ECUADOR
IRRIGATION SECTOR REVIEW

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USAID

WATER MANAGEMENT SYNTHESIS PROJECT

WMS REPORT 12

ECUADOR

IRRIGATION SECTOR REVIEW

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All reported opinions, conclusions or recommendations are the sole responsibility of the authors and do not represent the official or unofficial positions of any agency of the country of Ecuador or the United States or of Utah State University and the Consortium for International Development.

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WMS Report 12

PREFACE

This study was conducted as part of the Water Management Synthesis Project, a program funded and conducted by the United States Agency for International Development through the Consortium for International Development. Utah State University and Colorado State University serve as lead universities for the project.

The key project objective is to provide services in irrigated regions of the world for improving design and operation of existing and future irrigation projects and give guidance to USAID for selecting and implementing development options and investment strategies.

Contact the Water Management Synthesis Project for information about project support services or research findings.

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FOREWORD

This review of irrigated agriculture in Ecuador was made at the request of USAID/Ecuador on behalf of the national agency responsible for water, resource development, and administration: Instituto Ecuatoriano de Recursos Hidraulicos. The Water Management Synthesis Team visited Ecuador between August 22 and September 10, 1982. Members of the Team are listed on the title page.

The Team wishes to acknowledge the many courtesies extended to them by engineers and professionals of INERHI and other official arms of the Government of Ecuador who are charged with improving the welfare of rural families throughout the nation. In particular the Team appreciated the support received from Ing. Miguel Chehab N., Technical Director, Ing. Mario Guzman, Ing. Jorge Sotomayor, Ing. Franco Rios and the many others in the INERHI central office who were extremely helpful.

The Team is also grateful for the splendid cooperation of USAID personnel in Quito, including Dr. John Sanbrailo, then Mission Director; Dr. Vincent Cusumano and Mr. Paul Fritz; as well as all other staff members who assisted in any way.

CHRONOLOGY OF WATER MANAGEMENT SYNTHESIS TEAM
PRINCIPAL ACTIVITIES IN ECUADOR

Date	
Aug. 22	WMS Team arrives in Quito.
Aug. 23	Team meets with Dr. Vincent Cusumano of USAID/Ecuador and later with Ing. Miguel Chehab of INERHI to review and define team plans and schedule. Team orientation - start gathering background material.
Aug. 24	Team reviews data at INERHI in the morning (LeBaron and Anderson also visit MAG). Team visits INERHI's Pisque Project during the afternoon accompanied by Ing. Cesar Sarmiento of INERHI.
Aug. 25	Team begins field trip accompanied by Ing. Eduardo Hinojosa of INERHI. Visits INERHI's Latacunga-Salcedo-Ambato Project, the Salcedo DRI Project, and private irrigation institutions in the Ambato/Pelileo area.
Aug. 26	Team vists the Quiniog-Penipe DRI Project, some private irrigation systems, and INERHI's Chimborazo District offices.
Aug. 27	Team travels to Milagro. Keller and Meyer tour INERHI's Milagro Project. LeBaron and Anderson continue on to Guayaquil and visit with representatives of CEDEGE.
Aug. 28	Team visits private irrigation systems operating along the lower Daule River during the morning. Returns to tour Milagro Project in the afternoon.
Aug. 29	Team travels by air from Guayaquil to Quito. Daines arrives in Quito.
Aug. 30	Team meets with INERHI personnel and reviews materials on National Irrigation and National Hydrology Plans.
Aug. 31	Keller and Meyer visit INERHI's Montufar Project. Daines meets with INERHI personnel. LeBaron and Anderson contact FAO and IERAC. Daines, LeBaron, Anderson meet with representatives of CONADE.

Sept. 1 Team meets with SEDRI Secretary General. Begins formulation of written report.

Sept. 2 Team activities centered around written report and recommendations. LeBaron and Meyer meet with representatives of INIAP.

Sept. 3 Team meets with Vice-President of the Republic, Sr. Leon Roldos Aguilera. Keller and Anderson later meet with the Dean of the Facultad de Ciencias Agricolas of the Central University.

Sept. 4 Team members work on draft report.

Sept. 5 Preparation of draft report.

Sept. 6 Preparation of draft report's chief recommendations. Keller and Daines meet with INERHI and with representative of BID.

Sept. 7 Team members meet with representatives of CONADE during the morning, and work on draft report.

Sept. 8 Finish all sections of draft report and summary recommendations to present to INERHI and USAID.

Sept. 9 Preparation and typing of summary recommendations and sections of draft report.

Sept. 10 Morning - long meeting with INERHI and USAID in which team recommendations are presented and discussed. Final meetings at USAID in afternoon. Despedida for team by INERHI in evening.

Sept. 11 Team departs.

Oct. 30 Review draft of report received by USAID/Quito.

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IRRIGATION SECTOR REVIEW

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FRAME OF REFERENCE

The basic purpose of this study is to make suggestions and recommendations which might be incorporated into current national hydraulic and irrigation planning in Ecuador. Because some of our findings may influence public policy and the allocation of scarce financial resources, the frame of reference for what follows is presented in this section.

Irrigation developments can be quite expensive so the challenge is to obtain maximum social benefit from expenditure of public resources. But views may differ about what irrigation is meant to accomplish and, therefore, what maximizes social benefits. As outside observers of the Ecuadorian rural scene, the Team's fundamental concern is the interrelationship of irrigation and the satisfaction of future crop and livestock demand. And, insofar as increasing agricultural production is concerned, the degree of emphasis to be placed upon public investment in irrigation or other inputs depends upon a realistic assessment of all available options. A fundamental step in formulating an irrigation program, therefore, is to assess such options and schedule investments accordingly.

While such a detailed assessment is beyond the scope of this report, a general overview of food and fiber potentials is included and it is the basis for the direction and emphasis of some of the technical and policy recommendations as summarized here and presented in more detail in the main body of this report.

In many third world nations all the available farmland has been taken up and the only possibility to increase output is intensification of land use. In addition, there are definite markets for any new production response. This is not the situation in Ecuador (or for many other nations in South America). Ecuador has the resource capacity to feed itself with surplus left over.

It is true that currently some food is imported, but this is not a matter of life and death; generally speaking the population obtains enough to eat even if somewhat better nutrition might be desirable. While it is true that in the future, food demand will be much larger due to population growth, at any given moment there is a limit to the absorptive capacity of the domestic market. Agricultural output needs to expand at just the right rate to satisfy the market and not glut it; at the same time any supportive public expenditure needs to increase output and not be dissipated in unproductive ventures.

At this point in time Ecuador would seem to have many options to satisfy the domestic food and fiber demands of a growing population as well as to earn needed foreign exchange. Frontier or colonization type lands are available in the Oriente and in the Costa; the potential for rainfed agriculture probably has not been reached; in addition there is a quite extensive irrigation system, especially in the Sierra zone, and significant private capital is moving into irrigation in the Costa zone and into commercial farming operations elsewhere.

The Team's brief survey of the Ecuadorian agriculture output scene suggests the following broad frame of reference:

1. Most food crop production will need to more than double in order to meet year 2000 domestic demands. Export markets are less predictable, but Ecuador should be able to maintain its export position if quality levels are safeguarded;

2. If frontier and colonization regions can produce meat on a commercial basis, improved yields on current cropped lands (irrigated and rainfed) could satisfy most of the future demand (ignoring sugarcane and any pressures to devote more land to export crops);

3. For a variety of reasons the public irrigation projects now in service do not live up to pre-project expectations. Does this mean that projects now under construction or being considered for funding will follow the same pattern? Will they also fail to return their costs in the form of increased social benefits?

4. The benefits of any technical inputs (including expensive irrigation investment) which might serve to lower production costs per unit of output are continually in danger of being "swamped out" by an existing maze of central pricing, taxing and marketing policies, put in place for well meaning social and political reasons, but which are nevertheless mutually inconsistent with increasing agriculture sector output and human and natural resource productivity.

RECOMMENDATIONS

In order that public irrigation expenditures make a maximum contribution to future agricultural sector growth and output, the Team has the following suggestions for program emphasis.

Main Conclusion

The Team recommends that INERHI devote considerable effort in upgrading all existing irrigation works and irrigation methods.

Intensifying the production and irrigated area under both the public and private projects and systems should provide considerably greater income benefits to many more farmers at less social cost than expanding the irrigated area by building new projects. Probably the same argument can be made with respect to current areas of rainfed agriculture in Ecuador.

Viewed over a longer term, expansion of either or both the areas of irrigated or rainfed lands may be timed to satisfy the needs of production for domestic and international markets or for provision of new or upgraded farms for a growing rural population. Meanwhile, of course, some expansion in irrigated area will continue to occur under both public and private auspices, especially in the coastal lowland region.

Justification and Objectives

1. None of the existing irrigation projects which have been developed by the public sector have been fully exploited to serve their command areas. In fact the current average level of uptake (area actually irrigated as compared to command area) is less than 50 percent. Furthermore, current production from irrigated farming is only about one third of the potential which could be obtained with improved water management and other crop inputs. In view of the low productivity of public irrigation projects the Team recommends that priority be given to both increasing the extent and the performance of irrigated farming to all of the logical command areas.

2. There is considerable evidence from other countries that in some extreme conditions rainfed yields can be doubled or tripled if inputs, training, and assistance are provided to farmers. Given the current average national yields of 0.7 to 0.8 T/ha for grains, improved agronomic practices should provide a two to threefold increase under rainfed conditions and adding irrigation should provide another two to threefold increase at the minimum. It would seem wise to have a vigorous program for improving yields in rainfed agriculture and the existing irrigated agriculture now in pace before beginning any major new irrigation projects. This would require a close working relationship between INERHI and INIAP and INAMHI.

3. In view of the extensive area under private irrigation, the Team recommends that government policy should assist the private sector both technically and financially in rehabilitation of existing private irrigation works and in developing new works wherever under-utilized water can be readily developed with limited resources. Existing works should be upgraded to gain better water control and reduce losses in the delivery system as well as to improve field application efficiency. A model for accomplishing this might involve the following:

a) Provide INERHI engineers at the district level with the capability to design minor civil works and on-farm irrigation systems, to provide technical assistance to farmer groups, and to certify the work of private designers and contractors.

b) Develop a formula based on the area involved and numbers and sizes of land holdings as a basis for direct financial aid (grant) to farmer groups.

c) Organize farmers to provide labor for construction with the amount of labor contribution a function of the individual's land holdings.

d) Provide loan money through the Banco de Fomento (BNF) at favorable interest rates for the cash inputs needed.

4. Ecuador has very serious erosion problems in almost all regions of the country because of its geography, climate and soil characteristics. Overgrazing, deforestation, and improper soil and water management have made major contribution to erosion magnitudes. Soil losses due to soil erosion caused by wind, rain and/or irrigation may be cancelling much of the production gains resulting from opening new lands to rainfed agriculture and irrigation, or improving crop technology in the Sierra region. Therefore, the Team recommends that more serious attention be given to the soil erosion problems and that considerable adaptive research and technical assistance be devoted to solving the serious soil erosion problems that are rapidly evolving in Ecuador. There are many examples of lands abandoned because of erosion and the possibility of a potential catastrophe in the Oriente should not be minimized. There are examples of up to 3 m of soil being lost in Sierra fields and reservoirs losing more than 20 percent of their capacity in five years. It is imperative that INERHI work closely with the new Soil Conservation unit being developed.

Meeting the Objectives

1. INERHI Administrative Adjustments. It is recognized that INERHI has successfully implemented the first phase of the national water law by encouraging water resource use. Now Ecuador is moving rapidly into the control and protection phases of the law.

a) It is recommended that INERHI respond to these later phases by increasing its staff and capability to identify, refine, enforce and police water allocations and protective measures. This program emphasis should be given priority and commence with those water sources or river basins where there is the highest competition for use, potential for change in use and need for environmental protection. These measures are necessary to provide stability and confidence in fair allocation and protection of the resource under the law. Heightened public confidence will serve as a basis for continued private and public sector willingness to invest in water development.

b) In view of the fact that hydrological and meteorological data and measurements are the basis for the management and administration of water resources under the law, it is recommended that the function of INAMHI be merged with INERHI for improved gathering of data in a form promoting efficient water administration.

c) It is recommended that additional flexibility be introduced into the current system of water tariffs. In some cases the present system acts as a disincentive to more effective utilization of INERHI project water. In others higher prices might induce better use and secure needed revenues at the same time. INERHI's dealings with private appropriators raises different issues, but some flexibility will probably do more good than harm; the best approach to private users and groups is to monitor and meter the amounts they can actually appropriate. This will help lead to more efficient use by denying excess water.

d) It is recommended that INERHI turn over, through a planned phase-out process, the administration of the projects it now controls (beyond the primary or major secondary canal turnouts) to the project beneficiaries for the following reasons: These projects absorb valuable agency resources (human, physical and financial) which could be dedicated to higher priority activities; the historic willingness of the private sector to develop readily accessible water sources coupled with the well-known cooperative tradition in water use, suggests that such a program would have long run success. By encouraging more initiative on the part of farmers, the up-take of project water and adoption of new practices will be more rapid and thorough. The same assistance package as suggested in objective 3 could also be utilized in meeting this administrative objective.

2. Priority for System Improvement. Improving overall on-farm water application efficiencies is more difficult than improving delivery efficiencies. The former involves the skill, dedication, and inputs (capital, labor, and management) of the farmers served. The latter places more emphasis on strict engineering concepts and capital availabilities. On all irrigation works, both the main and on-farm systems need attention. The Team recommends that priority be given first to improving the on-farm portions of public system (which may include modification of the outlet works for the main system). After the necessary techniques have been mastered on the public systems the

successful methods should be extended to private systems. In addition to improving on-farm systems the main delivery portions of private systems should be upgraded by means of existing design techniques.

3. Conduct Baseline Studies and Introduce Appropriate Technologies. The farmers in the Sierra region may be irrigating as well as can be expected using traditional technologies. Research is needed to adapt and test new technologies in order to improve the current situations. This argument also applies to irrigated areas in lowland regions and to zones of rainfed agricultural systems.

a) There are no documented field evaluation or diagnostic (baseline) studies of how well various types of existing public and private irrigated systems are now working or what level of economic benefits are involved. The Team recommends that high priority be placed on obtaining representative field data for the important Ecuadorian irrigation sites or situations as defined by elevation, crop, slope and climate, in order to gain information on:

i) Delivery and field water application efficiencies during both day and night operation.

ii) Typical yields with and without irrigation.

iii) The usual quality of irrigation in terms of adequacy of water applications to each part of the field and scheduling of irrigation applications (timeliness and amount).

iv) Percentage of gross area under irrigation for typical fields.

v) Other inputs being used such as fertilizer, seed and pesticides.

vi) Farmers' perceptions of the system infrastructure, credit availability, and markets.

vii) Farmers' methods for organizing water turns and other managerial functions requiring collective action.

b) New irrigation technologies should then be tested and adapted for local conditions. The most promising new technologies should then be compared physically, sociologically and economically against the traditional methods and be adapted where there is potential for significant improvement. Some new technologies which come to mind are: night storage; pressure pipe delivery systems; surge flow surface irrigation; gravity fed sprinkle irrigation; hose-basin or drip irrigation of trees; precision (laser) leveling in coastal areas; and traveling and center pivot sprinkle irrigation on larger farms and cooperatives. This information is needed in order to develop strategies for the upgrading of existing irrigation works and for the design of new systems and projects.

4. Rapid Acquisition of Baseline and Technical Data. There exists an Ecuador experience base which can be analyzed to improve overall project performance. Some innovations which the Team noted being applied to improve delivery and or application efficiencies at the farm level include:

a) Lined tertiary canals (Montufar).

b) Pipe for steep sections of secondary channels (Montufar).

c) Pipes for secondary delivery with storage to eliminate night irrigation (Chambo - Italian assistance).

d) Sprinkle irrigation (Pisque - Belgin assistance; Banco de Arena; lower Guayas - private; a number of private systems on pastures and vegetables in the lower Guayas).

e) Drip irrigation (at Salcedo - SAED regional development; and Central University Experiment farm near Quito).

f) Fairly precise land leveling for rice paddies (private development along lower Daule River).

g) Center pivot and hose pull sprinkle systems are also used fairly extensively by the private sector (mostly in the coastal region but some in the Sierra).

These innovations plus a few other existing or potential alternate innovations should provide ample field situations for studying the potential benefits and cost effectiveness of physical irrigation system improvements.

5. Main System Design and Construction. Current INERHI design and construction practice is basically to use the design information developed for the project feasibility study directly and employ its own workers or small contractors to carry out the construction under the supervision of INERHI engineers. For relatively small projects these practices seem satisfactory; they have the advantage of reducing the design effort and providing more job opportunities within the local

communities as compared with using standard design and international bidding practices. Furthermore, it appears that the construction accomplished is satisfactory. The Team recommends continuing the current practices of minimzing design effort and using its own labor teams or small contractors on small projects. However, on large projects (over U.S. $5,000,000) in order to eliminate expensive delays which have been excessive in the past (for example over two years at Montufar and Latacunga Salcedo-Ambato) and cost overruns due to design errors, standard construction, drainage, and specifications should be drawn up and international bidding requested.

