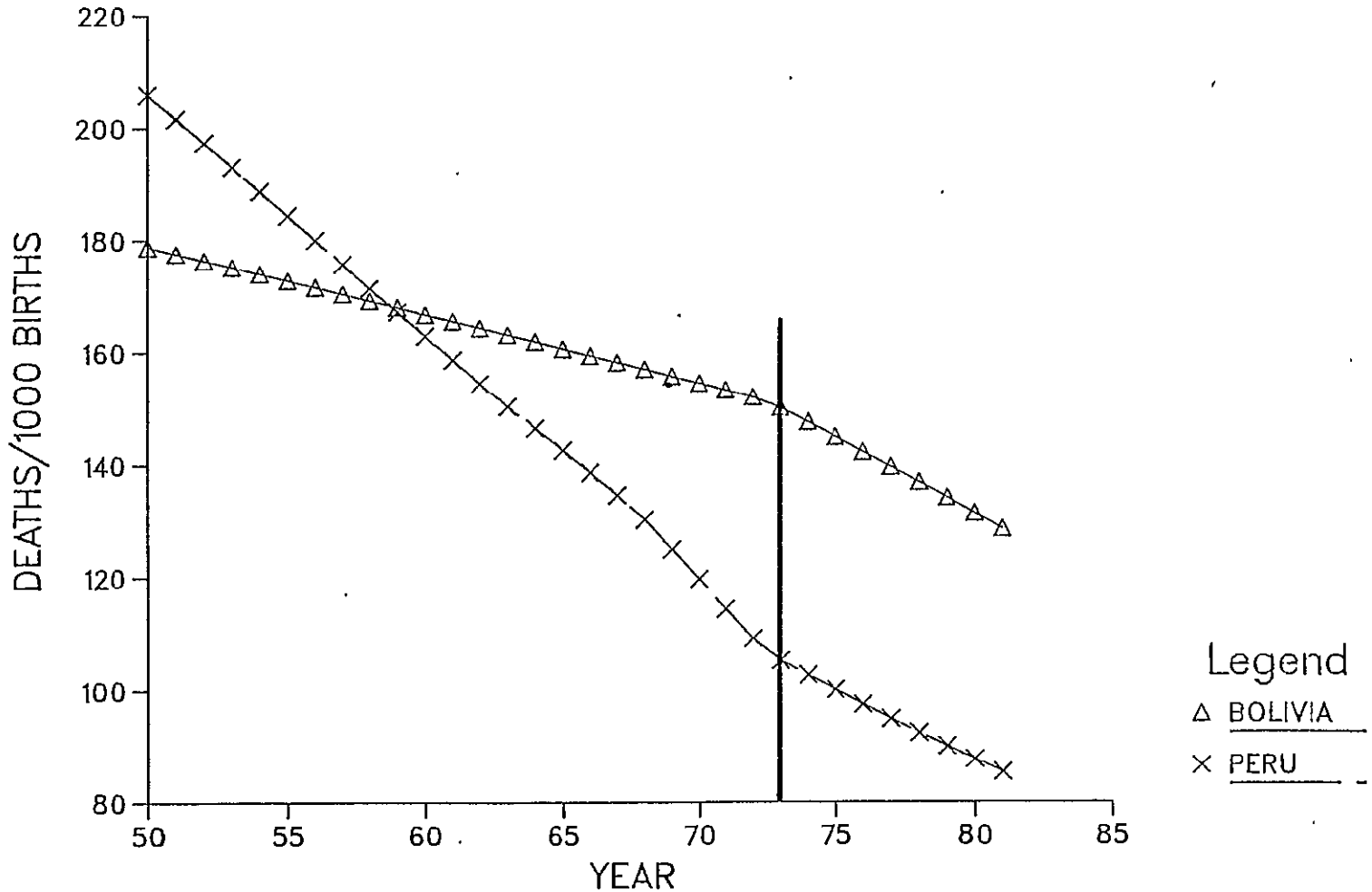


FIGURE 18

INFANT MORTALITY RATE

Definition: Annual deaths of infants under one year of age per thousand live births.



As shown in Figures 16 and 17, the total amount of agricultural production levels off in Peru in the period following the project but increases sharply in Bolivia. However, the index of food production per capita falls off in both Bolivia and Peru during the same time period. These data suggest that either agricultural products are being channeled into non-food areas, are being exported, or the population in Bolivia is growing at a much faster rate than their total agricultural production. One might argue that the slower rate of decline in Bolivia when compared to Peru in Figure 16 argues for a positive project impact. However, if this were the case, one would expect a concomitant increase in wheat--which does not appear.

The fact that food yield data from Peru are consistently more negative across all of these variables requires further exploration. One explanation is that a number of political and natural events have combined to lower food production levels. For example, between 1968 and 1974 many of Peru's larger farms were nationalized and redistributed to the poor. The history of such "land reform" has been that it seldom results in increased production levels. Also, in 1970 the largest natural calamity ever recorded in the Americas occurred in Peru--an earthquake killing over 50,000 peple (more than 1% of Peru's total population). In 1972, the anchovies, on which much of Peru's fishing industry depends, disappeared creating a major economic crisis. Finally, the period between 1973 and 1978 was marked by even more civil unrest than normal. Although civil turmoil is also commonplace in Bolivia, nothing of the magnitude of these combined events in Peru occurred during this time period. These events may explain in part the more substantial declines in Peru than are observed in the same time period in Bolivia.

Figure 18 contains time series data on infant mortality rate which one would expect to be related to substantial changes in food yield. As can be

seen, infant mortality begins dropping at a somewhat faster rate in the period since 1973, while the rate of decrease begins to level off in Peru. These shifts are minor, however, given the trends before 1973, and are probably not attributable to the project.

Information from those graphs which are most closely related to the project objectives are combined in Figure 19, which shows information for each of 10 variables. The pre-period line of best fit is forced through a common origin, so that changes in both the level and slope associated with each variable can be shown in relation to other variables. As can be seen, in Peru only the index of total agricultural production and barley yield are above the 1973 levels. In Bolivia, wheat and barley are below 1973 levels, with corn, rice, and food production per capita very close to 1973 levels. Total calories, total protein, calories and protein from cereals, and total agricultural production are all substantially above the 1973 levels. Those variables which should have been impacted most directly by the project decrease or stay the same, while variables more tangentially related increase. The total food yield improvement picture is much better for Bolivia than Peru, but these differences are more plausibly explained by the civil, political, and natural disturbances in Peru than by the success of the project in Bolivia.

Table 3 contains the pre- and post-intervention means, standard deviations, and slopes of the regression lines. These data are taken directly from the information which is presented visually in Figures 5 through 17. It is important to note how misleading it can be to only examine mean levels of production before and after the project. For example, the average supply of calories from cereals is lower since 1973 ($\overline{Y}$ = 796.6), than before 1973 ($\overline{Y}$ = 831.0). However, there was a dramatic improvement in supply

Figure 19

Relative Changes in Commodities and Indices Related to Food Yield Assuming Similar Levels in 1973

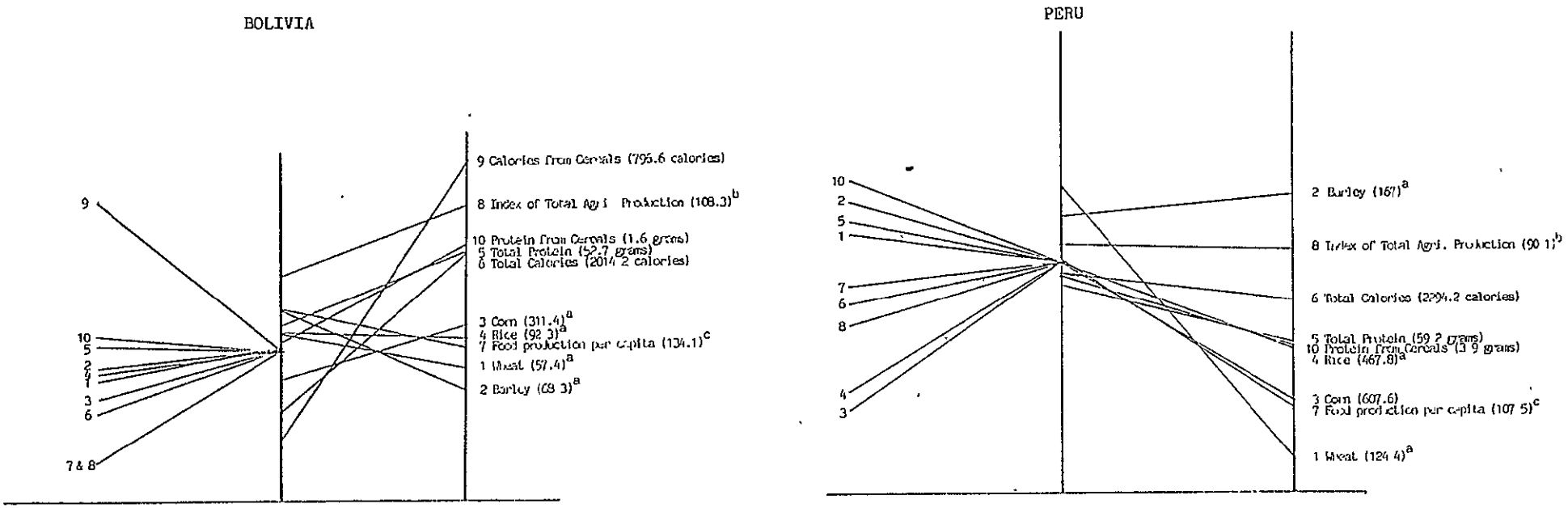


Table 3

Means, Standard Deviations, and Beta Weights for Most Important Food Yield Variables for Both Countries in Pre and Post Project Periods