6. Other Data Base Support, Continuing Research and Training. Very little research has been carried out in Ecuador to adapt modern water management technology and determine water-soil-fertility crop response interactions under Ecuadorian conditions. Furthermore, formal professional education programs give insufficient attention to irrigation water management and there are too few opportunities for in-service training to upgrade professional expertise in this area.

a) Extensive and reliable historical and continuing meteorological data are essential for technology transfer and rapid agricultural development. The data are essential for good system design in irrigated agriculture. They are also, however, equally important in rainfed agriculture, for crop zoning and for matching agronomic inputs to probable production. Rainfall probabilities also allow for better selection of planting dates, harvest dates, and crop varieties. The requirement for manpower and equipment is high. As with other governmental institutions, INAMHI is under severe budgetary and personnel constraints. It is imperative that INAMHI and INERHI have a close working relationship, particularly at the field level. INAMHI must be fully supported in order that the data necessary for good water management be available and reliable.

b) Because of the many types of climate, different parent materials and ages of formation, Ecuador has a wide range of soils. In general, these resources are excellent if properly managed. There is need for more detailed soil mapping and study. No irrigation projects should be initiated without a detailed soil map being developed with agronomic interpretations. Close working relationships between INERHI and the Soils Department of INIAP is required.

c) The Team recommends that a research unit in soil and water management be cooperatively established at several regional locations by INERHI and INIAP; that donor funding be obtained for long term assistance for appropriate training in all aspects of irrigation system design and water management; and that all levels of personnel, administrative, technical, project managers, extensionists, and agriculturalists receive training in the broad cross disciplinary nature of water management relevant to conditions in Ecuador. This is necessary in order to carry out the above recommendations.

d) In addition to the research on new application technologies described in the previous section, applied research concerning crop, soil, water, weather, fertility interactions and erosion control, is critically needed. The Team recommends that INERHI be responsible for the adaptive research concerning hardware components with the cooperation of INIAP in selecting crop materials and husbandry practices. INIAP should be responsible for the crop variety selection soil-water-weather-fertility applied research with the cooperation of INERHI in advising on and setting up the irrigation inputs. INERHI should take the lead with assistance from INIAP in conducting adaptive research to pinpoint water requirements of various basic crops.

e) In order to transfer both the directly adaptable and adapted water management technologies, training is needed at almost all levels. Furthermore, training is needed in research methods, system monitoring, multidisciplinary system diagnostics, and system design (especially at the farm level). The Team recommends that INERHI take the lead in the basic water management training for professionals and technicians. The INERHI/USU Water Management technology transfer Project Proposal which is currently under consideration for USAID Title XII funding gives a detailed description of the kind of training needed for transfer. We also recommend that the Multidisciplinary Diagnostic Analysis training program developed by and available from the USAID Water Management Synthesis Project be solicited and utilized. Finally, the Team recommends that IICA take the lead with assistance from INERHI in adapting water management training materials for presentation to farmers.

7. Future Food Supplies, Rural Incomes Policy and Public Investment.

a) Rough calculations of year 2000 supply/demand balance indicates potential for considerable corn supplies and a real possibility of substantial shortages in potatoes. Corn production might be substituted for predicted shortfalls in wheat supplies. The Team recommends that a thorough investigation be made of the future domestic demand for food and fiber production and of the potential future international demand for Ecuador's crop and livestock exports. The results of such a study should be incorporated into any national plan involving agriculture output targets and be used to screen the specific objectives to be achieved.

b) Rural families can only improve their family incomes through agricultural pursuits if production incentives are open and accessible. If there are constraints imposed by tenure arrangements, lack of sustained markets or otherwise, farmers will not be successful even if they have the infrastructure of a well designed irrigation project to back them up. The Team concurs with the suggestion made by a number of observers that national food marketing, price controls, subsidy and taxing policies should be re-evaluated with a view to eliminating such absolute economic contradictions as exist, while altering the remaining policies to eliminate mutually inconsistent social and production incentives. What is needed in each step of rural development is a clear indication of whether welfare or production goals are paramount; only then is it possible to design the particular public intervention (such as irrigation projects) necessary to achieve the goal.

c) Much higher yields, within the general structure of the existing land and water system, technically are achievable (as noted there may be considerable social and institutional barriers). It may be expensive to make major additions to this system and capital is scarce. Public money spent in the Sierra for irrigation should aim at regulating the use, protection, and administration of the highland water resources and social environment of the present system. Large investments connected with production enhancement probably should be concentrated in the Costa. Rainfed production can be increased in terms of yields and area exploited, at possibly lower cost per unit of output increase. In the long run additional irrigation projects may be feasible (as compared to alternatives) if the land holding and general agriculture and social policy of the nation has altered enough to create a genuine probability of high monetary returns to farm families and that the nation will recover the costs of such expensive undertakings.

II. RURAL DEVELOPMENT, MARKETS FOR AGRICULTURE PRODUCTS AND IRRIGATION INVESTMENT

SOME GENERALIZED LESSONS OF RURAL DEVELOPMENT[1]

Growth with Equity

The earliest thinking about national development tended to concentrate on the role of industry as the driving force and upon the need for the agriculture sector to generate much of the savings necessary to complete the transformation process, at the sacrifice of the sector's own progress. Later models emphasized the notion that the agriculture sector had to be brought along in order to guarantee demand for domestic manufactures sufficient to make the overall development process self-sustaining.

Meanwhile, whatever the route followed, the general experience in the third world has been rapidly expanding urban development, in conjunction with widening of the real gap between urban and rural incomes and standards of living. The argument of the early 1970's was that, despite expenditure of a lot of money and effort, the poorer classes were not benefiting from whatever development had taken place. International donor agencies, by one means or another, inaugurated schemes to ensure that development project benefits would be directed to the "poorest of the poor."

The practical expression of this aim at the local and farm level, is captured in the concept of integrated rural development or the necessity to think in terms of farming systems. Both concepts presumably operate to minimize the day-to-day conflicts and confusions brought about by national governments' long-standing inability or unwillingness to separate crop and livestock production from welfare goals and failure to recognize that it may be impossible to reach both at the same time, or, to put it another way, that policies to enhance agriculture sector output are often mutually inconsistent with policies designed to enhance local rural welfare.

For example, community development actions may or may not increase crop output, but governments tended to support such efforts in earlier times because they were relatively inexpensive and conferred political advantages. At the same time the most obvious way to achieve production

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[1] This description applies to most or all of Latin America, that is, to nations which readily could be self-sufficient in food production. In certain Asian or African nations, any and all production increases are to be welcomed, at least in the short run. In Latin America this <u>may not</u> be the case.

increases is to use the most modern and cheapest per unit techniques available under the circumstances. (This may focus reliance upon commercial farmers.) At the national level, the attempt to move in two different directions at the same time is encountered in regulations to control urban food prices at low levels (thereby holding down the apparent cost of living) coupled with attempts to stimulate farmers' efforts through crop and livestock subsidy programs. Since price controls may or may not be extended into rural areas, there may be no trade-off in the form of holding down the cost of living in rural areas as well.

An immediate consequence of what is happening throughout the third world is that international as well as domestic development efforts to alter the welfare of the poor are being subverted by subsidy of urban living standards. Unless a country is floating on a sea of petroleum or has an endless credit line to external financial sources, it is impossible to afford perpetuation of such contradictory policies for extended periods of time. A denial of this conclusion would have to rest upon a belief that third world countries structurally are able to create environments of ever increasing welfare and economic growth at real resource costs below those experienced in the rest of the world!

Elasticity of Demand for Food

The most general function of marginal agriculture is to feed both the rural and urban populations with fruits, vegetables and some meat, grain, potatoes, etc. In any situation where people are not starving in the streets, it is impossible at a given moment to increase supplies very much without creating a market glut. The domestic absorptive capacity is low because the poor (which make up the bulk of the population) support themselves through consumption of their own production, some sales or barter, or have limited amounts of money to spend on food, and any slack in the system is pretty much limited to the purchasing flexibility enjoyed by the wealthier classes in urban areas.

It only takes so much food to fill a given number of stomachs. This fact is reflected in the general coefficient of the price elasticity of demand for food is < 1; an increase in selling volume lowers not just prices, but also reduces the absolute magnitude of agriculture sector income. Therefore, reasoning that new inputs equal higher output equals higher rural income, can be dangerous even if the policy contradictions cited above are totally absent. Imagine a typical agriculture "production" project. In order to get the benefits high enough to "pay for" the new and higher priced inputs (read: cover their social cost), it is necessary to get the farmers to put greater emphasis upon vegetables or fruits where the returns per acre are higher than for traditional crops. In other words, farmers are pushed into the very crops which are most sensitive to market forces.

This doesn't necessarily mean an individual project of this nature will not generate some higher local income. But, if it is successful a new problem emerges: how much replication can the market tolerate? Is it simultaneously possible for all farmers to be paying for new production inputs by greater sales or by higher valued sales?

It is obvious that projects which have been lauded in development literature as success stories cannot be duplicated nationwide except at rather slow rates. If the Visosa experience, for example, had been successfully replicated throughout the length of Peru, that country now would be awash in specialized crops that have no buyers.

Normally there will be some potential or unrealized domestic demand in a simple marketing system. It may be possible to substitute out some imports or there may be some scope for increased food processing. However, unless there is a great deal of food being imported, such potential should not be given much weight. This is because the "slack" is probably on the order of 10 percent (value terms) of total food consumption and because the imports may be an indication the nation suffers from some comparative disadvantage which will not automatically go away. The long run domestic absorptive capacity should be analyzed mostly in terms of a steady expansion in demand due to growth in population and concurrent growth in percapita disposable income.

Thus, in the first instance, we may imagine potential for a one time substitution for current food imports coupled with continuing annual growth in food and fiber demand of about 4 percent.[1] Any production increases above such levels threaten drastic price repercussions unless the domestic surplus can be exported.

Technology in Rural Development

Successful technology introduction reduces the unit costs of production on existing land or opens the way to exploit marginal land. Given that the area of land farmed is not reduced, successful introduction of technology means that total output rises, prices fall and farmers who are unable to get their costs into line are driven off the land. This is the classic pattern of rural development. The only way for individual farm families to raise their incomes via greater production is for fewer families to share total sector income. If good export markets are involved in the process, sector income can rise for some period of time without a corresponding reduction in the number of farm households.

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[1] Import substitution programs absorb some domestic resources so that net benefits are less than the value of the imports being substituted.

Dissemination and adoption of the results of investment in research and development is the process by which farming costs per unit of output are reduced (increase individual family output). Output can be increased in other ways such as by exploiting underutilized land and water resources. Such utilization may require R&D as well, but the new knowledge alone may not justify farming marginal lands unless there is reasonable expectation of higher real selling prices in the future. In fact, in the absence of subsidies, higher prices would almost always be a requirement before moving to more marginal land.[1] The same might not be necessary for development of an enlarged water supply; it all depends on the actual situation, i.e., what irrigation R&D can really do to reduce unit costs.

In situations of fundamentally adequate land and water resources, virtually all farm programs, other than R&D, of whatever nature, are linked to lack of domestic demand (over production). By definition they include a primary welfare component that attempts to prop up income levels and thereby hold greater numbers of farmers on the land. It is true that such programs may be implemented in a manner that impacts upon production decisions with the result that, in many cases, larger, wealthier farmers obtain the benefits of the public subsidy and the actual targets of the program are not helped. Examples are price supports, certain government product purchasing programs, or marketing boards whose operation prevents long term adjustment of the farm sector to market and comparative advantage realities.

South American nations fall between these program extremes: some cost reducing, production enhancing, benefits of R&D are obtained, but output increases are also sought by production subsidies which may not be particularly intended for welfare purposes at all. The end result is the same, however: any public subsidy, if allowed to be transmitted through the economic system, tends to raise consumer prices and to that degree offsets long run benefits of lower consumer prices conferred on society by voluntary adoption of new technology by farmers. (None of the above is directed at strictly price stabilizing operations based upon marketing orders or purchase/sell operations that operate as intended.)

In the case of some export crops, there is a third varient of government intervention into free markets that is analogous to land or income taxes. The object is dis-welfare of the rural sector for the perceived greater good of society. Revenue sources such as an export

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[1]The general society may be willing to bear the costs of subsidy for other than production reasons (as in the USA) or, the potential production may be desired (as in some third world situations where subsidy is utilized to call forth more output).

tax or centralized government purchases or marketing of exports mean the farm sector does not receive the benefit of international prices. This revenue source is only available where the nation's comparative advantage is positive.

ANALYSIS OF RURAL STRATEGY IN ECUADOR

The Highlands

In the Sierra, mere availability of some new technological package may not make the farmers react because what is offered may be too costly in terms of time and effort and ignores dis-economies of scale, or because it does nothing to satisfy the real necessity for open and cheap commercial channels and the incentives of free prices as urban demand grows, or because the tenure pattern is unsatisfactory.

It is very possible that no amount of technical assistance will overcome the current disincentives in pricing and marketing. If new inputs include irrigation water, the problem may be compounded by the way water supplies are administered.[1]

It is true that farmers may increase output somewhat to better feed themselves and their animals if they are able to adopt some new ideas, and this may be worthwhile even if little commercial impact is obtained from a technical assistance program. However, at the present time it is estimated that 60 to 85 percent of small plot holders work off-farm and many are so engaged 60 percent of their time. (Q) Therefore, potential benefits of new technology must at least equal or exceed the annual sum of the daily wages that are available in other pursuits. (This phenomena may be playing a role in the slow rate of spontaneous colonization.)

Irrigation components may be at a relative disadvantage because projects may be costly if difficult terrain and complicated access problems must be overcome. To get the benefit/cost ratio into an acceptable range, planners have to assume that farmers can be induced to move into production of "higher priced" fruit and vegetable crops which in turn require more precise management practices as well as reliable

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[1] The best rule for going into new projects would be that they be able to stand economic scrutiny on the basis of increased production of traditional crops (where meeting domestic demand is involved). Then, if more valuable crops are actually produced as a result of firmer water supplies or whatever, so much the better. Projects designed to support the export crop and livestock sub-sector should be realistically geared to trends in international prices and fundamental demands.

and timely delivery of all the other needed new and expensive inputs to make the whole thing work.

These observations suggest that any public effort focused on integrated rural development should be viewed from the start as having the potential to develop into only a general welfare scheme, since production benefits may not materialize at the national level.

In summary it may be difficult to increase the incomes of poor farmers in the Sierra until some fundamental alterations are made in the region's social and economic structure. Meanwhile population growth will put more and more pressure on traditional or even improved farming systems due to a worsening man/land ratio among small plot holders.

The Frontiers

Successful land tenure and colonization programs do not have to be measured in terms of large output increases or large increases in per family incomes. Opening up new lands has the advantage of making subsistence easier for a growing (landless or *minifundista*) population in the short-run; in the long run it opens the door to potential enhancement of family wealth positions. As many experts have observed, Ecuador could benefit to a considerable degree by building roads and rudimentary infrastructure into areas suitable for colonization. All manner of families are thereby put in better position to benefit from any windfall gains that such infrastructure creates in the form of demand for land. Eventually, such families may become more productive as well. Besides roads, adequate money should be spent immediately on cadastral surveys, up-to-date land records and straightforward and rapid land titling.

Frontier lands should be held by the nation as a means for inducing settlement of small farmers. Lands should not be parcelled out in large segments in a capricious way. Grants of any sizable blocks should involve a guarantee to the nation of highly commercial production and some genuine hope of creating employment opportunities.

The Western Lowlands

Although the *Costa* is a relatively flat area, there are some technical problems to solve before it can be fully productive. Nevertheless its overall potential for agriculture has "barely been scratched." (C, p. 177) At present some dynamic developments are occurring in rice production technology, in movement to tobacco production and in livestock husbandry.

Approximately one-half the nation's population resides in this region so there is ample scope for many small farmers to better their position as primary producers of such export crops as cocoa, coffee and banana. Any expansion of output, though of great benefit to the region and to the nation, is unlikely to push world prices down.

It is true, of course, that producers of export crops are at the mercy of the vagaries of international prices. However, the comparative and even absolute advantage Ecuador enjoys is great enough to cushion some export taxes on such crops; at the same time there is scope for improving export quality, and a sure knowledge that such improvements will be rewarded in the international marketplace.

At present, there is little doubt that many Costa farmers are still quite poor, but there is more opportunity (relative to the Sierra) to alter methods of operation such as by renting land, registering water rights (in some instances), developing private water supplies, etc. The historical evidence to support this conclusion is clear cut; a) average small plot sizes exceed those of the Sierra; b) many small farmers are in cooperative arrangements and have access to extra land; c) some of the rice production cooperative arrangements have been instrumental in the dramatic switch from upland to paddy production; and d) as a consequence of the possibilities for credit and effective resource management practices such social arrangements have caused dramatic alteration in cultivation of an important food and potential export crop.[1] This experience can be repeated for other agricultural products, even exports.

All in all, the Costa is the zone that can produce the necessary agricultural production for domestic and international markets in the most direct way with the least pressure on scarce resources relative to potential national benefit. (Obviously, a crop in short supply such as wheat cannot be grown in the very lowlands, but many other crops can be

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[1] Several factors all fell into place at an opportune time: a lot of technology had been demonstrated by larger commercial farmers who initiated the paddy method over 10 years ago; the technical information was available, and enough engineering and specialized machinery companies, competing for land leveling and tree removal business, came into the picture. (All cost data collected by the team concerning the tree removal step indicated that it is a cheap operation relative to expected benefits.) It is, therefore, possible to prepare significant sized pieces of land in a short period of time. Credit for the land conversion is available and the organization and techniques for lifting and distributing river water are well worked out. Most important of all, there is a good domestic (and contraband) market for rice.

grown and sold to earn foreign exchange to import all the wheat necessary.)[1] There is considerable potential to raise farm family incomes and general welfare in the Costa because there is market potential for the increased outputs that could be achieved by introduction of better technology which pays for itself directly through private pocketbooks or adds enough real increment to national and regional GDP to off-set any social investment that has been made. Moreover, many more farm families can be absorbed in the region (in a colonization sense) and can create a reasonable life style with minimal infrastructure support in the initial stages.

Irrigation Policy

The implications for irrigation policy of the preceding overview of the range of agricultural development choices are easily detailed:

1. Substantial public investment in traditional irrigation projects in the Sierra (with the objective of increasing production) should be carefully analyzed. Large investments connected with production enhancement should be concentrated in the Costa. (There seems to be scope to utilize the water resources of the lowlands in such a way as to obtain marketing and social benefits over and above the initial resource investments which the larger society must shoulder to foster development objectives.)