Variable	BOLIVIA						PERU					
	50 - 72			73-81			50 - 72			73 - 81		
	$\overline{Y}$	SDy	b	$\overline{Y}$	SDy	b	$\overline{Y}$	SDy	b	$\overline{Y}$	SDy	b
Wheat USDA	42.7	14.7	1.1	57.4	6.7	-1.5	145.3	14.3	-1.3	124.4	26.0	-10.3
Barley	55.3	7.9	.9	68.3	14.1	-4.3	183.4	22.8	-2.7	167.0	7.4	-0.5
Corn	236.5	54.7	7.1	311.4	24.6	8.2	436.5	128.9	18.9	607.6	78.9	-16.3
Rice	39.9	22.6	3.4	92.3	18.9	-0.9	343.2	112.6	14.6	467.8	61.7	-5.7
Total Protein	51.0	.8	-0.0	52.7	1.1	0.5	61.6	1.4	-0.2	59.2	0.7	-0.3
Protein from Cereals	1.2	.1	-0.0	1.6	0.2	0.1	5.2	.7	-0.2	3.9	0.2	-0.1
Total Calories	1962.4	50.2	12.1	2014.2	5051	33.3	2283.0	34.1	6.7	2294.2	27.4	-7.4
Calories from Cereals	831.0	29.9	-7.4	796.6	21.0	13.2	N O D A T A					
Index of Total Agri. Production	101.5	2.9	2.4	108.3	4.2	-0.9	99.8	1.9	0.5	90.1	7.5	-2.8
Food Production Per Capita	87.2	13.5	3.6	134.1	5.8	2.3	90.6	7.8	1.9	107.5	2.2	1.2

of calories from cereals because a steep decline was reversed to a positive increasing trend. This change is shown in the beta weights which change from a negative pre-project value (b = -7.4) to a positive post-project value (b = 13.2).

Conclusions About the Feasibility of a Time Series Analysis Strategy

In our opinion, the preceding data suggest that time series analyses utilizing existing data do provide a feasible and meaningful evaluation technique which could be used economically and productively to evaluate the impact of AID projects which focus on increasing food yield. One major advantage with the demonstrated evaluation strategy is that it focuses on the impact on food yield rather than monitoring activities.

In addition to the information and analyses presented, several further refinements could be made to further strengthen the analyses and increase our confidence in the conclusions. These refinements fall in two areas--statistical analyses and additional contextual information.

Statistical Analyses

In addition to the descriptive statistics and visual information which have been presented in the previous sections, a number of statistical analyses could be done to determine if shifts in level and/or slope are greater than would have been expected frequently from random fluctuation. Such analyses are best done using the interrupted time series analyses techniques described by Box and Jenkins (1970) or Glass, Willson, and Gottman (1975). One potential problem with these statistical analysis techniques, given the available data, is that the number of data points in the series is a little short leading to erroneous conclusions. Consequently, when data points are limited and the data are visually clear such as is the case with much of the preceding data, statistical analyses may not be necessary.

However, one advantage of the interrupted time series analysis is that it allows one to statistically control for (i.e., covary out the influence) of concomitant variables on the variable in question. For example, it would be possible to statistically determine whether there was a pre to post shift in either level or slope of wheat production after statistically controlling or covarying for each year's value on variables such as the following:

- Central government expenditures on agriculture by the central government of the country
- Total revenues of the country
- Total U.S. assistance to the country
- Total AID assistance given to the country
- Total financial assistance from external countries
- Climactic conditions such as rainfall or temperature

Information on the first two of these variables are available through the ESDS data bank and are shown in Figures 20-21. Information on total U.S. assistance and AID assistance is available from Wilkie (1974, 1978, 1980) (see Figures 22-23). Unfortunately, none of these data are adjusted for inflation. Adjusting for inflation is not difficult for U.S. financial data as shown for the AID data in Figure 24. For data from countries such as Bolivia and Peru, such adjustments are more problematic, but possible. Estimates of the total financial assistance from external countries is available from the Organisation for Economic Cooperation and Development but would be difficult to adjust for inflation since the money is coming from so many different countries. Data on rainfall and other climactic conditions are obtainable, but are unlikely to play a major role on data such as these according to agricultural experts.

FIGURE 20

CENTRAL GOVERNMENT EXPENDITURES: AGRICULTURE

Definition: Includes expenditures for programs in support of farm prices and incomes, extension programs, irrigation projects, reforestation, fire prevention, supervision of hunting, protection of wild life, support for inland and ocean fishing. Bolivian data adjusted by a factor of 100.