2. Public money spent in the Sierra for irrigation should aim at regulating the use, protection, and administration of the highland water resources. Much higher yields within the general structure of the existing land and water system are possible. Such increases coupled with additional output from the Costa should cover growth of internal demand. This conclusion assumes that considerably more social benefit can be obtained from the large amount of private irrigation works already in place. In the long-run some new highland irrigation projects may be feasible if the land holding and general social policy of the nation has altered enough to create a genuine probability of high monetary returns to cover the costs of such expensive undertakings.

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[1]Part of the present short-fall in national wheat production is a direct consequence of pricing/subsidy policies. The very process of artificially depressing bread prices has the effect of increasing the quantity demand of this popular grain and retards the grain substitution process that otherwise would be occurring. In fact, there is no good way Ecuador can satisfy domestic wheat demand except at a real resource cost far out of proportion to nations having agroclimatic conditions more suited to its production. This situation is unlikely to change for a very long time.

FOOD DEMANDS AND LAND CAPABILITY IN YEAR 2000

Rapid population growth in Ecuador means that there will be steady growth in markets for food products over the long-term, at a rate which will absorb most of any normal growth in agricultural supplies. This domestic market demand plus any pressure to increase exports of crop and livestock products can be met by expanding onto presently uncultivated land or by increasing yields, or both. In this section some rough calculations are presented to estimate how well existing cultivated land could supply the growth in domestic demand for the main food products if achievable yields are assumed to be obtained in the future.

Demand for Food

INERHI's current long term planning document, initially drafted in June of 1979 (R), contains a wide range of estimates of the potential production shortfalls that would exist if certain diet requirements were to be met in the future. Table 2-1 shows the particular estimates chosen by INERHI as the example upon which discussion is centered in the main body of the planning report. This example indicates the "deficits" that would have to be made up by the year 2000 to achieve the nutritional levels of 2500 calories per day, based on a diet pattern as recommended by nutritional experts. The results are interpreted to indicate a need for "extraordinary" augmentation of output to satisfy domestic and international markets (R, Annex V, p. 25).[1] Whether the proposed diet pattern of the chosen example represents the most likely shape of the future is a matter of conjecture. It is quite useful, however, because the results clearly show that a marked change in product emphasis would have to take place (legumes and dairy output). Even though alterations in tastes and preferences come about rather slowly, twenty one years is a long time (1979-2000) and such shifts are certainly possible.

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[1] Based on current yields, the INERHI report estimates a need for the equivalent of 1,662,400 ha of additional land. If 1 million ha is provided by opening up new land, the residual of 662,400 equivalent hectares needs to be obtained from dry season production. Allowing for 25 to 30 percent higher irrigated yields the equivalent figure becomes 474,300 ha. To this must be added 500,000 ha of irrigated pasture. The sum, 974,300 hectares is a rough estimate of needed equivalent of new irrigation. Of this total, INERHI proposes 500,000 equivalent from its own program, 350,000 from other public institutions (such as CEDEGE) and 124,300 ha from private investment. The INERHI calculations are a clear illustration of the need to improve yields by 100 percent or more. Yield increases are an important way to avoid the need for such tremendous capital investments.

TABLE 2.1. Areas and Volumes of Agricultural Production as Estimated by the Ministry of Agriculture and INERHI.

Product	Area 1977 M.A.G. 1000 ha	Gross 1977 Production M.A.G. 1000 MT	Average Yield 1977 M.A.G. MT/ha	Yr 2000 Reqmt INERHI 1000 MT	Yr 2000 Area Reqmt 1000 ha	Avg Yield Under Irrig MT/ha	Equiv Area w/Irrig 1000 ha
Cereals	455.5	627.9	1,378	876.0	635.7	1.873	467.7
Legumes	85.9	39.6	461	437.0	947.9	0.760	575.0
Vegetables	12.9	166.5	12,906	500.0	38.8	17.000	29.4
Tubers	69.3	652.0	9,412	876.0	93.1	12.000	73.0
Fruits	251.5	4,170.3	16,562	4,170.3	251.8[2]	21.000	198.6
Coffee/cocoa	499.3	161.3	323	272.0	842.1	0.420	647.6
Oil seeds	58.6	211.6	3,612	726.4	201.1	4.700	154.6
Sugarcane	109.3	7,518.0	68,873	13,397.0[1]	194.5	88.000	152.3
TOTAL	1,542.6				3,205.0		2,298.2

[1] The demand for sugar has been transformed into tons of cane.

[2] The demand for bananas is not expected to grow, thus the area is not changed.

Source: K, Table III.2

A more typical way to estimate future demand is to begin with current consumption patterns and then allow for population growth and the influence of rising incomes on the future pattern of consumption. In addition, if trends in supply plus accumulating effects of newer technology are taken into account, some indication of positive or negative demand/supply gaps may be obtained for selected points of time in the future. It may be possible to design public programs to reduce or eliminate the worst of the forecast extremes.

The simple, rough projections contained in this section are designed to add some information (beyond that of the INERHI study) about supply/demand gaps in the year 2000. Of course, the results are only indicative of what might occur in the future. Better data and a shorter forecast horizon would improve the accuracy a great deal, but the results are accurate enough to illustrate the importance of some reasonable forecasts if public funds are going to be invested in rural development projects. Such forecasts also have the virtue of highlighting what accomplishments have actually been obtained from investments of public funds made in earlier times.

For purposes of this report only crude estimates of income elasticity of demand coefficients are utilized because accurate calculations for Ecuador could not be located within the statistical sources available to the study team. Official estimates of trends in disposable incomes also could not be located, so 90 percent of gross domestic product is used as an approximation. The key variable, of course, is the rate of growth of population; official estimates and projections are readily available.

The estimate of future demand for any product is calculated from the following relationship:

$$c_0 \left(\frac{y_i}{y_0}\right) P_i = C_i$$

where,

c_0 = per capita consumption in base year.

$\frac{y_i}{y_0}$ = total increase in growth of per capita disposable income between year o and the selected target year, i.

P_i = population estimate for the target year, i.

C_i = forecast total consumption in the target year, i.

η = coefficient of income elasticity of demand.

Estimates of population growth are available from the Centro de Analisis Demografico. These cover the years 1974-1986. Study team estimates through the year 2000 are shown in Table 2-2.

TABLE 2-2. Estimated Population, Ecuador 1974-2000 (1,000)

Year	Urban	Rural	Total
1974	2811	4019	6830
1980	3640	4714	7500
1990	5606.	6124	11730
2000	8626	7963	16589

Source: Adapted from (L), p. 196. Projections are by WMS Team.

Growth in disposable income is estimated from data reported by the Ministry of Finance and the Central Bank. As a first approximation, disposable income is estimated at 90 percent of gross domestic product. GDP data 1972-1982 were extrapolated by the method of least squares using linear and exponential functions. The final estimates shown in Table 2-3 are approximate averages of the two methods.

TABLE 2-3. Indicative Projections of Ecuador per Capita Disposable Income (1975-2000)

Year	s/x 10^9 (in constant 1975 prices)	$\frac{y_i}{y_o}$
1975	13,003	--
1990	19,182	1.475
1995	21,607	1.662
2000	22,244	1.711

Source: Adapted from (B), Table V. Projections are by WMS Team.

Current per capita consumption of agricultural products are available from the Agricultural Section of the U.S. Embassy.[1] These 1980-81 estimates are treated as being unchanged from 1975. This assumption is reasonable since consumption patterns change slowly through time, and it probably does have the general effect of making forecast demands slightly more conservative. Table 2-4 contains these consumption values.

Also included in Table 2-4 are the Team's estimates of coefficients of income elasticities for various food products (η). The values are based on past experience with coefficients calculated for other Andean countries. The main part of the table consists of forecasts of future consumption demand in the years 1990 and 2000. In the case of industrial crops, no coefficients are available so the forecasts are the result of simply doubling current consumption estimates since population is e[illegible]ted to double by the year 2000.

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[1] These estimates utilize import/export figures that the USU Team was able to cross-check for general accuracy from other sources. The U.S. Embassy estimates also make some allowance for beginning and ending stocks to arrive at values for apparent consumption. See Appendix Table F-4 for detailed version of the Embassy data.

TABLE 2-4. Estimates of 1980-81 Consumption, Income Elasticities of Demand and Potential Demand for Food and Livestock Products (1,000 MT).

Commodity	Cons Kg/Cap		Cons 1,000 MT	Future Consumption 1990	Future Consumption 2000
Abaca	.024	1.0	.2	.41	.68
Bananas	11.6	.2	96	147.06	214.24
Cocoa	.44	.5	3.65	6.41	11.15
Coffee M.Bag	1.73	.4	0.23	.20	.35
Cotton	1.36	1.0	11.3	23.53	38.59
Pyrethrum					
Sugar	37.7	.1	312	496.90	734.70
Molasses	7.9	.1	65.5	104.12	153.95
Tobacco	0.46	1.2	3.8	8.60	14.53
Barley	7.8	.1	69.5	95.11	136.53
Corn	3.8	.2	242	48.17	70.18
Oats	3.5	.1	28.5	42.68	61.26
Rice	23	.6	218.8	340.64	526.55
Sorghum	.1	.1	1	1.21	1.75
Wheat	38.8	.2	330	491.9	71.66
Lentils	7.8	.2	6.35	98.88	144.06
Potatoes	62.7	.4	520	859.17	1289.29
Castor Bean			10.3		20.6
Castor Oil			0.1		0.2
Castor Meal					
Cotton Seed			20.5		41.0
Cotton Meal			7.2		14.4
Cotton Oil			3.1		6.2
Palm			95.0		190.0
Palm Oil			42.2		84.4
Palmiste			11.4		22.8
Palmiste Meal			4.3		8.6
Palmiste Oil			5.2		10.4
Peanuts			2.7		5.4
Peanut Oil	.12	.8	1.1	1.92	3.05
Peanut Meal			1.5		2.2
Sesame			0.5		3.0
Soybean			47.5		1.0
Soybean Oil			39.1		95.0
Soybean Meal			37.7		78.2
Fish Oil			24.0		75.4
Fish Meal			20		48.0
Lard	2.3	.5	19.3	32.76	49,90
Tallow	2.5	.4	20.8	34.25	51,40
Wool	0.37	1.5	3.1	7.77	13.73
Hides	2.5	1.8	20.7	55.02	109.00
Beef	11.5	.5	95.3	151.65	248.73
Pork	6.3	3.3	52.2	84.0	136.26
Goat	0.5	.5	4.5	6.78	10.81
Lamb	0.67	.5	5.1	8.47	14.49
Milk ML	69	.8	574	1000.98	1775.32
Eggs M	157	.1	1217	2513.22	4001.75
Poultry	4.3	.8	36.7	64.54	109.05

Source: Basic data adapted from Appendix Table D.4; values for are team estimates based on similar Bolivian and Peruvian data.

Some of the food products are processed or semi-processed; their forecast demands must be converted to raw form in order to compare demands with trends in the supply of raw products. The necessary raw product equivalents are estimated in Table 2-5. In addition, the apparent consumption demand must be adjusted for waste, seed requirements, or average crop and livestock losses. The assumed correction percentages are taken from INERHI estimates as given in Table 2-1 above. In some cases they have been adjusted somewhat; the final values utilized are shown in column 2 of Table 2-5.

Trends in Agriculture Supply and Estimates of Ecuador Land Capability

The production trends in important crop and livestock products are tabulated in Appendix E (Tables E-6 and E-7). Extrapolation of these trends are shown in Table 2-6.

In a number of cases, such as wheat and barley, reported production has declined during recent years. As a consequence, extrapolation of trends leads to low or even negative estimates of production, that is, to unlikely or impossible results. In such cases, a purely arbitrary estimate is made of what the future might hold (see Table 2-6 notes). These estimates take into consideration past reports of the highest levels of production, the type of crop and probable domestic and export trends and comparative advantage of Ecuador production (in the case of bananas). These arbitrary estimates are shown in the righthand column of Table 2-6 (data from Table 2-6 are shown in column 6 of Table 2-8).

Obviously, long-term extrapolations have much to be desired. What is needed is an additional estimate of supply potentials to compare with linear extrapolations. The potentials chosen are based on estimates of possible supplies that could materialize if better techniques were employed by Ecuadorian farmers. The estimates are developed in Table 2-7. The supposition is made that increased yields are attainable on lands currently used for each named crop. (The amounts and general location of such lands are as shown in Appendix Table E-13.) In this calculation no allowance is made for the likelihood that some crop areas will be increased whereas others will fall, but that on balance the overall hectarage cultivated will probably expand. The only question asked is this: could existing lands reasonably satisfy the food and fibre demands in the year 2000 with little or no change in current land use patterns (except for application of better technology and farm management)?

The assumed yields utilized in the calculations of Table 2-7 are those currently being obtained on Ecuadorian experiment stations and by the better farmers in the country. This simple test supposes that all farmers could reach such yield levels over the course of the next 18

TABLE 2-5. Estimated Raw Product Equivalents of Year 2000 Consumption Prediction - Ecuador (1000 MT)

Food Product	Future Food Product Consumption Demand	f	Future Raw Production Demand	Raw Product
Sugar	734.7	1:16	13,140.3	Sugar Cane
Molasses	153.9	1:9		
Castor (Products)	20.6	1:1	20.6+	Castor Bean
Castor Oil		1:4		
Castor Meal		1:1.3		
Cotton(unginned)		1:1	8.2	Cotton (ungin)
Cotton Lint	26	1:3.15		
Cotton Seed	41	1:1.45		
Cotton Oil	6.2	1:7.14		
Cotton Meal	14.4	1:1.25		
Cocoa Bean	11.6	1:1.2	13.9	Cocoa
Soybean	95	1:1	742.1	Soybean
Soy Oil	78.2	1:7.14		
Soy Meal	75.4	1:1.18		
Peanuts	5.4	1:1	17.3	Peanut
Peanut Oil	3.05	1:2.7		
Peanut Meal	2.2	1:1.6		
Palm (Products)	190	1:1.3	247.0+	African Palm
Palm Oil				
Palmiste				
Palmiste Oil				
Palmiste Meal				
Coffee	35.4	1:3	106.2	Coffee (green)
Sesame Oil	3.0	1:35	10.5	Sesame seed
Beef	248.7	1:5.7	1,421.4	Cattle (1,000)
Poultry	109.0	1:870	94,782.6	Fowl (1,000)
Pork	136.3	1:28.6	3,894.3	Hogs (1,000)
Milk (1,000 lt)	1,445.1	1.02 L/kg	1,488.2	Milk
Eggs (1,000 ea)	4,001.7	20/kg	200.1	Eggs

Source: Conversion factor (f) from Source (J) and (R); data in column 2 from Table 3-4.

TABLE 2-6. Linear Extrapolation of Trend in Agriculture Supply

	Trend	1,000 MT 1990	2000	Arbitrary Estimate
EXPORT[1]				
Sugarcane	+	4,861	5,747	
Coffee	+	89	98	
Cacao	+	107	130	
Bananas	-	(1,578)	(960)	1,400
INDUSTRIAL				
Cotton	+	62	87	
Hemp	+	27	39	
Tobacco	+	4.6	6.3	
Africa Palm	+	381	568	
Soy Beans	+	63	104	
Peanuts	+	22	28	
Sesame	-	(1)	(2)	
Castor Bean	-	-	-	
DOMESTIC				
Rice	+	568	798	
Wheat	-	(8)	(48)	50
Corn	-	(22)	(198)	
Barley	-	(0)	(10)	80
Potatoes	-	(30)	(261)	700
Cabbage	-	-	-	120
Tomatoes	-	-	-	80
Cassava	-	-	-	600
Plantains	-	-	-	
Oranges	-	-	-	
LIVESTOCK				
Beef & Veal	+	102	129	
Mutton & Lamb		-	-	
Pork		-	-	40
Milk	+	828	962	

Source: Tables E-6 and E-7, Appendix E

[1] Assumptions about future export.

Sugar (sugarcane)

Some sugar is exported but in recent times the harvest has more or less only satisfied domestic consumption. Only a relatively small amount is assumed by the INERHI demand study to be available for export in the year 2000 (about 90-100 thousand metric tons). This is about 1,441 thousand MT of sugarcane equivalent.

Banana

Little or no growth in absolute weight exported per annum between 1967 and 1978. (The linear trend during 1967-78 is slightly negative; this should turn around in the future.) We assume a growth more or less equal to growth in world demand and upon the notion that Ecuador will bring more quality control into the picture (1.5 percent per year). Based on the 76-78 average of about 1,180,000 tons, the 1990 estimate is 1,330,446 tons and 2000 is 1,470,370 MT.

Cocoa

The long-run 1967-81 trend was also slightly negative, so that extrapolation is not used. Cocoa should have an overall upward trend in world demand. Ecuador quality is good but yields are very low. In the long-run a lot more cocoa could be sold, since sales in several years during the early 1970's were three or more times those of 1976-78. 1981 exports were estimated at 76,000 MT (B). Exports could average 80,000 by 1980 and 90,000 by 2000.

Coffee

There has been a steady growth in coffee exports. The 1967-78 trend suggests sales of 119,096 in 1990 and 152,020 in 2000.

TABLE 2-7. Estimated Effect of Improved Yields on Current Land Areas Dedicated to Selected Crops

Product	Area of Major Crops* Irrigated	Area of Major Crops* Rainfed	Attainable Improved Yield (MT/ha) Irrigated	Attainable Improved Yield (MT/ha) Rainfed	Potential Production 1000 MT
Cereals					
Rice	60**	70	7.0**	2.5	595
Wheat	0	36		2.7	97
Barley	0	52		2.2	114
Corn	33	225	6.2	2.4	744
Other		4		2.5	18
Legumes					
Beans	10	60	2.1	0.9	75
Peas	3	14	1.6	0.8	16
Oil Seeds					
Cotton seed	6	20	1.1	0.9	25
Soybean	5	20	2.8	1.7	48
Palm	3	20	3.2	1.2	336
Peanut	8	9	3.2	2.1	44
Roots, Tubers					
Potatoes	21	17	35	18	933
Yuca	0	25		22	550
Fruits					
Plantains	25	25	30	19	1225
Other	35	21	27	16	1281
Vegetables	6	5	29	17	259
Exports					
Bananas	60	60	33	21	3240
Coffee	0	272		0.7	180
Cocoa	95	137	1.4	0.7	229
Sugar Cane	60	40	112	67	9400

* Based on Table E.13.