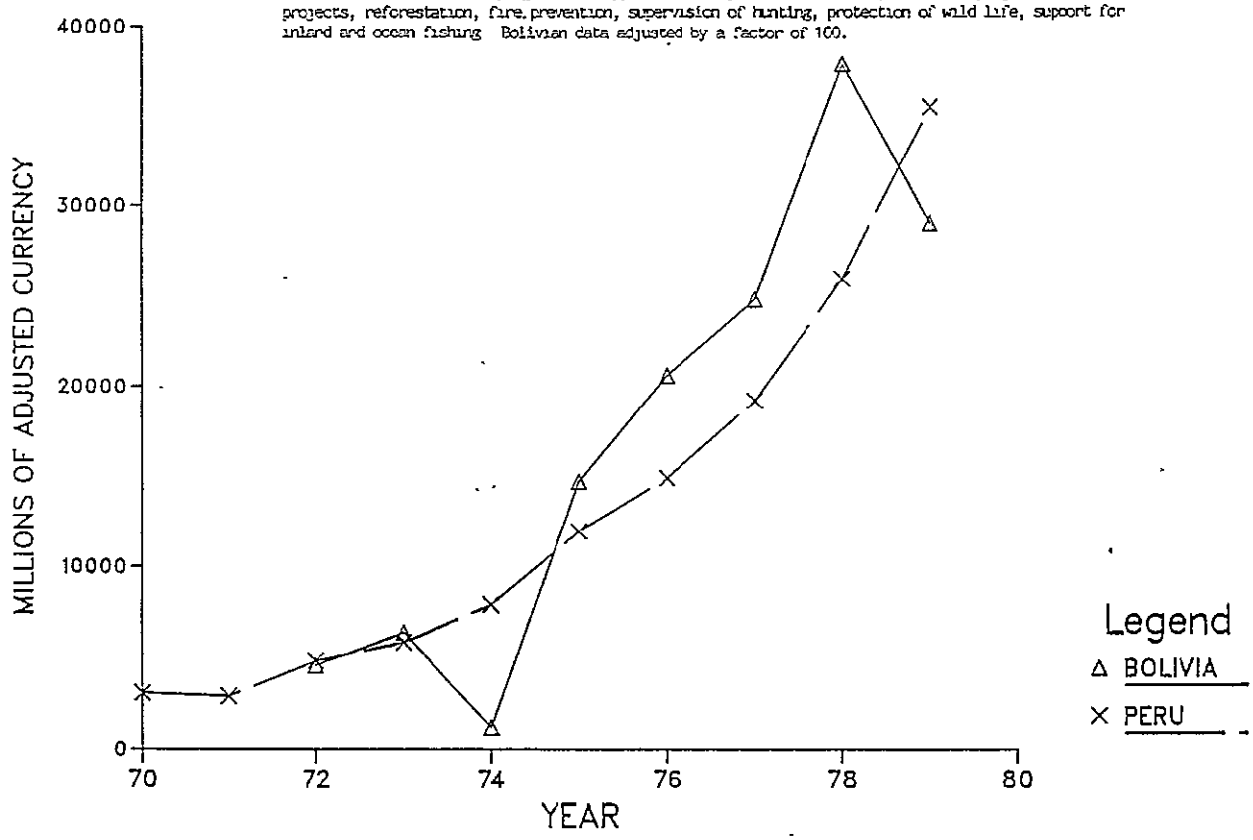


FIGURE 21

TOTAL REVENUE

Definition: Includes revenue derived from net income and profits, property (including death and gift taxes), sales, business and professions, motor vehicles, customs duties; and non-tax revenue such as administrative fees, income from property, and capital revenue from the sale of fixed assets (stocks, land, and intangible assets).