** Estimated Average 1.5 crops/year.

years. The yields selected and the related total potential production are shown in Table 2-7. (The potential production estimates shown are the weighted impacts of irrigated and non-irrigated land as listed.) Finally, the calculations of Table 2-7 are transferred to Table 2-8. They are shown in column 7 of that table.

Indicative Supply/Demand Balance in Year 2000

Table 2-8 brings together the key elements of the INERHI nutritional demand requirements along with the USU team demand projections based upon effects of population and per capita income growth. Also included are the supply trends and land capability data as described in the proceeding section. Indications of possible future shortfalls or surpluses are shown in columns 9 and 10.

In many instances, the Team's demand forecasts are as great or greater than the INERHI forecasts based on meeting specified nutritional needs (Table 2-1). Unfortunately, no comparisons are possible in the cases of legumes and vegetables (where the reverse would probably be the case) because insufficient consumption data were available upon which to base any projections. The Team's projections for milk are much lower than the nutritional demand requirement, and the projected demands for beef and pork are somewhat lower. The data for current banana consumption (domestic) as shown in source (0) appear to be quite low. On the other hand, the consumption estimates for all fruits have been taken from the INERHI analysis and, although five times as high as the Embassy data (Table 2-4), probably result in a far better picture of the future for fruit consumption.

To the degree possible, all the study team's demand forecasts are compared with the long run supply trends and the estimated land capability potential as given in columns 7 and 8. The resulting shortfalls or surpluses are shown in columns 9 and 10. In some cases projected levels of exports are subtracted from the supply estimates before the net result is calculated.

In the case of rice, it appears that further expansion of areas devoted to this crop, added to improved technology, should keep Ecuador self-sufficient. The country can easily be self-sufficient in corn. Wheat and barley are a different matter because Ecuador is at a comparative disadvantage in growing these crops relative to world markets. Only large, expensive public expenditures could cure the projected deficits.

The projected shortfalls in tubers give warning that additional land area may be needed for these crops. Data for legumes, vegetables and most fruits are not adequate for discussion of future probabilities.

TABLE 2-8. Year 2000 Indicative Supply/Demand Balances for Selected Agriculture Products - Ecuador (1000 MT)

Selected Crops	Future Consumpt. Domestic	Seed Losses %	Demand at Farm Level: MAG (INERHI)	Demand at Farm Level: WMS Team	Supply: Trend	Supply: Possible	Allowance for Export Trend	Shortfalls/ Surpluses[1] (∓): Trend	Shortfalls/ Surpluses[1] (∓): Possible
1	2	3	4	5	6	7	8	9	
Cereals									
Rice	526	30	716	684	798	595		+114	- 89
Wheat	716	20		859	50	97		-809	-762
Barley	136	30		177	80	114		- 97	- 63
Corn	70	25		87	198	744		+111	+657
Other					--	18		--	--
Tubers		33	876						
Potatoes	1289	20		1547	700	933		-847	-614
Yucca	650	20		780	600	550		-780	-230
Legumes		22	437						
Peas	--					75			
Beans	--					16			
Vegetables		15	500			259			
Tomatoes					80				
Cabbage					120				
Fruits (All)	3043		4170						
Plantains	640	37	900	876	--	1225		--	+348
Other	703	20	843	--	--	1281		--	+437
Oil Seeds		--	726						
Cotton seed	82	10		90	87	25		- 3	- 65
Soy	742	10		816	104	48		-712	-768
Palm	190	--		190	568	336		+378	- 46
Peanut	17	10		21	28	44		+ 7	+ 21
Export									
Bananas	640	37	2427	2891	1400	3240	1470[2]	-1491	+349
Coffee	60.8	6	103	226	99	190	152	-127	- 36
Cocoa	13.9	6		121	130	229	100	+9.0	+ 108
Sugarcane	13,140.3	32	13,397	19,247	5,747	9400	1441	-13,500	-9279
Meat, Dairy									
Beef			383	326	129	--		- 197	--
Pork			243	177	40	--		- 137	--
Poultry			65	136	--	--		--	--
Milk	2561	10	4350	2817	962			- 1855	--
Eggs	200.1	8	162	216	--	--			

Source: Annex Tables F-5, E-6, E-7, E-8, E-13; Tables 3-1, 3-4, 3-5.

[1] Calculated utilizing WMS team demands only.

[2] Allows for policy of reducing banana exports.

The supply trend data do not capture the large plantings of African palm which are not yet producing or are still being developed, so it is not possible to say whether or not the indicated shortages in fats and oils will materialize. However, in addition to new palm plantations, there is no technical reason why considerable expansion of soybean acreages should not be possible.

Among industrial and export crops, only sugarcane seems to be facing large shortfalls. The area of cane needs to be considerably expanded. Bananas and plantains could keep up with domestic plus export demand if yields were to be increased considerably.

Unless substantial advances are made in dairy herd management, the shortages of dairy products will continue into the far future. In addition, shortages of some meats may arise unless the national herds increase in size or become considerably more productive. No doubt considerable pasture expansion or intensification is possible especially in the Costa and Oriente regions and such expansion will take place automatically if price and marketing incentives are made more attractive for livestock products.

Where do Irrigation Improvements Fit into this Total Future Pattern?

In all zones it is clear that fruits and vegetables generally create higher values per hectare and are relatively best situated to "pay" for irrigation improvements. In the Sierra zone (in addition to fruits and vegetables, e.g.) some good returns to potatoes and to animal husbandry come first to mind. (However, in the case of the latter, there may be some contradiction between pasture improvements and the need for more cultivated land for Sierra campesinos.) Wheat and barley are unlikely irrigation candidates for reasons elucidated elsewhere in this report.

Virtually all the other products, beginning with an important cereal (rice), involve a crop adapted to the Costa zone. However, not all the important Costa crops, for example cocoa, coffee and corn, are presently thought of as being heavily dependent on irrigation. The same may be said for animals (pastures) in this zone. Thus, sugarcane may be the main crop other than rice, fruits and vegetables for which public irrigation provision should be considered in this zone. Note also that much irrigation has been developed under private initiative and to some degree this probably can continue.[1]

[1] The irrigation demand on the Daule River indicates the need for public investments to control the water resources of the Guayas Basin to make the whole area more productive during the dry season. Many studies have been made which show the social benefits should exceed social costs.

In summary, vegetables, some fruits, rice, sugarcane and potatoes are the prime candidates for private and public irrigation investment. These products should be able to pay for the systems if construction costs are not too great. In many situations, especially in the *Sierra*, existing irrigation systems might be made much more useful at quite a low cost to the general public.

III. EVOLUTIONARY CONTEXT OF IRRIGATION STRATEGY

Irrigation has been practiced for hundreds, even thousands of years, in widely separated and diverse environments and social conditions. Despite the fact that this experience has not been continuous, and that whole societies have died, taking part or all of their irrigation knowledge with them, an examination of this history suggests certain common evolutionary elements. These elements in turn define "stages" of irrigation development. In modern terms, the movement between "stages" can be associated with particular sets of development strategies. Therefore the appropriateness of a particular strategy may be judged in part on the basis of understanding the contextual setting in terms of evolutionary stages. In this section we try to answer the question, "what evolutionary stage defines Ecuador's current irrigation development and what does this mean for overall strategy?"

A GENERAL MODEL OF STAGES OF IRRIGATION DEVELOPMENT
(G. Levine, May, 1981)

It can be argued that the evolutionary pattern of irrigation development generally proceeds from rainfed agriculture to irrigation supplemental to the wet season in those areas where the water supply can be developed and utilized easily. As the cultivated rainfed area expands to less desirable areas, the area of supplemental irrigation expands with the development of more difficult supplies and the construction of more conveyance and distribution infrastructure constructed. Some dry season capability becomes available and is utilized on the most accessible areas. As the pressure on the land increases, there is an intensification of utilization of the supplemental irrigation and greater emphasis on the development of dry season capability through storage type systems and/or groundwater. In each stage of this development, there is a balance between the forces - economic and social - which act to encourage the expansion and intensification of irrigation and those which act to resist its development.

Increasing land prices, higher produce prices, increased population pressure and the need for more land efficient techniques of production all act to encourage irrigation development. Increasing cost for water supply development and for physical infrastructure of irrigation, social concern for the concentration of governmental investment, the availability of undeveloped land and a lack of population pressure all act to limit irrigation development.

Programmed irrigation development assumes that this normal pattern of autonomous response to socio-economic forces can be superceded by an imposed pattern of development which either brings supplemental irrigation into areas not yet under significant land pressure, or more frequently, introduces dry season capability more rapidly than would otherwise occur. It is not obvious that this will result in the magnitude nor type of utilization typically anticipated in the project designs. In fact, there is at least some evidence to suggest that the availability of irrigation or of dry season capability does not insure anticipated utilization and that the actual pattern of use more nearly approximates what might be expected in the revolutionary pattern of development. For example, there are a number of areas in Latin America where supplemental irrigation has been introduced, with variable levels of utilization. Similarly, dry season capability in the central plain of Thailand was not significantly utilized for ten years, and even now, almost 15 years later, represents less than 50 percent of the wet season production.

To the extent that this very brief analysis is valid there is an implication that programmed irrigation development must be accompanied by a very careful analysis of the stage of evolutionary development, and a wide range of governmental policies and programs must be adjusted before effective utilization of the irrigation investment could be reasonably expected.

Coupled with the evolutionary development of the irrigation systems themselves, is the evolution of governmental attitudes or perceptions about the systems. Three stages of governmental view can be identified. In the early stages of governmental irrigation development, the systems are viewed as hydrologic-hydraulic systems. The emphasis is upon the water, its capture and conveyance. Typically, there is little understanding of the agricultural use of the water. In addition the design, construction and operation of the systems are the responsibilities of an engineering based governmental organization. The second stage in governmental view of irrigation systems is recognition of the agricultural utility of water. Information about soils, crops, and other agronomic elements are then incorporated into the design and operation of the systems. By contrast to the headwater down approach of the first stage, there is now a command area upward approach to the design. The third stage perspective recognizes that the farmer is an active participant in the utilization of irrigation capability and that farmer needs, as well as soil and crop needs, must be recognized in system design, construction and operation. It is my impression that Sri Lanka is just starting to move from the first to the second stage; the Philippines and Indonesia are just starting to move from the second to the third stage. It is my view that there is an underlying assumption inherent in the programs for irrigation development that the governmental policies and bureaucracies can be moved rapidly toward the third stage. It is not obvious that this can in fact happen, nor is it obvious that the irrigation bureaucracies can be moved from the first stage to the third without passing through the second for some significant period. Again, there are evidences that establishing the forms for farmer participation does not automatically result in the type of participation necessary for effective utilization of the systems capability. The agencies look upon farmer participation in much the same way that company unions were looked upon by the industrial sector in the United States during the early period of union organization. There is significant evidence to suggest that a lack of effective farmer participation in those systems where there is an intent to utilize irrigation water efficiently will result in significant problems and a relatively high probability of failure.

If the ideas proposed here are valid, then irrigation investment of a programmed character must either be very selective or must consider a much wider range of factors for inclusion in design considerations than is customary. It must be recognized that implementation and successful operation will be difficult and will require more flexibility than is currently considered necessary. Even with this more open view, the degree of "modernization" that can be instituted is open to question. (See Appendix A)

RELATIVE STAGE OF IRRIGATION DEVELOPMENT IN ECUADOR

In terms of the evolutionary process just described, it is quite clear that Ecuador governmental attitude is at this moment seriously straining to move from the first stage (hydrologic-hydraulic systems) to the second stage (a recognition of the agricultural utility of water) and that the third stage (farmer as an active participant) is a distant goal in this logical framework.

As pointed out by Levine, active farmer participation in irrigation system development and improvement may not result in achievement of improved farmer incomes or optimal utlization of those systems. There are two classes of constraints beyond farmer level control.

a) Sometimes there are barriers to effective marketing or pricing disincentives working against introduction of new technology;

b) There is always danger of glutting markets if significant increases in crops and livestock occur in rapid order. These constraints are explored in more detail in Chapter Two but they are mentioned here to emphasize the inalterable dependence of successful staging of irrigation development on the performance of the total economy.

c) Poor public administration will have negative impact upon farmer participation in irrigation system development and may prevent hoped for increases in productive and rural incomes.

There is no rational alternative to strong and forceful public control and protection of scarce water resources. Effective public administration and management under the law is central to the orderly development and evolution of the irrigated agricultural subsector. This thesis is particularly true where, as in the case of Ecuador, private sector irrigation systems constitute over 80 percent of the total irrigated hectarage.

Levine's work suggests that there are phases in public control of water resources that parallel the ever increasing competition for water utilization. Thus, it is important when proposing allocation of public resources to water development that governments know where they have been, where they are now, and in what direction they ought to go. This allows them to adequately assume their critical role in water resource control and administration.

Phases of Water Administation Evolution

One way of analyzing the level and impact of government control and administrative programs and policies is by setting their development parallel to Levine's notion of evolving general social and official attitudes toward irrigation systems. So as not to confuse the two concepts, administrative development may be viewed in terms of "phases" in contrast to Levine's more general irigation "stages." For Ecuador such a comparison yields the following observations.

Phase A. Institutional Response to Hydraulic Systems Stage. The institutional and policy response to Levine's Hydraulic System Stage is characterized by the establishment of governmental institutions to construct large works and main systems. In Ecuador the Caja de Riego and its successor INERHI, as they operated prior to 1972, typified the policy objectives of government institutions in the Hydraulic Systems Stage A.

Phase B. Official Encouragement of Water Use. This is accomplished primarily by granting concessions to use water within some generally defined priorities. In any given water source the granting of concessions does not require or demand any additional action until the quantity of the concessions granted and used on a particular source approach the level where the available supply is unable to satisfy total concession demands during low flow periods.

This phase is usually achieved by enactment of a law which encourages use by formally recognizing and protecting rights to use the public water resource coupled with institutional capability to grant said use rights.

This institutionalized policy (Phase B) would commence sometime after the beginning of Levine's Stage Two. This is when "awareness of agricultural value of irrigation" has achieved sufficient priority in the collective public mind that public resources are allocated to establish public programs to encourage general water use. Phase B is usually of general country-wide application. In Ecuador this phase was institutionalized with the establishment of INERHI's regional offices and delegation of authority to grant concessions pursuant to, and within, the Water Law of 1972.

Phase C. Defining, controlling and limiting direct private water uses. As competitive stress is placed upon a given water source a critical phase is reached. The social friction resulting from the high level of competition for water use will inevitably result in chaos if the public control and administration system does not intervene to bring some semblance of order out of disharmony and discord. But, if the public control system does actively intervene on its own initiative, and does establish equity and order (through adequate programs of sound allocation and policy enforcement), the problems of stress among competing users may be reduced. Under a controlled system some users will be forced to somewhat limit their uses below previous levels (and subjective expectations) and, on occasion, will be restricted to lesser quantities than provided for in their concessions. This corresponds to Levine's Stage Three, in which all users concentrate on maximizing production with the same or smaller quantities of water than they may have used or expected while still in Stage Two.

Successful administration refinement and control of water uses in Phase C require a new and increased commitment of public funds and administrative energy if chaos is to be avoided during the Phase B to Phase C transition. Public administrators have very little control over when phase C will be reached on any given water source. Therefore they will only be able to appropriately intervene and avoid disorder if they observe and accurately diagnose the symptoms of transition, and administer the appropriate medicine (justice under the law) before the patient dies (before phase transition) on a water-source-by-water-source basis.

Chaos and disorder may be very contagious and may prematurely infect other water sources that have not yet reached Phase C if competitors observe that an infected patient (some other source) died (became chaotic) because of inadequate public intervention. A very strong, just and forceful intervention at the first suggestion that any water source has contracted "phase transition disease," may well limit the adverse effects and reduce the long-term, country-wide public cost of fighting an "epidemic." Frequent violence reported over equity in water distribution in the province of Tunguragua, and the problem of salt intrusion on the lower Daule River are indications that some water sources are already stressed by competition and that public intervention is needed to resolve private conflicts at this time.

Phase D. Direct Public Intervention to Protect the Broad Public Interest in Water Resources. Certainly, as a given water source is stretched to its full use, there is a parallel danger that serious environmental side effects may arise from over-utilization. Forstalling and controlling such effects may require even further restrictions and limitations by the control agency on rights and concessions which may have already been somewhat restricted and limited in Phase C. Failure to diagnose the approach of Phase D and respond adequately by imposing and implementing the necessary restrictions, protecting the broader public interest, could result in a more general type of water utilization disfunction (negative environmental impacts) that would harm or permanently destroy both broad public and private interests. An example of phase C to D "transitional disease" is the threat to land and water resources by encroachment of salt water further upstream on the Daule River, resulting in part, from recent excessive fresh water pumping to meet irrigation and other fresh water demands.

Where Is Ecuador Within Administrative Phases?

The Water Law of 1972 is one factor, among others, that accounts for the explosion of hectarage placed under privately financed irrigation systems in the past ten years. Private sector interests apparently obtained a sense of security from holding a decree or concession document under the new law, something that was absent under the old law, as previously administered. This serene state of mind is an incentive for investments in irrigation infrastructure. It appears that most of the easily exploitable water sources appropriate for irrigation have now been tapped. Ecuador has at least passed well into Levine's Stage I.