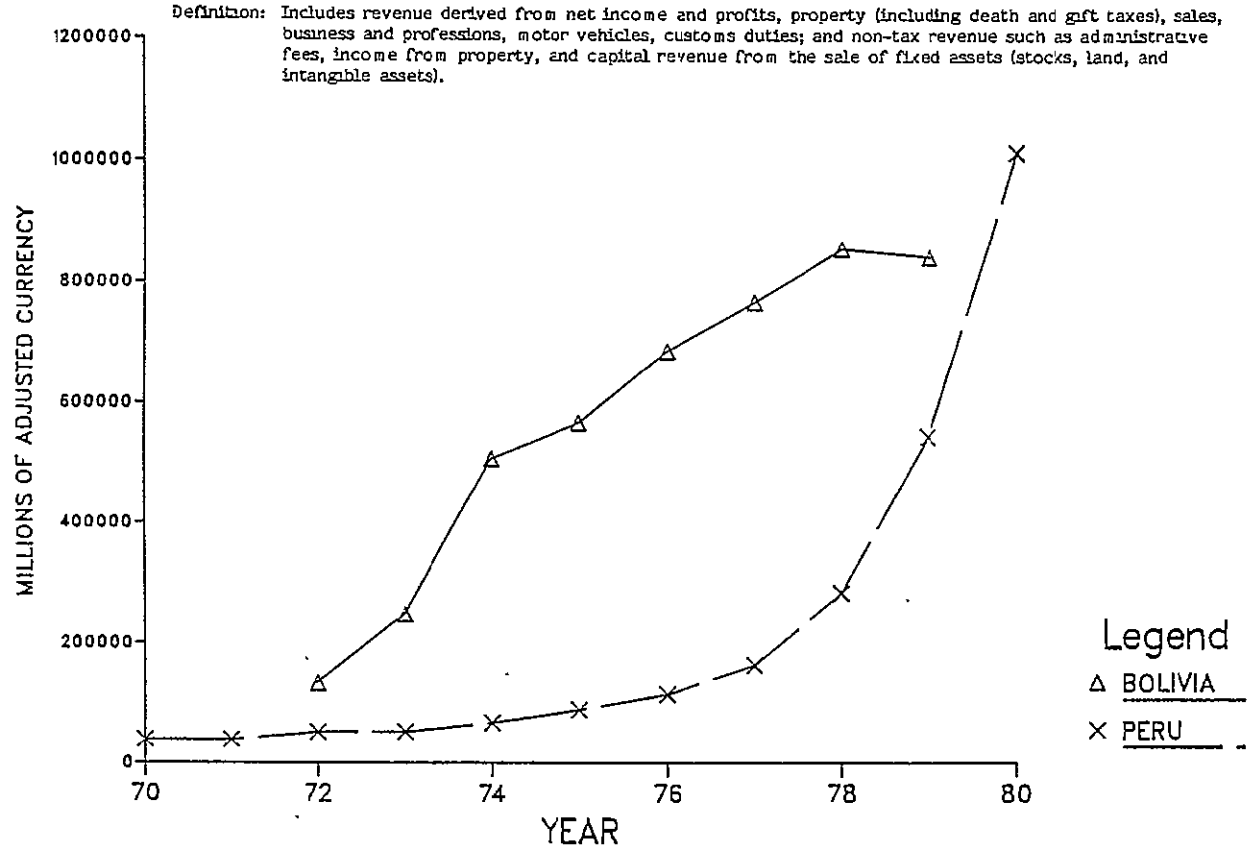


FIGURE 22

TOTAL U.S. ASSISTANCE

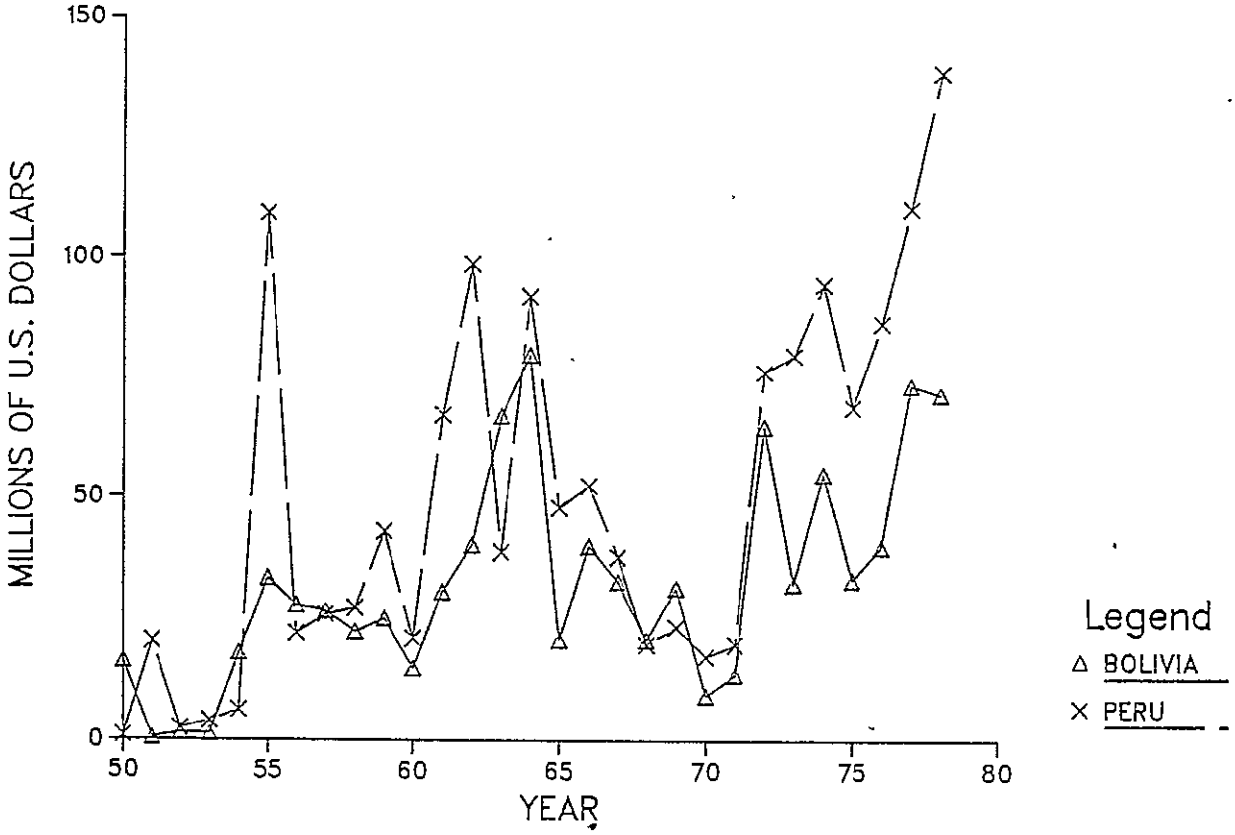