In terms of the administrative phases presented above, the transition to Phase C is currently being experienced on a number of water sources, basins, or sub-basins in Ecuador. INERHI should be given the public resources to identify and deal decisively with "phase transition" on impacted water sources on a priority basis. Specific areas where Phases C and D are approaching simultaneously, as in the previously cited case of salt water intrusion and competing uses on the Daule, and cases of contamination and quality degradation cannot be ignored without disasterous results. It is critical that these types of conflicts be resolved to protect rights, natural resources and society's interests.

There is one major flaw in the capacity of INERHI to allocate water reasonably in Phase C. Other public water user entities have generally refused to subject themselves to INERHI's role as the nation's water administrator. Many of these agencies do not register concessions for significant withdrawals though the law requires them to do so. This condition will result in premature chaos on impacted water sources.

PUBLIC SECTOR ORGANIZATIONS INVOLVED IN IRRIGATION

Overview

Ecuadorian public policies related to irrigation are subjected to the common framework of socio-political institutional dynamics present in democracies. The legislative assembly establishes general policies, taking into account the desires of constituents and the good of the public at large. In Ecuador, the will of the Executive is also an important policy factor. Assistance in policy formulation comes from CONADE, the national planning group, and its feeder agencies. Media rhetoric or legislative pronouncements aside, the best way to identify real public priorities is to note the actual allocations flowing out of the budgetary process.

Within the executive branch the various ministries are the line agencies through which programs are executed. Both inside and outside the line ministries there has been a proliferation of semi-autonomous public institutes in charge of executing government policy on a specific subject matter. (INERHI, for example, has a mandate for general water administration, public irrigation development, and technical assistance in irrigation to the private and public sector.) Semi-autonomous institutes appear to have developed a certain freedom from some of the political instability, red tape, and other bureaucratic problems traditionally associated with the line ministries and their dependencies. In addition to central government bodies, there are also a number of regional and local groups such as CEDEGE and CREA that are involved to some extent in promoting irrigation systems.

Inter-Agency Dynamics

Positive. INERHI is, and has been, interacting with executive planning groups such as CONADE and with budget and finance groups such as the Ministerio de Finanzas and Banco de Fomento. It also works with external funding sources.

There has also been substantive interaction with regional groups such as CEDEGE, CREA, etc., in relation to their involvement in public irrigation projects.

Negative. There is a notable lack of substantive interchange or meaningful communication betwen INERHI and other public institutes and agencies whose mandates appear: a) to interfere with INERHI's mandates; b) overlap with INERHI's mandates; and c) require coordination with INERHI to secure maximum benefit for the public interest in irrigation development.

One of the reasons why this interaction is not occuring is because none of the agencies involved (in spite of their mandates or rhetoric), have the substantive budget or other resources to execute programs serving the full scope of their mandates. They naturally tend to concentrate limited funds on those perceived core areas of their mandates that can be performed without having to depend on interaction with other agencies. This vertical mode of operation is viewed as the rational way to demonstrate measurable accomplishments with limited funds. All agencies then tend to pull back from the overlapping or interfacing activities within the scope of their mandates.

There is little cooperation between agencies in the water sector. INERHI cannot be shouldered with all the blame. To a great extent, in some very critical ways, INERHI is the victim of the coordination problem more than its cause. As an example, INERHI has the critical function of granting, controlling and limiting water concessions in water sources and integrating private uses with public agency uses, to provide orderly allocation. The private users, large and small, have generally cooperated and complied with the law in quantifying and documenting their water use rights. However, in general, other line and semi-autonomous public agencies, who frequently extract large quantities of water from these same water sources, have refused to register their rights. They have made INERHI's task of equitable orderly allocation of water in affected water sources virtually impossible. INERHI will someday be criticized severely for the consequences of this refusal of other government agencies to comply wi the water law. There are numerous examples of severe restraints to productive horizontal cooperation in the public sector which result in narrow, limited, non-overlapping task activities at the expense of the general public interest.

It is unlikely that budgets will increase in INERHI to permit broadening of its institutional horizons. There must be a shifting of its internal priorities from the safe narrow track to the more risky but higher potential payoff of cooperative interactive programs as suggested in this report, in order to survive and contribute to the growth of the country by putting more emphasis on overall water resource administration.

IV. STRATEGIES FOR IRRIGATION DEVELOPMENT

The Team observed a number of public and private irrigation systems in both the Sierra and Costa regions. In addition the Team visited with many administrators, technicians, local managers and farmers involved with the various projects and systems. The quality of the physical infrastructure and water management practices varied from excellent to terrible.

INERHI PROJECTS

The physical works of the main system portions of the INERHI projects appear to be reasonably well designed and constructed. A number of specific problems such as ineffective diversion structures and lined main canals with inadequate capacities or lack of provision for cross drainage (which results in excessive siltation) were observed. These situations were being corrected.

The secondary canals branching from the main canals on the INERHI systems visited were lined and the water division structures being used in the newer systems should provide an adequate means for controlling accurate deliveries to modules (10 to 20 ha) of users. Current practice is for the users, collectively and/or individually, to be responsible for the tertiary system and delivery of water within their module. The users are left to their own devices and abilities to construct the tertiary canals and apply the water to their individual fields. INERHI does assist in organizing the rotations of water among users.

On the newest projects in the Sierra region water is delivered continuously to each module and rotated between the farmers' fields on a 7.5 day basis, to alternate day and night turns. For the most part each farmer gets the entire stream of water allocated to that module for a period of time equivalent to the farmer's proportionate land area within the module. For example, in a 10 ha module a farmer with a 0.1 ha field could receive the entire stream entering the module for (0.1 ha/10 ha) x (180 hrs/7.5 days) = 1.8 hours every 7.5 days.

Typical water delivery rates to the modules range from 0.7 to 1.0 liters/ha depending on the average evapotranspiration and rainfall probabilities in the specific regions. From a review of water requirement computations for specific areas, it appears that the anticipated water deliveries are only adequate for optimum irrigations (where other inputs are not limiting) assuming high tertiary delivery and field irrigation efficiencies for both day and nighttime irrigations. (A stream of 1.0 lt/s would provide 4.3 mm/day to 1.0 ha at 50 percent efficiency.)

These designed irrigation deliveries are inadequate in view of the probable low tertiary delivery and field application efficiencies; the fact that rainfall is treated on an (80 percent probability) average monthly basis; the average crop water use coefficients for a project-wide mixture of crops are used to give average deliveries throughout the systems; and night and day irrigations are treated as equivalent (assumes full nighttime irrigation).

. Some innovations which the Team noted being applied to improve delivery and or application efficiencies at the farm level include:

1. Lined tertiary canals (Montufar).

2. Pipe for steep sections of secondary channels (Montufar).

3. Pipes for secondary delivery with storage to eliminate night irrigation (Chambo - Italian assistance).

4. Sprinkle irrigation (Pisque - Belgin assistance; Banco de Arena; lower Guayas - private; and private systems on pastures and vegetables in the lower Guayas).

5. Drip irrigation (at Salcedo - SAED regional development; and Central University experiment station near Quito).

6. Fairly precise land leveling for rice paddies (private development along lower Daule River).

7. Center pivot and hose pull sprinkle systems are also used fairly extensively by the private sector (mostly in the coastal region but some in the Sierra).

These innovations plus a few other existing or potential alternate innovations should provide ample field situations for studying the potential benefits and cost effectiveness of physical irrigation system improvements.

Since in many cases observed improvements were in medium to large scale private or cooperative hands, the Team concludes that improved tertiary delivery and application systems are both workable and cost effective given the necessary other crop inputs and dependable medium to high value markets. But an important point is that the farmer-irrigator must be satisfied that both the irrigation innovation (complete with all the other implied inputs--both external and internal) plus his/her skill to take advantage of them, will pay off at an acceptable level of risk. What counts is the farmer's perception of his/her irrigated-agriculture environment--not the perceptions of external planners. Of course, in the case of relatively large private holdings, the planners and farmers are one and the same. This leads us to the question of private irrigation development.

PRIVATE IRRIGATION PROJECTS AND SYSTEMS

Even so-called public irrigation projects require a certain degree of private development. For example, under current INERHI practices, the farmers within each 10 to 20 ha module must individually and/or collectively develop their own tertiary delivery and field application systems. The dilemma in Ecuador (and also throughout the world) is to decide how far the public system should be extended towards individual holdings where small (less than 5 ha) farms are involved and how much public service should be provided to improve on-farm applications of water.

The ultimate "top down" irrigation development approach is for the public sector to provide direct services to each farm (no matter how small) and to even assist with the field system. Even after supplying all this expensive infrastructure there is no assurance that the water will be utilized and productivity increased, according to plan, unless the cultivators know how to utilize the water and are convinced that it is worth the effort. Furthermore, the farmer is left with the expectation that the public sector will continue to operate and maintain the system as built. All this is so expensive in terms of investment and operational costs, and so risky in terms of benefits achieved, that this option is not very attractive.

At the other extreme the public sector merely provides the infrastructure for capturing, storing, and delivering the water at turnouts serving 40 to 200 ha modules. From this point it is the farmers' responsibility to develop the rest of the distribution system and apply the water to their fields. With this approach there is even less chance that the water will be beneficially utilized because farmers at the head end of distribution ditches can take all the water they want and have little incentive to cooperate in developing an equitable distribution system. Although this approach may appear to be less expensive than the complete delivery system described above, when measured in terms of the theoretical command area, in reality, it may be even more expensive in terms of the land actually irrigated.

It is interesting to note that in Ecuador only about half the irrigable lands theoretically commanded under the public sector projects are actually being irrigated and the cropping intensity on this half is probably not even 100 percent (although year round cropping is practiced). Admittedly, this more limited development strategy does offer potential benefits to a larger number of small farmers per unit of investment capital.

It is estimated that there are more than 320,000 ha of completely private irrigation systems and projects in Ecuador and about 40,000 ha of lands actually being irrigated with water developed by the public sector. (Currently, considerable new private irrigation is being developed in the coastal region and about 60,000 additional hectares lie within the boundaries of operating public projects. Other public projects are planned.)

In view of this large level of private development the Team suggests that the public sector's irrigation development strategy take fuller advantage of the apparent vigor of the private sector. Two ways in which this might be accomplished are:[1]

1. The development strategy should be such that the private sector is encouraged through technical assistance, credit, and subsidies to reach as far up the system as possible. Where water is reasonably accessable in terms of distance and lift (such as a spring, small stream, nearby river, or shallow groundwater) the private sector has been and still is active in developing the resource consistent with capabilities and economic situation. Where the potential water supply is too difficult to be tapped by private entrepreneurs the public sector is the logical entity to develop the resource (such as the dam, the diversion and main canal).

Obviously, certain social, economic and agro-hydraulic conditions must be met. However, the final planning and construction of projects serving existing rainfed and partially irrigated farms should not be started until the farmer groups representing at least 50 percent of a project's irrigable land have agreed to perform their part in developing the water.

The principal canal might be constructed with outlets only at locations where groups have organized. Additional outlets should then be installed only as new groups come forward seeking water service.

2. A somewhat similar strategy of providing technical assistance, credit, and subsidies should be adapted for rehabilitation of the existing private projects and systems. It appeared to the study team that the first order of business in this connection would be to assist with improved diversion structures (with gates and measuring flumes) on streams and rivers which have more than one diversion point. This would not only help secure the supply to the users but is needed for adequate regulation and monitoring of water resources. The next type of assistance would be to rehabilitate critical portions of delivery

[1] See Appendix C, "A New INERHI Orientation" and Appendix D, "Assisting Private Irrigation Institutions: An Approach for the 1980's," for details on how this strategy can be carried out.

systems to reduce seepage losses and ensure greater reliability of water deliveries. More substantive technical assistance and capitalization could also be given to the current Banco de Fomento program in irrigation development.

REHABILITATION VERSUS NEW PROJECTS

The Team estimates that the probable overall efficiency of existing farm irrigation in Ecuador ranges from about 2 to 40 percent where traditional methods are used for small holdings. Actual efficiency depends on the amount of channel lining; soils and topography of the fields; and irrigation management. The Team's rough estimates of efficiency ranges during water scarce-periods are as follows:

	Percent Efficiency		
	Earth		Lined
Principal Canal	20-70		95
Secondary Canal	60		95-100*
Tertiary Canal	70		90-100*
Overall Farm Delivery	8-30		81-95*
Farm Ditches		80	
Field Application		30-60	
Overall Farm Application	2-15		20-45

* 100% where pipe is used in place of open channels

The above figures are illustrative only. Obviously, a diagnostic examination of representative systems is needed to more accurately pinpoint problem areas and to obtain a clearer picture of the actual water availabilities. With high technology, system farm ditches are eliminated and field application efficiencies will range between 75 and 90 percent. One important point to keep in mind is that the losses from one system or project may provide return flow and form the water supply for a lower system. Therefore, reducing losses in a given system may not result in comparable regional water savings but may improve local water management.

For the most part Ecuador's public sector projects have lined principal and secondary canals. On the other hand few private systems have lined canals. Furthermore, private systems typically have insufficient water supplies for the areas they command. Therefore, in view of the fact that private systems are a predominant component of

Ecuador's existing irrigation, the Team recommends that the current INERHI initiatives to provide assistance for upgrading the main channels of private systems be intensified. (See program "Plan de Obras a Ejectuarse con Asistencia del P.M.A. - INERHI 1983-1987).

In addition the program should provide more substantial diversion works to reduce silt loads in channels as well as to provide more secure deliveries with means for controlling and measuring withdrawals.

The efficiency table presented above is a reminder that no matter how effective the delivery system between the supply and the farm, poor field application efficiencies can reduce project effectiveness to unacceptable levels. The result is not only the waste of water (that even if abundant still required considerable effort to deliver), but also poor crop performance due to some areas receiving excess water while other areas are left unirrigated. Furthermore, when the quality of irrigation is quite poor, the response to high yielding seed and added fertilizer inputs is usually disappointing. This quickly discourages the use of such inputs and the gains with, as compared to without,irrigation may only be worthwhile in the driest zones and/or seasons.

Most of the irrigation systems in Ecuador depend on direct stream diversions to take full advantage of water supplies and delivery systems; therefore, water must be diverted continuously and (unless there is storage along the system) irrigations must be made day and night. The Team has considerable doubt (based on interviews with farmers and managers) that effective irrigation applications are being made at night. This is especially true for steep fields in the Sierra region. This creates two problems: first, the computed system flows which are based on continuous irrigations are only half enough; and secondly, where small fields are served on a rotational basis, the effective interval between irrigations is twice as long as the official interval.

The effect of the above scenario is that there is only half as much irrigation water effectively available as officially indicated. Furthermore, for small farmers the actual irrigation interval may be twice the official interval which on thin or light textured soils or on most higher value crops would reduce the effectiveness (possibly to less than half) of the water applied. The Team recommends that more consideration be given to providing 12 hour in-line canal storage where practical. Where this is not practical, consideration might be given to using principal canal flows to generate power during nighttime hours; or providing high technology application systems which can be used to more effectively apply limited water supplies during nighttime irrigations.

Improving overall farm application efficiencies is more difficult than improving the delivery efficiencies. This involves the skill, dedication, and inputs (capital, labor, and management) of the farmers served. What is needed is research to create application systems and crop production packages which hold promise and training to provide a mechanism for transferring the needed information. These subjects will be covered later.

In conclusion, the Team recommends that INERHI devote considerable effort toward upgrading existing irrigation works. Intensifying the production and irrigated area under both the public and private irrigation projects and systems should provide considerably greater benefits to many more farmers at less cost than expanding the irrigated area by building new projects.

MAIN SYSTEM VERSUS ON-FARM

As mentioned earlier, for the most part the main system portions of the public projects are adequate. However, the on-farm irrigation activities under the projects has been extremely disappointing. On the average less than half the commanded areas are actively irrigated, cropping intensities even on the irrigated portions are low, and irrigated production is considerably below expectations. For example, in the Interamerican Development Bank's "Expert Evaluation of the Montufar Irrigation Project" (dated May 1981), the harvested area was only 29 percent of project design and the increase in profits per hectare was only 43 percent of design expectations. Thus, the overall increase in profits from the project was only 17 percent of the expectations suggested in the original feasibility study, in spite of the fact that it was five years after project completion and the tertiary canals were lined. The project included lined tertiary canals. The project cost US $6.9 million including a cost overrun of 64 percent, and, although the project commands some 3500 ha of irrigable lands, it is actually only serving 1800 ha. This represents a total investment of almost US $4,000 per irrigated hectare.

Based on the Team's field surveys, it is clear that considerable attention needs to be given to improving farm irrigation (and other crop input) activities. (In the case of Montufar marketing is not a problem.) We have referred to the Montufar project in this discussion because it is the only INERHI project which has had a recent evaluation.

Suppose an additional US $1,000/ha were invested to improve on-farm irrigation at Montufar by providing some new technology. If this would lead to irrigation of the total project area (3500 ha) the overall investment would actually drop to about US $3,000/ha irrigated. Such an added investment (possibly sprinkle irrigation) would undoubtedly also increase the profits per hectare and the originally expected profitability of the project might well be reached by achieving a 300 to 500 percent yield over the existing situation.

On private projects, both the main and on-farm systems need attention as discussed earlier. In view of the preceding observations the Team recommends that priority be given first to improving the on-farm portions of public systems. After the necessary research and training has been tested on the public systems the techniques should be extended to private systems.