FIGURE 23

TOTAL AID ASSISTANCE

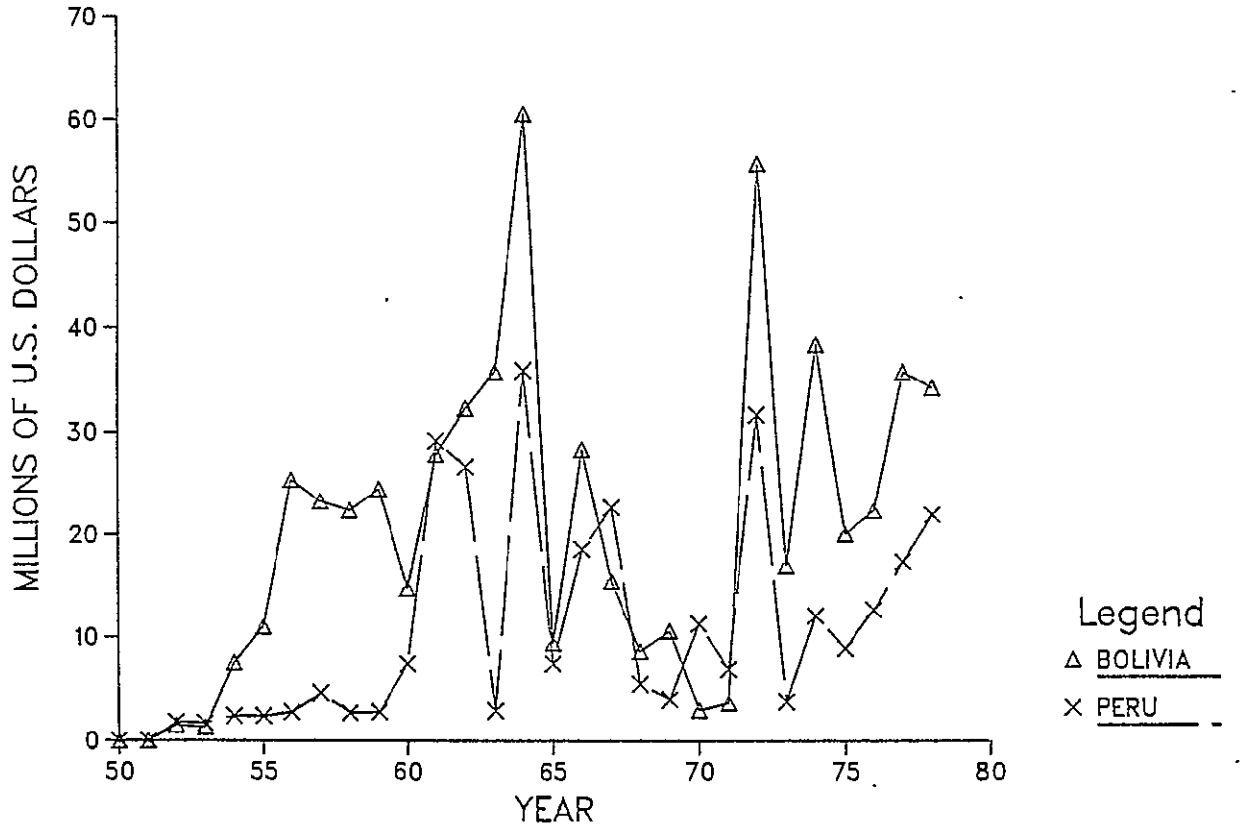
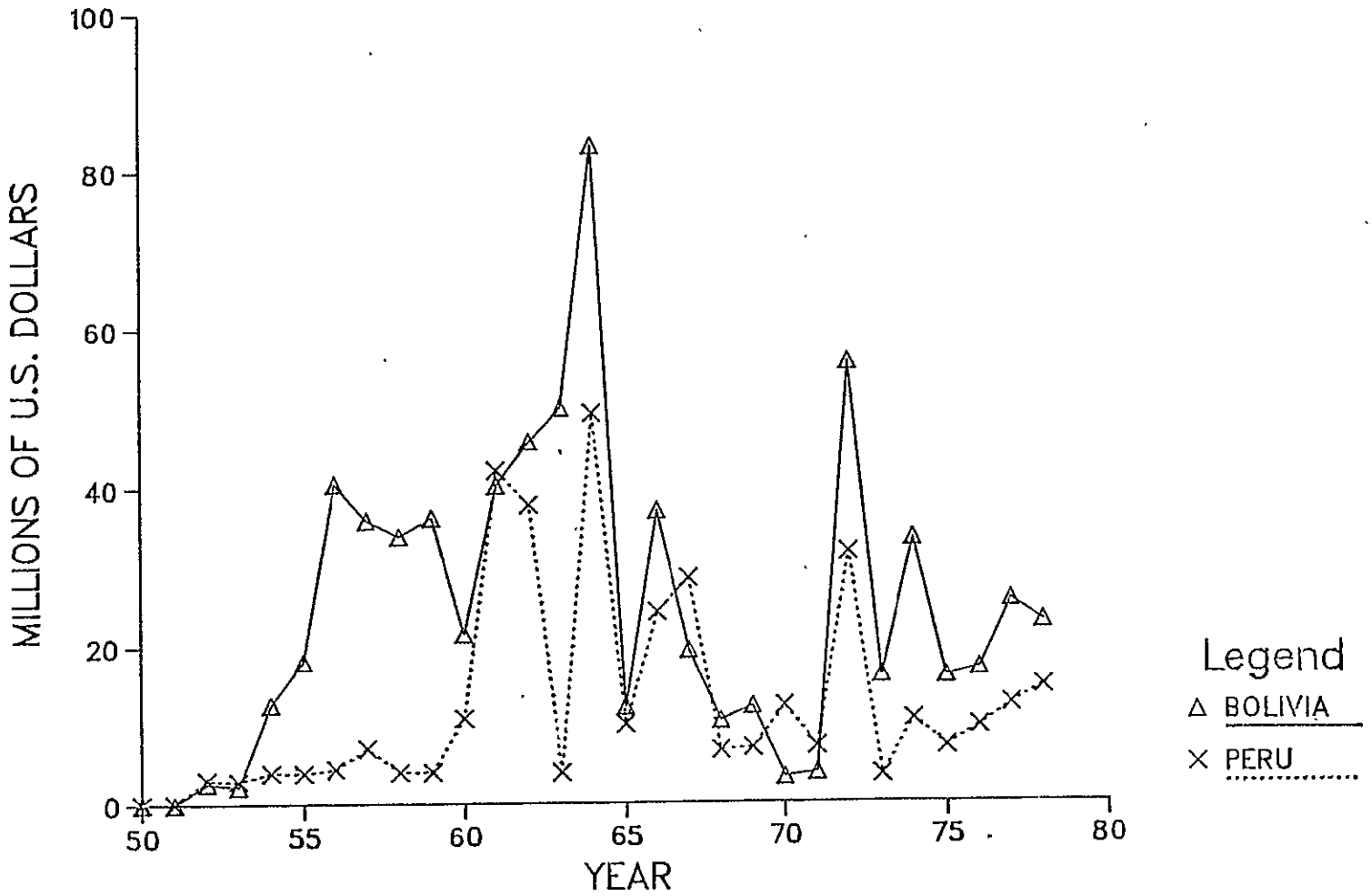