TRADITIONAL VERSUS NEW TECHNOLOGY

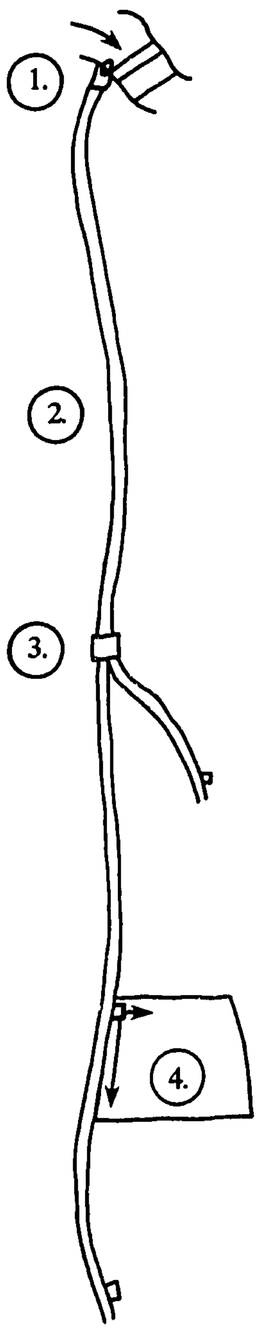
The farmers in the Sierra region may be irrigating as well as can be expected using traditional technologies. Research is needed to adapt and test new technologies in order to improve the current situation. In view of the large capital investments needed to extend the irrigated area (especially in the Sierra region) there is considerable incentive to improve the performance of existing systems.

The Team recommends that baseline studies be made to evaluate the performance of traditional irrigation systems and field application methods. New irrigation technologies should then be tested and adapted for local conditions. The most promising new technologies should then be compared physically, sociologically and economically against the traditional methods and be adapted where there is potential for significant improvement. Some new technologies which come to mind are: night storage; pressure pipe delivery systems; surge flow surface irrigation; gravity fed sprinkle irrigation; hose-basin or drip irrigation of trees; precision (laser) leveling in coastal areas; and traveling and center pivot sprinkle irrigation on larger farms and cooperatives.

SOFTWARE VERSUS HARDWARE

Software involves applied and adaptive research, training, and all of the multidisciplinary management aspects of operating irrigation systems at various levels. Hardware involves upgrading existing irrigation systems and constructing new ones. Thus, as mentioned earlier, both software and hardware are critically needed to reach the full potential of existing systems and develop cost-effective new projects.

An outline of the various components and the functions of each is presented in Figure 4-1. Since the needed hardware has already been discussed above we will concentrate on the software needs in this



1. DIVERSION WORKS

   1.1 Divert allocated water (measure flows)
   1.2 Reliable under flood conditions
   1.3 Keep silt out of canal system
   1.4 Control and/or shut off flow to canal

2. SUPPLY CANAL with Control Structures

   2.1 Carry diverted water
   2.2 Efficient conveyance of water
   2.3 Durable and stable
   2.4 Reliable under flood (rain) conditions
   2.5 Does not intercept excessive silt and debris

3. DISTRIBUTION CANAL with Dividers and Farm Turnouts

   3.1 Efficient delivery of water
   3.2 Equitable distribution of water
   3.3 Efficient water control
   3.4 Timely delivery of water

4. FARM IRRIGATION AND DRAINAGE SYSTEMS

   4.1 Efficient delivery of water to parcels
   4.2 Uniform distribution of water on parcels
   4.3 Timely distribution of water to crops
   4.4 Efficient application of water to crop root zone
   4.5 Remove excess rain and irrigation water
   4.6 Conserve soil (control erosion and salinization) resources

Figure 4-1. Irrigation System Components and Functions section. Practically no soil-water-plant research has been conducted in Ecuador. However, the Team did encounter a water use research experiment at INERHI's Milagro Project headquarters and one at the Central University's station at Tumbaco. Undoubtedly there are, and have been, other water related experiments, but there is no comprehensive research program in progress. Furthermore, the experiments in progress appear to be poorly coordinated and suffering from lack of needed financial support.

With the variety of different types of irrigation being employed throughout the country it should be possible and quite cost effective to make quick field studies on these systems to not only obtain information for technology transfer, but to gain insights as to practical water requirements for different crops, soils, locations, and irrigation systems.

In addition to the adaptive research on new application technologies described in the previous section, applied research concerning crop, soil, water, climate, fertility interactions and errosion control, is critically needed (see Appendix B). The Team recommends that INERHI be responsible for the adaptive research concerning hardware components with the cooperation of INIAP in selecting crop materials and husbandry practices. INIAP should be responsible for the crop variety selection-soil-water-climate-fertility applied research with the cooperation of INERHI in setting up the irrigation inputs. INERHI should take the lead with assistance from INIAP in conducting adaptive research to pinpoint water requirements of various basic crops. (See Appendix A for further details on Agronomic Considerations.)

In order to transfer both the directly adaptable and adapted water management technologies, training is needed at most levels. Furthermore, training is needed in research methods, system monitoring, multidisciplinary system diagnostics, and system design (especially at the farm level). The Team recommends that INERHI take the lead in the basic water management training for professionals and technicians. The INERHI/USU Water Management Technology Transfer Project Proposal which is currently under consideration for USAID Title XII funding gives a detailed description of the kind of training needed for transfer. We also recommend that the Multidisciplinary Diagnostic Analysis Training Program developed by and available from the USAID Water Management Synthesis Project be solicited and utilized. Finally, the Team recommends that IICA take the lead, with assistance from INERHI, in adapting water management training materials for presentation to farmers.

IRRIGATED VERSUS RAINFED AGRICULTURE

In much of the Sierra region production increases from irrigation (alone) with traditional cropping practices are about the same as can be expected from using improved seed and fertilizer under rainfed conditions.

In most of the Costa region, on all but the lightest textured soils, irrigation is of marginal value for rainy season crops. However, it is essential for most crops during the dry season.

In much of the Sierra region the irrigation is applied to traditionally grown crops as a substitute for other improved inputs. (If irrigation supplies are already developed and the water is "free" this is to be expected.) In the case of new development, except in situations where irrigation water supplies can be inexpensively developed and applied, it would be more cost effective to obtain the same crop production increases by improving the crop inputs (seeds and fertilizers) under rainfed conditions or by opening new lands to settlement.

In coastal regions there is extensive undeveloped rainfed agricultural potential. Except for specific crops requiring full moisture supplies all year long (or rice) it should be more effective to obtain production gains by opening new agricultural lands to agricultural development than by developing expensive irrigation projects. Of course this does not imply that irrigation from easily accessible water supplies is not a cost effective means for improving production in coastal regions.

Unfortunately there is not sufficient resource information (soils and climate) and data on gains from irrigation with and without improved cropping practices to accurately deal with the rainfed versus irrigation question. However, there is considerable evidence from other countries with similar conditions that, in some extreme conditions, rainfed yields can be doubled or tripled if inputs, training, and assistance are provided to farmers. Given the current average national yields of 0.7 to 0.8 T/ha for grains, improved agronomic practices should provide a 2 to 3-fold increase under rainfed conditions with irrigation providing an additional two to threefold increase, at the minimum. It would seem wise to not begin new projects until the existing ones are brought up to this standard. This would require a much closer working relationship between INERHI and INIAP and INAMHI.

Soil erosion is a serious problem in both rainfed and irrigated agriculture on certain of the steep soils in the Sierra region. The Team saw serious erosion due to rainfall on fields which will be served by the Quimiag-Penipe and the Latacunga-Salcedo-Ambato Projects.

Careless irrigation practices on the steep (up to 70 percent slopes) lands under these projects will aggravate erosion and the production gains based on irrigation may well be cancelled due to the loss of top soils and general degradation.

On an even larger scale the soil losses due to soil erosion caused by wind, rain and/or irrigation may be cancelling much of the production gains resulting from opening new lands to rainfed agriculture and irrigation, or increasing crop inputs in the Sierra region. Therefore, the Team recommends that more serious attention be given to soil erosion and that considerable adaptive research and technical assistance be devoted to solving the serious soil erosion problems that are rapidly evolving in Ecuador.

SMALL VERSUS LARGE CONTRACTORS

Current INERHI design and construction practice is to basically rely upon the design information developed for the project feasibility study and utilize their own labor or small contractors to carry out construction under the supervision of INERHI engineers. For relatively small projects these practices seem satisfactory; they have the advantage of reducing the design effort and providing more job opportunities within the local communities as compared with using standard design and international bidding practices. Furthermore, it appears that the construction accomplished is satisfactory.

The Team recommends continuing the current practices of minimizing design effort by using agency labor or small contractors on small projects. However, on large projects (over US $5,000,000) in order to eliminate expensive delays which have been excessive in the past (for example over two years at Montufar and Latacunga-Salcedo-Ambato) and cost overruns due to design errors, standard construction, drainage, and specifications should be drawn up and international bidding requested.

WATER USE COMPETITION

As more and more water resources are developed for irrigation and other uses, competition between users and uses will intensify. During the field trip in the coastal area the Team observed two interesting cases of competition. Undoubtedly there are many more.

In one case there appeared to be severe competition wherein farmers with a few hectares of corn were having a hard time obtaining requested water on the Milagro Project. This was because two large tobacco growers had apparently pre-empted most of the water flowing near the end of the secondary canal from which they all were supplied. Perhaps this situation was caused more by a lack of understanding of the prevailing water management/regulation on the Milagro Project, than by actual shortages because the project is only partially developed and there should be plenty of water. Team members did not visit with the tobacco growers. However, it was noted that one of the growers was diverting most of the water from the concrete lined secondary canal by blocking the channel!

Of greater interest was the extensive rice irrigation development along the lower reaches of the Daule River. (Upstream and downstream from the town of Daule.) Withdrawals are made from the river by pumping water into canals which extend as far as 5 km inland. The Team was informed that there are approximately 280 such pump installations. Apparently most of this new development has been in the last six years and there appeared to be extensive paddy-rice development activities still in progress. Lands were being more precisely leveled and earth channels strengthened.

The Team noted considerable pumping from tidal affected reaches of the river downstream from Daule and visited a few cooperatives several kilometers upstream from Daule. The rice paddies look good and the farmers appeared proud of the irrigation potential they had developed. Unfortunately during the dry season (i.e., the season of the Team's visit) the river already appears to be overdeveloped. It was estimated that flows several kilometers upstream from Daule were in the neighborhood of 10 m^3/s. This may not be a large enough flow to hold back salt water intrusion. (Apparently salt water intrusion already is a problem for the Guayaquil's potable groundwater supplies and this is probably caused at least in part, by irrigation withdrawals from the Daule river.)

Obviously, further irrigation development along the Daule River and increased withdrawals will aggravate the above situation. If a series of wetter than normal years (which would appear to allow unabated development with not too serious consequences) should be followed by a very dry year the situation could become catastrophic.

In view of the above, the Team recommends that INERHI respond to transition into advanced stages of irrigation evolution by increasing its staff and capability to identify, refine, enforce and police water allocations and protective measures. This program orientation and intensification should begin on a priority basis, commencing on the water sources (such as the Daule River) where there is weak control over mounting competition for water, potential for changes in use, and need for environmental protection.

RESEARCH AND DEMONSTRATION (See Apppendix B)

There is a serious need for applied or adaptive research on water management under both rainfed and irrigated conditions. Reliable information on potential production increases and costs of achieving them with improved rainfed water management is necessary in order to assess the real costs of irrigation projects. Delivering the necessary improved technology is part of irrigation costs. Many of Ecuador's current irrigation projects are not producing yields that are even double the overall national averages. This results in extremely costly production from the national viewpoint. It is quite evident that current yields obtained in some of the irrigation projects could have been obtained with improved rainfed practice at much lower costs. The addition of a second crop is a real advantage but seems quite costly when there are extensive rainfed areas present in Ecuador not being utilized intensively. It seems apparent that better and more realistic analyses must be developed for determining feasibility, need, and priorities for project implementation.

It is costly and duplicative for INERHI to develop its own research unit for meteorological data collection and analyses. By means of convenios or subcontracts, working teams could be developed wherein INERHI provides the irrigation engineer, INIAP the soils management person and INAMHI provides the agrometeorology input. This is of particular importance in the Sierra where the soil conservation section of INIAP should be involved from the beginning of any project.

Demonstration farms should be established in different areas in order to provide more realistic basis for irrigation water management under both rainfed and irrigated conditions. It is quite evident that with the soils present on some of the INERHI projects that a 15 day application interval is simply too long and will drastically reduce yields.

Improved technology should help to achieve the desired growth rate in agricultural production coupled with stability of production from year to year. There should be as much emphasis on factors that promote stability as on those that enhance productivity. Among the major factors causing large undulations in production from year to year are:

1. weather abnormalities;

2. pest epidemics;

3. public policies in the area of pricing and marketing; and

4. availability of inputs.

Nowadays, accommodation to these and other production variables are studied and response and accomodation are built into a "package of practices."

The proper package is determined by extensive applied field research conducted over long time periods and may vary with climatic and economic conditions. Each element in the package must be introduced and followed in the right sequence or the advantage of the others may be lost. Interaction is very high. For example, planting improved varieties without proper weed control or appropriate fertilizer rates or needed seedbed preparation may actually decrease yields. Fertilizer application without weed control may nullify or decrease yields. Improved initial tillage without secondary tillage for weed control or seedbed preparation may actually decrease yields.

In many countries the rapid development of a complete production package is not easy. Fortunately much of the information in the soil-water-plant-climate continuum is transferable. Transferring information may save time and cost. It is also possible for qualified individuals to predict general crop responses to modified techniques if the environment has been sufficienty characterized through good agroclimatic analyses.

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APPENDIX A

AGRONOMIC CONSIDERATIONS IN ECUADOR

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AGRONOMIC CONSIDERATIONS IN ECUADOR

IRRIGATED AGRICULTURE

Irrigation is practiced to increase crop yields. This may take the form of supplying water during a precipitation deficient period in a supplemental manner or by supplying water during the dry season for a second crop in the same year. The second crop has the same effect as opening new land, and possibly at lower cost if the water supply is available. A second crop may, however, have unexpected socio-economic effects in that while it allows for more efficient production (as some fixed costs are spread over two seasons), the increased production may lower prices which in turn creates adversity for other farmers who remain limited to one crop per year.

Supplemental irrigation may act to lengthen the growing season. A pre-irrigation may allow planting before the rainy season and thus allow the crop to receive more benefit from the subsequent normal rain. An additional benefit of irrigation is that it allows a better payoff from inputs such as fertilizers, pesticides, improved seed, etc. The converse, however, is also true. To increase yields significantly and obtain maximum return from the applied water the associated complementary inputs of high yielding varieties, fertilizers, disease and pest control, and improved agronomic management must be supplied. If these inputs are not provided, then the impact of irrigation is lost. Evidence from various countries including Ecuador suggests the following can be assumed almost universally.

If normal "unimproved" practices produce grain crop yields of 0.6 to 0.8 T/ha, providing improved agronomic inputs or irrigation will result in yields of 1.5 to 2.0 T/ha, and providing improved agronomic inputs plus irrigation will result in yields of 2.5 to 4.5 T/ha.

Irrigation is often a very costly means of substituting for other inputs. For this reason, emphasis on irrigated agriculture is generally concentrated in areas of potentially high production per unit area and high population concentration. It would appear that in the case of Ecuador some of the projects have been based on other unrelated considerations.

It is clear that none of the irrigation projects visited by the Team have achieved the economic, social or production impacts expected. In every case the area irrigated and crop yields are less than projected. While delays in project completions (some more than 10 years) are serious, agronomic factors seem to be a major reason for failure to achieve production levels expected. Unfortunately there is no systematic monitoring or evaluation of existing projects. Thus, there cannot be any realistic analysis of benefits from the project documents. There has been no social or economic accounting carried out of project investments.

Existing irrigation production systems must be improved or serious questions must be raised about the economic viability of irrigated agriculture and efforts to develop new projects. Farmers cannot be expected to make investments in inputs and adopt appropriate irrigation crop production practices if they do not believe that irrigation water will be available on a reliable and timely basis, nor can the system be viable without necessary inputs and improved agronomic practices. If existing irrigation does not perform as designed and cannot be improved, it is not realistic to extend these projects or design new projects on the same unrealistic criteria. Thus, existing irrigation must not only be improved for the sake of current investments, but also to ensure the economic viability of new projects. Social and political considerations should not be charged against agricultural objectives and needs.

RAINFED AGRICULTURE

Technology must be made available to reduce the risks associated with rainfed agriculture while increasing and stabilizing production consistent with conservation of available soil and water resources. Improvements are warranted because the rainfed areas of Ecuador now and in the foreseeable future, will produce much of the grains and tubers upon which an expanding population is dependent for sustenance. These are also the lands that exist in a tenuous ecological balance (particularly in the Sierra), the land that is being degraded and whose productivity is declining due to mismanagement, poor cropping practices and improper land use. In many cases erosion is critical and the already limited soil and water resources continue to decline.

It is very difficult to find satisfactory data showing the true potential yields under rainfed agriculture in different regions of Ecuador. Generally, the values for important factors, particularly soil and water, are unspecified or identification of the soils is not given, or the duration of the experiments is insufficient to provide response probabilities over time. In general, 2 to 3 T/ha would seem to be reasonable potential yield estimates for most grains. Data on the profitability of rainfed areas under intensive agriculture is also limited but there are indications that "management" can decrease input costs and greatly increase profitability.

Water is the natural resource which is the most limiting to agricultural production in these areas. It is limited in amount and often distributed during a rainy season in unpredictable and frequently intensive storms that erode the land. Reliance on natural rainfall limits production to those periods when sufficient moisture is available and thus under-utilizes the soil and climate resource for a significant portion of the year. There is, however, no concensus on how to weigh this factor in a country like Ecuador that also has very significant land resources under-utilized to an above average extent, as in the northern Coastal region and the Oriente. Intensification of technique is necessary where the man/land ratio is high, but the alternative of opening new land may be relatively cheap. Are these alternatives substitutes or are they complementary?

IMPROVING THE ENVIRONMENT FOR RAINFED AGRICULTURE

Rainfed croplands are the source of much of the world's food. Indeed, the current food role of rainfed techniques would be even more important except that output is somewhat constrained in regions that still rely upon a traditional technology that evolved to reduce risk of losses in dry years. With this emphasis some of the potential benefits that could accrue in good years are usually lost. The design of new or improved technology should be focused on opportunities for farmers to invest safely in anticipation of good years. New technology should prevent destruction or diminution of the biological potential of land, maximize economic benefits from a given environment and minimize damage through manmade as well as natural processes of desertification.