FIGURE 24

TOTAL A.I.D. ADJUSTED ASSISTANCE

U.S. A.I.D. support adjusted for inflation



Although accounting for these factors through covariance adjustment would result in a more fine-grained analysis, for this particular project it would not have changed the overall conclusion that the project had little, if any, impact. For example, since the inflation adjusted value of AID assistance has been generally on an upward trend from 1970 to present (see Figure 24), any covariance adjustment would have further reduced the already small or negative impacts.

Additional Contextual Information

To assist in identifying and examining additional plausible explanations for the observed data as well as potentially confounding factors, additional contextual data should be gathered and integrated with the statistical data already presented. At least the following information would be useful:

- Interviews with AID "country experts" for the target and comparison countries who also have expertise with agriculture. These interviews could collect information about whether a better comparison contry exists, whether there are other factors (political, economic, natural, etc.) which may confound the data and should be examined, and whether there are other outcome variables which should be considered.

- A thorough analysis of the project reports for the project being considered so that the impact data reported here could be integrated with descriptive information about the project and the monitoring and process evaluation data which are reported.

- An analysis of what other agriculturally related projects were being conducted in the target country and experimental countries during the time period being considered. Projects which should be considered have been identified based on the computer-assisted searches done earlier (see Table 4). A detailed analysis of each project would be useful to integrate with the other data already collected.