Newer rainfed agricultural systems revolve around the principle that water is the limiting factor. To increase or maintain yields, the water use efficiency (WUE) for crop production must be maximized. This efficiency may be defined as the yield of product per unit area and unit of water (Kg/ha mm). The efficiency achieved is, to a considerable extent, a reflection of management skill. Thus, while the yield potential in rainfed areas may be limited by the moisture supply, the actual yield obtained is determined by the skill in manipulating agronomic practices to optimize water use. It is frequently discovered that improved management practices account for 50 percent of the yield increase in rainfed agriculture with improved varieties accounting for 30 percent and improved planting and harvesting accounting for the other 20 percent.

General objectives for rainfed agriculture are:

1. To conserve the basic resources of soil and rain water and devise techniques for using these resources optimally for increased crop production.

2. To generate appropriate technologies for increasing the average farmer yield by at least 100 percent.

3. To devise techniques for stabilizing rainfed agriculture production by evolving alternate contingency plans to meet seasonal aberrations.

To achieve these objectives and improve "actual" yields with known production techniques involves essentially a double focus:

1. Finding and using systems that are more effective in storing the rainfall that reaches the earth. This may be achieved by management practices that increase infiltration or reduce losses of runoff or evapotranspiration.

2. Finding and using systems that convert this water into more usable plant material per unit of water. This may be achieved by agronomic management practices that are tailored to the available and expected moisture supply.

These systems, or strategies, must be applied within the realistic resource limits of land, climate, and socioeconomic patterns. Systems that increase infiltration include tillage or residue management practices which affect the surface characteristics through surface roughness or prevention of sealing. Other practices that increase the time available for infiltration include contouring, terraces, and stripcropping. In general, those practices that will improve infiltration will also decrease erosion problems.

Agronomic management factors include the fertility-moisture balance. The highly variable moisture supply, typical of rainfed regions, requires that fertilizer requirements be tailored to the season. Optimal fertility is the easiest and most profitable way of increasing crop water use efficiency. A nutrient deficient plant uses water at approximately the same rate as a nutritionally balanced plant but with much lower yield.

Short season plants reduce the time of climatic exposure in the field. Crops do not vary much in daily water requirements during the growing season, therefore the length of the growing season is a major factor in total water demand. Although a short season variety may have a lower potential yield, actual yields may average somewhat higher because of reduced climatic risk.

The type of crop is important for obtaining a minimal yield under extremely adverse conditions. Some crops such as potatoes have a much higher minimal water requirement than others such as sorghum. The importance of reducing the risk of having a zero yield cannot be over-estimated. Survival is possible with extremely low yields but impossible with a zero yield.

Weed control is extremely important for efficient water use and becomes more critical as the moisture supply becomes more limiting. It may also be more important under poor soil and crop management practices.

Emergence and stand establishment is a major constraint in rainfed systems and is a parameter preferable to that of the planting date. Planting in dry soil during a period of a probable precipitation occurrence may be a major advance in cropping security. It is a function of the risk of dry planting, the risk involved with crusting, and weed problems.

Better use of limited moisture supply is possible with more careful attention to plant population and distribution in rainfed regions. Contrary to the generally accepted practice of close row spacing with sufficient precipitation, under limited water it may be beneficial to have sufficient within row competition to slow growth rates in the early part of the season together with wide between row spacing to prolong root extension into untapped stored soil water. Agro-meteorological research data will have to be integrated into crop-planning models, so that contingency plans suited to different weather probabilities can be prepared.

There is growing evidence that successful programs of assistance to small-scale agriculture can be successfully designed and implemented. However, the margin of error for success in project design is narrow with rainfed agriculture because: 1) farmers are hard to convince, their risk leverage is small and, since productivity is dependent on weather conditions, they are used to extreme variability in productivity; 2) they are extremely poor; and 3) technology diffusion is difficult as extension services are poor to non-existent. In addition, socioeconomic constraints such as market availability, price policies, credit availability, land tenure and lack of management skills contribute to the dilemma in which the small farmer finds himself. Farmers simply cannot afford to risk their limited resources on new practices which they are not certain will succeed. This risk factor must be added to the normal resistance to change and influence of custom and tradition.

APPENDIX B

RESEARCH/DEMONSTRATION/TRAINING FARM

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RESEARCH/DEMONSTRATION/TRAINING FARM

Demonstration farms which could be used for variety trials, new agronomic practices, other management practices, and as a source of initial local data on these items, should be initiated in various areas. This would allow the presentation of various practices and production systems without imposing them upon the farmer until shown to be viable. It would also offer a place for training technicians, extension personnel, and farmers allowing for actual hands-on experience. Farmer organizations should have input in the management of the demonstration farm. Training and field days on such a farm could be a very effective means of presenting new technology and management, and getting it accepted.

The farm could present actual examples and/or provide data on some or all of the following, both irrigated and/or rainfed.

On-Farm Water Management

Farm irrigation system design, control structures, leveling; effects of application rates, timeliness of application, methods of application.

Soil Management

Soil-water relationships; tillage practices for seeding, weed control, residue management-infiltration; fertility management; erosion control.

Climate

Data collection and analyses, rainfall probabilities.

Agronomic Management

Plant-water relationships, water-yield relationships, production per unit of water vs. cost per unit of water.

Crop Systems

Variety selection-testing, cereals, potatoes, corn, grain, sorghum, vegetables, oilseeds, legumes, forages; short season, high yields, drought tolerant, pest resistant.

Planting Patterns

Populations, row spacing, even seed distribution, seedlng emergence.

Rotations

Economics of legumes as source of N; supply of high inputs to cash crops and use of residual by succeeding food crop.

Weed Control

Rotations, mechanical, chemical.

Pest Control

Diseases, insects, birds. Rotations, planting times, chemicals.

Grain and Seed Storage

Drying techniques, structures, insect control.

Integrated Crop-Forage-Livestock Systems

Cereals, legumes, tame and native grasses; harvesting, grazing, storage.

Labor

Needs, availability and efficiency.

Marketing

Infrastructure, middlemen competition and commercial channels in general.

Home Economies and Financial Managerial

Better diets, off-farm employment, risk minimization and profit seeking.

It is essential that the farm be a cooperative venture of INERHI, INIAP, and INAMHI. Donor support for such units with technical assistance and training components would be very effective and provide a more reliable data base for the future.

APPENDIX C

A NEW INERHI ORIENTATION

By

D. Craig Anderson

APPENDIX C

A NEW INERHI ORIENTATION
(D. Craig Anderson)

ECUADOR'S WATER LAW AND THE PRIVATE SECTOR

The 1966 law which created INERHI as the public institution responsible for water control nationwide places the following responsiblities on the public sector, and on INERHI in particular:

a) the overall management of the water resource;

b) establishment of technical norms and specifications for the irrigation and drainage systems;

c) carry out a thorough evaluation of the nation's water resources (establish a baseline of hydrology data);

d) look after the general protection and integrated development of river basins;

e) determine water requirements for irrigation and other uses; and

f) administer water rights, including granting use right concessions and maintaining a complete registry of such concessions (Ley de Creacion del INERHI, Capitulo I, Articulo 3).

Each of these are functions to be performed by the government acting on behalf of the public at large. These are very legitimate and necessary functions, and INERHI, in cooperation with other public agencies, should continue to devote adequate attention to them.

In addition to the preceding functions, the law also details several obligations which INERHI has toward irrigation and water management in the private sector. Specifically, they are:

i) "Protect, study, construct, and develop irrigation and drainage systems, within the national territory, on its (INERHI's) own accord or in cooperation with other institutions or entities;

ii) promote organizations or entities comprised of water users and establish, through regulations... standards for the administration and conservation of irrigation canals...;

iii) promote the establishment of private or mixed public and private irrigation enterprises, including allocations of capital, and the stimulation of capital investment in irrigation works;

iv) lend technical assitance to public or private entities or to private persons..." (Ley de Creacion del INERHI, Capitulo I, Articulo 3, subarticulos b, s, h, and l).

The first of the obligations listed above is less direct than the others but does indicate that INERHI, in its official capacity of "super-intending the best use and protection of the nation's water resources" (Ley de Creacion del INERHI, Capitulo I, Articulo 2) can work in cooperation with other bodies, be they public or private, in the fulfillment of its duties. INERHI does, in fact, allow other public funded agencies such as CEDEGE, CRM, and PREDESUR develop and administer irrigation systems under its general supervision. However, these kinds of collaborative efforts have been, to date, exclusively with public sector organisms.

With regard to this particular provision of the law, INERHI, in reality, has placed a predominance of fiscal and human resources effort on the part that states "on its own accord." This is evidenced by the number of irrigation projects and systems INERHI is unilaterally designing, constructing, and operating directly under its own control. These include the six irrigation districts now referred to as projects, which it inherited from the Caja Nacional de Reigo (National Irrigation Bureau) as well as other large projects such as Montufar and Latacunga-Salcedo-Ambato. The total number of irrigation projects, whether in the design or the construction phase, has proliferated greatly since the creation of INERHI in 1966. (N)

Items two and three above are both focused more directly at privately controlled and operated irrigation organizations. Clearly, some of INERHI's efforts are to be directed at strenghtening private sector irrigation by promoting and assisting, even to the point of financial aid, private irrigation enterprises. These may be directorios de aguas, communities (comunas), cooperatives, comisiones de riego, and the like. Indeed, one of its obligations is to stimulate the investment of private capital in irrigation delivery systems. In order to satisfy the demands of effective and proper administration and conservation of the resource INERHI is empowered with the right to establish standards to which these private organizations are to adhere.

The fourth of the obligations which INERHI has toward private sector irrigation is to provide technical assistance in water mangement and use to individual water users and to private organizations. It must do the same for its sister public entities. In essence, this sub-article of the law sets forth INERHI's extension duties; duties which, heretofore, it has not been able to carry out to any significant degree. Nevertheless, this activity remains a necessary and fundamental complement to INERHI's overall responsibilities in managing the nation's water resources in general, and irrigation in particular.

To summarize, the law creating INERHI makes it clear that the private sector is recognized as a viable vehicle for irrigation development in the country and that it is to be assisted by the public sector in this regard. However, this has not been the case. Private sector irrigation, as noted previously, has grown tremendously in the past ten years, but has done so, with few exceptions, with no direct assistance from INERHI or other public agencies.

SUGGESTED PUBLIC EMPHASIS

The question may well be raised at this juncture as to how INERHI, and the public sector institutions in general, could better stimulate and assist the private sector? The following paragraphs will describe a general philosophy and approach for working with and stimulating irrigation development within the private sector in Ecuador.

Restricting Public Projects

The public sector, especially INERHI, might adopt a philosophy of generally restricting new projects and construction to avoid the problem of overextending its limited resources and spreading them too thinly among a large number of projects. This suggestion was offered ten years ago in a book entitled "Los Obras Hidraulicas y la Supervivencia del Ecuador." (M) Priority projects should be finished before new projects are placed into the construction phase. Thus, several adverse conditions could be avoided. The current government's national development plan directly addresses this issue in the following fashion:

> "What's more, the favorable impact expected from State investments in irrigation works has not been produced due, principally, among other things, to the growing number of projects begun simultaneously, with a wide dispersing of resources that has resulted in:
>
> 1. prolonging the time periods for project execution;
>
> 2. the inopportune dispersal of funds which impedes the fulfillment of construction on a timely basis;
>
> 3. political pressures and demands arise;

4. the lack of preparation of farmers in the use of irrigation and farming development techniques is reinforced; and

5. the absence of policies for encouraging private investment in irrigation works to the degree it has had in the past is accentuated." (Plan Nacional de Desarrollo del Gobierno Democratico, 1980-1984, Segunda Parte, Tomo II, ps. 145-146).

Attention is drawn to the last of the above points. As has been previously noted, one of the government's main responsibilities is to promote growth in private sector irrigation by stimulating private capital investment infrastructure. Large projects to be constructed entirely through public means could, indeed, be a disincentive for private investment and often reinforces the phenomenon of "patronismo" on the part of the central government.

Reorientation of Project Concept

The physical scope of projects, in general, should be reoriented in that they should not be extended beyond what INERHI, or other public sector entities can logically and effectively control within the agency's realistic capabilities. The following points are the major tenets of this reorientation in current philosophy.

a) INERHI would develop water sources which are for topographic or other reasons so difficult as to be beyond the capability of private investors and irrigators to develop without public assistance. INERHI is equipped to design and construct diversion works and conveyance structures in larger streams, rivers, quebradas, and the like which private water users, on their own accord, would be unable to develop.

b) INERHI, or other public entities, however, would only initiate such works in areas where the needs and benefits of irrigation can be clearly demonstrated and in which the future project beneficiaries have demonstrated their willingness to participate by previously joining together to form some type of legitimate water user organization. This would be a requirement. The form of user organization would be optional, and this point will be addressed later. The user organization's purpose would be twofold: first, to be responsible for the construction and development of the delivery system beyond the primary canal or diversion constructed by the government, and second, to administer and manage the entire system once it is in operation.

c) INERHI, then, would construct a "limited" system that takes the water from a difficult source such as a large river, and conveys it to a point where the water user organization can then take the water and put it to beneficial use. The public sector thus assists private sector irrigation by, in essence, providing a ready and accessible source of water.

d) INERHI, or other implementing agency, would also offer assistance to the new water user group in the design and construction of its delivery infrastructure where required, without becoming directly involved in the construction itself. The new organization would be free to use INERHI's advice and assistance or to work with private engineers and contractors. However, all design and construction would be approved by INERHI. One significant vehicle for INERHI assistance would be in the form of supervised credit.

Incentives for Private User Groups

Items, then, which could be employed as incentives to stimulate the success of the newly formed "private" systems would be:

a) Engineering and design advice;

b) Technical assistance on farming inputs such as water use and management, contour farming, improved agronomic practices, and the like. A variety of public entities would be involved in giving such assistance, and the responsibility would not fall entirely on INERHI;

c) Immediate adjudication of the water right by INERHI;

d) The elimination of any water tariff on the water right concession. Water tariffs are viewed as a disincentive to water use at the present time, are a burden to the individual water user, and yield no positive benefit above the cost of collection. General water administration costs ought to be a burden of the government, not individual water users;

e) The security of the water source stemming from the fact that INERHI manages the larger water sources (e.g., the river) and permanent diversion and primary conveyance structures have been installed. Effective regulation of water rights by INERHI is imperative.

f) INERHI assistance in arranging for local contractors and the general supervision over such contractors. This would provide a much needed source of support. INERHI would be responsible for the quality of design and construction, thus eliminating this burden from the newly formed water user group. Such action may well require the licensing and bonding of private contractors; and

g) Credit with convenient terms and payback periods.

In general, public sector agencies, primarily INERHI, would assist the user organization as it begins to function without becoming directly responsible for the construction, administration, and continued operation and maintenance itself, as has been the case in the past.

ASSISTING EXISTING PRIVATE SYSTEMS

The philosophical points presented in the preceding section have been discussed in terms of government support of irrigation organizations in areas where "new," formerly unused, water is developed. They are equally applicable to water user organizations that already exist. For example, there are literally hundreds of small, private systems nationwide which could greatly benefit from an infusion of technical and financial assistance from the public sector. Those which now operate poorly could be improved and those which operate well could perhaps become even more effective, thus improving efficient water management and use across the private sector.

An example of this type of assistance is the straightening and lining of canals and the general improvement and modernization of infrastructure, including the construction of permanent diversion works where possible. This would be a general upgrading that would stabilize the availability and security of the resource. Such investments by the public sector would also be to its own benefit since permanent diversion works would greatly enhance INERHI's ability to regulate water use along a given watercourse, something that at present it is not able to do.

The above approach would be followed when working with either old or new systems, and with any form of user organization that could legally exist under current law. This could include, then, the traditional water user associations (directorios o juntas de aguas) and communities (comunas) common in the Sierra as well as the agricultural cooperatives more common to the coastal area.

Such organizations would also include the irrigation and drainage commissions (comisiones de riego y drenaje) which can, according to current law, be organized to administer irrigation and drainage systems as part of overall production activities. Credit loans from the National Development Bank (Banco Nacional de Fomento) are also provided for these commissions by law. Detailed information on these organizations is found in Title IV, Chapters I and II of the regulations for implementing the water law, which is the Reglamento de la Ley de Aguas.

The government should seriously consider utilizing the entrepreneurship, initiative, and manpower of viable user level organizations both for the creation of new irrigation systems as well as for the upgrading of pre-existing ones. Over time, a great deal of irrigation has been developed in the country, primarily through group action and without any government intervention. The preceding suggested plan of action, or philosophical reorientation, is a prime method of approach which the public sector ought to use to keep the momentum in the private sector insofar as irrigation development and administration are concerned. The public sector, in its role as overseer of the nation's water resources, "manages" water nationwide by providing a proper level of assistance and incentives to private water users. Recently, INERHI has been studying the possibility of establishing a program to support the rehabilitation of small scale private systems. This type of activity should not only be actively supported but should be expanded to encompass the type of program orientation presented in this section.

CURRENT INERHI IRRIGATION PROJECTS

Another logical extension of this newly defined public sector role would be for INERHI to turn over the administration and daily management of the irrigation projects it now controls and operates to the water users. This would be a planned transition in which the users would be first organized in user associations and step by step begin to assume control over the delivery infrastructure. In some of the larger existing projects INERHI may have to perform the operation and maintenance of the primary canal. However, the general objective is to pull back to the point where the users themselves are operating the maximum portion of the delivery system possible. The water users of these systems would be offered the same sorts of technical and financial assistance as for any other newly formed organization as described in previous sections. The benefits would also be the same, plus some additional ones.