Table 4

Agriculturally Related AID Funded Projects
Conducted in Bolivia

Title	Project No.	Year Started - Year Completed	Amount Authorized	Status	Printout No.
Rural Electrification I	5110046	73-79	11,800	C	2
Rural Electrification II	5110049	73-80	16,735	A	2
Subtropical Lands Development	5110050	74-81	9,700	A	2
Basic Food Production & Marketing	5110052	75-80	8,000	C	2,3
Agricultural Development Sector I	5110053	75-80	9,200	A	2,5
Small Farmer Organization	5110055	76-83	7,500	A	2
Rural Access Roads I	5110056	76-81	8,500	A	2
Agricultural Development Sector II	5110059	77-82	11,300	A	2
Infrastructure Monitoring	5110205	74-80	1,229	C	2
Agricultural Refinancing Fund	5110364	71-81	17,562	C	1,2,5
Basic Food Production & Marketing	5110451	75-82	6,900	A	2
Small Farm Organization I	5110452	76-83	4,147	A	2
Rural Access Roads II	5110466	78-83	13,300	A	2
Renewable Natural Resource Production	5110470	?	?	P	2
Agricultural Business & Artisanry	5110472	78-82	6,600	A	2
Care Agricultural Credit La Paz	5110476	?	?	P	2
Small Farm Production	5110481	77-82	2,200	A	2,3
Farm Policy Study	5110485	78-82	1,115	A	2
National Urban Development Service II	5110487	?	?	P	2
Rural Electrification III	5110488	?	?	P	2
Small Farm Organization II	5110489	?	?	P	2
Development of the Yungas & Chapare	5110491	?	?	P	2
Rural Electrification IV	5110493	?	?	P	2
Village Development	5110499	78-83	15,600	A	2
Agricultural Extension	5110502	?	?	P	2
Consolidation of Colonization Program	5110514	79-82	1,482	A	2
La Merced Cooperative	5110533	79-82	496	A	2
Rural Electrification Management	5110534	79-81	200	C	2
Legal Assistance for Campesinos	5110535	?	?	P	2
Agricultural Credit	5110538	80-80	16,000	C	2
Natural Resource Management	5110546	?	?	P	2
Chapare Regional Development	5110548	?	?	P	2
Rural Access Roads	5110457	76	?	?	4

1 - OIS Titles from Grain or Food or Vegetable Production Projects
2 - PBAR Search Using Agriculture (000) as Technical Code
3 - PBAR Search Using Agriculture (120 and 140) as Purpose Code
4 - DIS Abstracts from Food or Grain or Vegetable Production Projects
5 - DIS Abstracts from Agricultural Production Projects and Not Food, Grain, or Vegetable Production

A = active
P = pending
C = complete

Table 4 (continued)

Agriculturally Related AID Funded Projects
Conducted in Peru

Title	Project No.	Year Started - Year Completed	Amount Authorized	Status	Printout No.
Agricultural Development & Operations	5270060	62-81	17,257	C	2
Housing and Urban Development	5270065	62-81	1,801	C	2
Rural Electrification	5270119	67-73	1,594	C	2
Feasibility Studies	5270133	63-68	2,980	C	2
Food Marketing	5270135	68-75	385	C	2,3
Supervised Agricultural Credit Program	5270136	72-74	5,000	C	2
Private Investment Fund	5270139	68-76	1,500	C	2
Campesino Para-Tech. Training	5270143	77-80	100	C	2,3
Fresh Water Fisheries Development	5270144	77-81	465	A	2,3
Soy and Corn Production on Small Farms	5270149	79-81	2,302	A	1,2,4
Use of Treated Sewage for Irrigation	5270150	77-81	220	C	2,5
Agricultural Cooperative Federations	5270155	76-82	7,000	A	1,2,4
Sierra Water and Land Use	5270156	76-84	11,000	A	2
Rural Development Agribusiness Farms	5270159	78-82	15,000	A	2
Appropriate Rural Technologies	5270162	78-82	1,276	A	2
Development of Sub-tropical Lands	5270163	78-83	19,000	A	1,2,5
Small Farm Prod. Technology	5270164	?	?	P	2,3
Tech. Support for Food & Nutrition	5270166	74-81	2,309	A	2
On-Farm Water Management	5270170	79-81	490	A	2
Rural Agro-Industry	5270171	?	?	P	2
Sierra Fisheries Production	5270175	?	?	P	2,3
Rural Enterprises II	5270176	79-83	8,000	A	2
IPFE Campesino Skills Training	5270179	78-81	210	C	2,5
Care-Urban Feeding Program	5270186	80-82	550	A	2,3
Agricultural Research. Extension & Ed.	5270192	80-85	14,000	A	2,5
Sepas Reforestation Work	5270206	78-82	490	A	2
Expand Urban Food Work Program	5270212	80-82	450	A	2
Soil Conservation	5270220	80-84	1,000	A	2
Small Hydro Development	5270226	80-85	10,000	A	2
Renewable Energy Development	5270227	?	?	P	2
Use of Treated Sewage for Irrigation	5270229	?	?	P	2,3
Expand Reforestation Food for Work	5270231	82-85	?	A	2
Central Selvia Resource Management	5270240	82-87	22,000	A	2
Upper Huauaga Agricultural Development	5270244	81-86	15,750	A	2
Improved Feeding Capability	5270180	78-80	160	?	1,4
Community Food Production	5270184	79-82	300	?	1,4
Supervised Agri. Credit--Flood Disaster	5270138	73	5,100	?	5
Water Management in Small Communities	5270188	79	100	?	5
Internal Development of Campesino Com.	5270207	79	75	?	5

A = Active
P = Pending
C = Completed

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