Primarily, this movement would result in savings to INERHI. As has been cited in previous research, INERHI's irrigation projects require fairly large sums of money to operate and maintain. (I)

By divesting itself of the obligation to maintain and administer extensive infrastructure networks in its projects, the government will be able to be more flexible in using those newly freed funds for other purposes more consonant with its responsibilities as overseer and general manager of the nation's resources. Basically, such a strategy will allow INERHI to get out of the business of water delivery per se and to focus more of its resources on water administration duties in a more general sense, and on developing research, training, and technical assistance programs in irrigation sciences.

A FURTHER INERHI FOCUS

Another important aspect of this new philosopjy, as noted in the previous paragraph, is the movement of INERHI into water management research and technical assistance programs. These functions are necessary and integral components of the new profile which the public sector, principally through INERHI, would assume. Expansion of INERHI programs into these areas will be a positive step in solidifying the institution's role as the innovative force in irrigation and drainage development and in allowing it to fulfill its technical assistance mandate toward the private sector and other public sector entities.

This new direction will require INERHI to shift current organization and resources in such a way as to adequately staff, finance, and prepare sections for research and technical assistance. In addition, ties will be established with sister institutions such as INIAP and INAMHI for integrated research, and with SEDRI and INCCA for coordinated technical assistance and training programs.

CONCLUSIONS

Some may view the strategy presented above as an abandonment of principles. It is not. What it does suggest is a redirection of policy and practice in such a way that the public sector assumes a much more limited profile in actual irrigation delivery by essentially leaving this function to the private sector and by assisting it in accomplishing this end. On the other hand, INERHI has the opportunity of expanding its operations into new dimensions, for instance, research, technical assistance, and improving its performance in thorough administration of the water law and the overall regulation of the resource. Such a philosophy basically allows INERHI to more fully fulfill its broad range of responsibilities under the law. The new result should be a fundamental improvement in water use and irrigation management nationwide. This new perspective should be attractive to the government. Through it, everyone involved in the irrigated sector comes out ahead.

The above reshaping of approach to management of the irrigated sector is timely. The government cannot conceivably really manage and control the sector in any other fashion. For one, resources are far too limited to permit the continued expansion of public funded and controlled delivery systems, a practice which has received excessive emphasis to the detriment of other responsibilities. For another, important functions such as the processing and administration of use right concessions need additional manpower and fiscal resources if they are to be fully effective. There is enough to be done that the diversion of valuable resources too heavily into areas such as design, construction, operation and maintenance keeps an agency from fulfilling its broader purposes and objectives.

If the government, for example, could more fully support the inventory and policing of water uses so that it is done fairly and justly under the law, it would give stability to the allocation system and the confidence to the private sector which should lead to continued investment in irrigation development. Likewise, expansion into technology transfer and assistance activities backed by appropriate research, also engenders stability in the sector to the benefit of all.

APPENDIX D

ASSISTING PRIVATE IRRIGATION INSTITUTIONS
AN APPROACH FOR THE 1980's

By

D. Craig Anderson

APPENDIX D

ASSISTING PRIVATE IRRIGATION INSTITUTIONS: AN APPROACH FOR THE 1980's

(D. Craig Anderson)

INTRODUCTION

The purpose of this brief paper is two-fold: (1) to provide the interested reader with an overview of the primary types of water user organizations in the private sector; and (2) to propose a philiscphical approach for assistance agencies to follow in working with these organizations.

Irrigation delivery by the private sector in Ecuador is extremely important since it is reponsible for some 88 percent of the current total irrigation in the country. Much of private sector irrigation is performed by fairly large landholders and commerical enterprises acting independently of other water users. These independent irrigation operators are not the subject of this presentation. This focus is on the large number of private user organizations which distribute irrigation water either as their primary function or as one of several agricultural related activities. These consist of both formal and informal types, formal being legal entities and informal being nonlegal bodies which are nonetheless organized and operational. This paper discusses private irrigation delivering organizations in Ecuador, both those of the Sierra as well as those of the Costa.

HISTORICAL SETTING

The vast majority of private irrigation organizations are in the Sierra, where farming and irrigation have been traditional for centuries. This is the area of predominant Indian ancestry where communal organization and mutual cooperation have long been customary. Even prior to the pre-colonial period many Indians of the highlands have practiced irrigation in some form. Crude irrigation systems were constructed and operated by the Inca Empire, whose northern headquarters were located in Quito. Nearly all the old canals and ditches were later destroyed. Consequently, virtually all the irrigation works in operation today have been constructed in the post-colonial and modern eras. At present, irrigation entities operate many canal systems throughout the Sierra. Such organizations are most common among small and medium-scale class farmers.

The oldest of these modern day water user organizations date back to the 1930's, but some continue to be created even at the present time. They are most commonly known as Directorios de Agua or Juntas de Usarios, hereafter referred to as water user associations. These user associations have become very important as irrigation distribution organizations in Ecuador, and they are by far the most numerous of any formal irrigation institutions, public or private. For the most part, water user associations function well and are responsible for the delivery of a great deal of irrigation water. Table D.1 is a listing by province of formal water user associations in 1973.

A brief description of the water history of the country will aid in understanding the development of private irrigation practices and organizations.

Beginning several hundred years ago, much of the productive land in highland areas was divided among very large haciendas. This type of landholding is termed latifundia, the extreme opposite of minifundia, which are very small subsistance landholdings. These haciendas were originally awarded to privileged people as a concession from the colonial government.

Between 150 to 200 years ago the large land owners began to construct irrigation canals, utilizing the Indian labor of those people who lived and worked on the hacienda.[1] Upon the completion of such canals the hacienda owners would rent or sell the water to the laborers who had built the canals or to other users who would pay for it.

Two significant things have occurred during the last century. One is that many haciendas no longer exist today because they have been subdivided and fragmented into smaller units. Second, in many cases the water rights and land titles were sold separately and therefore did not necessarily correspond to one another. The relationship between land titles and water use rights had become, in many cases, confused.

The history of unregulated water rights and land sales led to two serious conditions. The first, is the previously mentioned disparity between legal water rights and land titles. Unfortunately, this problem has never been adequately addressed and continues to persist. The second was the resulting high cost of obtaining a water right. Consequently, in the past, the acquisition or purchase of a water use right represented a considerable investment. One often recovered part of this investment by renting water at extremely high prices to subsistence farmers who absolutely needed the water to survive. This

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[1] The terminology used in Ecuador to describe this form of servitude is hausipungo.

TABLE D-1. Formal Water User Associations by Province

Region	Province	Number
Sierra	Azuay	10
	Bolivar	0
	Cañar	1
	Carchi	4
	Cotopaxi	50
	Chimborazo	23
	Imbabura	37
	Loja	3
	Pichincha	24
	Tunguarahua	98
		250
Costa	El Oro	0
	Esmeraldas	0
	Guayas	0
	Los Rios	0
	Manabi	1
		1
Oriente	Morona Santiago	0
	Napo	0
	Pastaza	0
	Zamora Chinchipe	0
		0
	Total	251

Source: Anderson, D. Craig, Irrigation Water Management in Ecuador. Unpublished Master's Thesis. Utah State University, Logan, Utah. 1973, p. 80.

exploitation of the rural poor was a social injustice which rose to alarming proportions in Ecuador. In an effort to bring this situation to a halt, the Water Law of 1972 absolutely prohibits the sale, purchase, or rental of water by private individuals. Today, the problem is virtually non-existent thanks to this law and the vigilance of INERHI in implementing the law.

IRRIGATION ORGANIZATIONS OF THE SIERRA

This history of water and land transactions has also left another lasting impression on irrigation development in the Sierra. Fundamentally, it prompted many farmers, especially small landowners or minifundistas, to come together into groups for the common purpose of jointly acquiring water for irrigation and then administering that water among themselves. Clusters of users along a canal or section of canal began to organize in order to secure and administer an independent source of water which they would acquire and use as a group. This custom of banding together into private water distribution organizations is common throughout the Sierra.

Today, water user associations consist of anywhere from a handful to several thousand users. Many of these associations have now been organized according to legal statute and are recognized by the law as legal entities which have power to enter contracts and agreements. Others, however, have traditionally existed as informal organizations for many years and may or may not have formal bylaws or regulations. Figure D.1 outlines the basic organization of a typical water user association. Many of these organizations were formally structured under the now defunct Water Law of October 6, 1939. The current Water Law of 1972 preserves this basic organization, as well.

Water user associations are entirely financed through assessments levied upon each shareholder according to a set rate on the volume of water used or the number of hours specified in the use right. Both fees and labor assessments are levied. The levels of assessments vary with each organization and are usually fixed by the Board of Directors. These organizations commonly operate on low budgets with relatively few expenses. Consequently, the cash cost per shareholder per year is not burdensome.

The economic impact of the labor provided by each association member for infrastructure maintenance must also be taken into consideration. The labor assessment is also generally minimal and is calculated on the volume of water corresponding to each use right. Therefore, association members only pay in cash the amount necessary for basic administrative matters. They provide voluntary labor for the

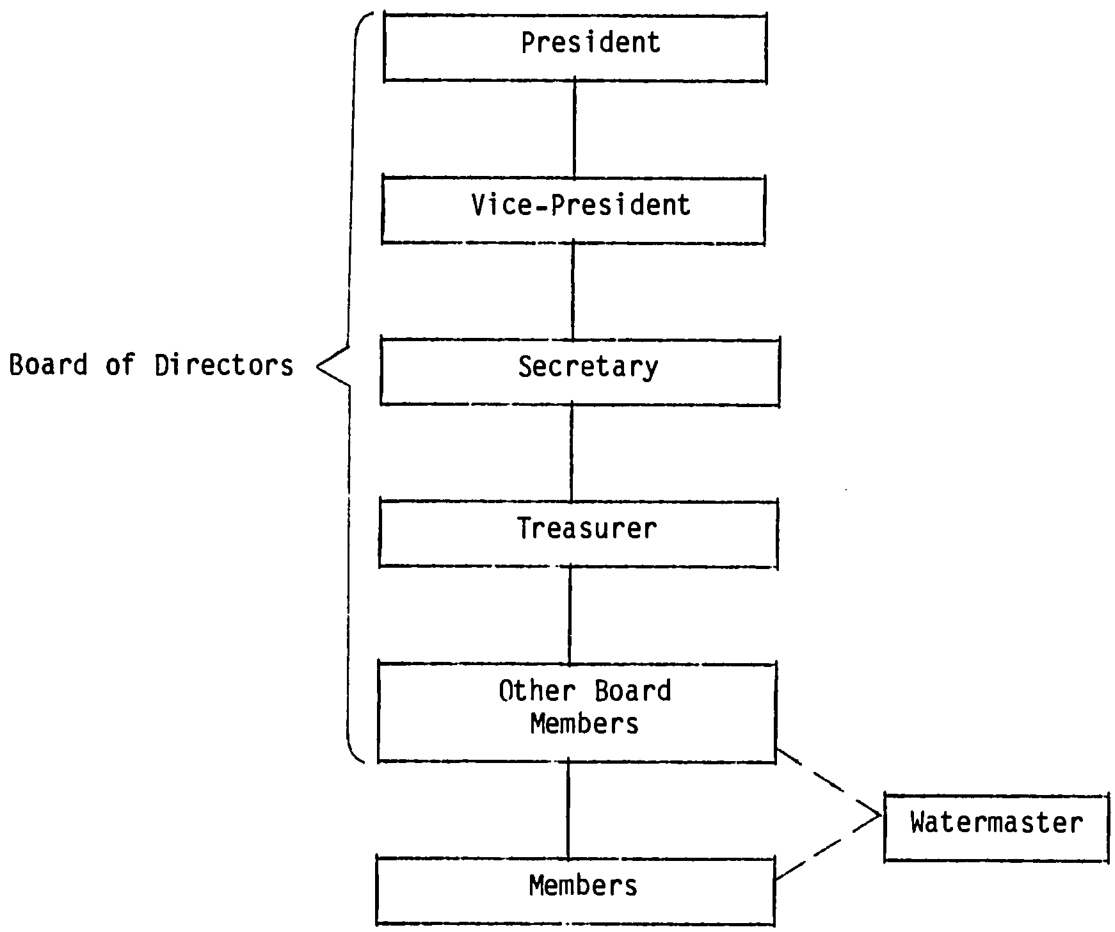


Figure D-1. Organization of a Typical Water User Group in Ecuador.

cleaning and maintenance of the distribution works, and most association officers serve without monetary remuneration. These factors help keep the cost of operation down. These organizations were originally created for acquiring and delivering water, and to do it at a reasonable price. For the most part, they do this quite effectively.

The principal characteristic of the irrigation networks utilized by these associations is their simplicity. They are generally not too large or extensive, and have rudimentary diversion works and unlined ditches. Water is usually distributed by hours, which is the total volume of water in the ditch for one hour every so many days. The number of hours needed is calculated by the size of the plot to be irrigated and/or customary past practice.

There are, of course, other types of institutions in the Sierra which distribute irrigation water, but they are much less numerous than water user associations, are not dedicated exclusively to irrigation, and in comparison, distribute relatively insignificant amounts of irrigation water. Some of these are agricultural societies (sociedades agricolas), agriculture cooperatives (cooperativas agricolas), small indigenous communities (comunas), and family garden groups (huertos familiares).

COSTA PRIVATE INSTITUTIONS

The development of private irrigation institutions on the Ecuadorian coast has been quite different from the more traditional patterns of the Sierra. Irrigation in general has a shorter history on the coastal plain and, therefore, so do private irrigation organizations. Indeed, until some 40 years ago, no irrigated agriculture existed in the Costa. Although today there is a significant amount of coastal private irrigation, most of it has been developed by individuals acting on their own initiative or by private business enterprise such as the large private sugar and banana plantations. These individuals and enterprises are autonomous in their irrigation operations. Consequently, relatively few entities composed of various private irrigators are in existence on the coast. As Table D-1 indicates, only one water user association similar to those in the Sierra is known to operate in the entire coastal region.

Beginning in 1972, several (approximately 22) agricultural cooperatives were created under a Ministry of Agriculture (MAG) program funded at the outset by USAID through the National Development Bank (Banco Nacional de Fomento). In this program uncultivated land in the lower Guayas Basin was acquired and turned over to interested farmers to operate after having organized themselves in a cooperative arrangement. Credit was extended to them and technical advice was available from

MAG. These cooperatives constructed and currently continue to operate, limited irrigation canal systems as part of their overall production activities, most of which were in rice. They are still some of the few private farmer organizations engaged in irrigation known to exist on the coast.

These agricultural cooperatives, as is the case with many of the individual private irrigators on the coast, generate water for irrigation purposes by pumping it from the large rivers in the area. Several modes of operation are prevalent in these cooperatives. Some work all, or nearly all, their cultivable land on a communal basis while others farm on a more individual basis, each member being responsible for a certain land area. Most, however, operate on some combination basis by allowing members to farm individual plots for themselves but by also maintaining significant areas under communal farming. Members are required to provide the labor inputs necessary to maintain the communal portions of the cooperative's production activities. What is gained from their individual plots is for their personal consumption or disposition.

IRRIGATION ORGANIZATIONS SUMMARY

The diversity in patterns of agricultural development between the Sierra and Costa of Ecuador has impacted present day differences in irrigation and irrigation user level organizations. The Sierra, the highland area of traditional habitation and of longstanding agricultural production, is characterized by large numbers of small canal systems and water user associations. The heavily vegetated and humid Costa is an area which for many years was unattractive, agriculturally. In recent decades, however, both rainfed and irrigated agriculture have expanded rapidly in this zone. Nevertheless, the water user associations which have enjoyed a long tradition in the Sierra are virtually unknown in coastal areas. Irrigation delivery is much more independent and individualistic.

WORKING WITH PRIVATE IRRIGATION INSTITUTIONS

The irrigation development strategies suggested in the body of this report involve, in part, the government working in cooperation with private water user organizations of various types. In some instances these will be existing organizations now utilizing water and in other cases new organizations will be formed in localized areas which at present do not enjoy the benefits of irrigation. This applies to both Sierra and Costa regions and to the entire range of organization types which administer the delivery of water for agricultural purposes. Since carrying out the strategy as recommended would require working under a variety of possible circumstances, what is suggested in the following paragraphs is a general philosophy about how best to interact with user level organizations in a manner that will yield positive results.

First, there are some important points that government agencies must keep in mind, points which help orient their plan of action when working with rural institutions. Briefly, they are as follows:

a) Campesinos are generally skeptical of promises of assistance from the government that purport to help them. Agencies should not come on too strong or too fast, and should be careful not to offer more assistance than they are able, willing, and intend to provide. Once a project is underway, however, agencies ought to finish it as quickly as possible and move on.

b) Agency personnel should appreciate the campesino point of view. Programs should focus on the campesinos best interest, especially when it may conflict with what agencies feel would be in their own interest.

c) Related to the preceding point, public agencies should not assume they "know" how farmers think and what they want. They probably don't, because most public officials have never been farmers! Agency field personnel should ask for, seek out, and be receptive to campesino opinions and desires and incorporate their ideas into project planning.

d) Another suggestion is to keep assistance as uncomplicated, yet as helpful, as possible. Each case is considered separately to determine the best level of assistance and approach under that individual circumstance. Again, assistance is simple, direct and appropriate to the group's needs.

e) Assistance programs should take advantage of group dynamics by involving the group in every way possible. This includes utilizing its manpower, creativity, and dynamism whenever possible to successfully reach project goals. Group participation in the project is vital to its long term success.

f) From the outset, the assistance project should not be viewed as a "public" project. It is the group's project, for its benefit. The public agency is only assisting the group. This is a crucial point. The assistance agency and its representatives must have the proper mind-set. Remember, when the project is completed it is the user group who will operate the system and have to be happy and satisfied with it. The agency will merely move on. Therefore, it should do everything possible to make it the group's project.

g) Public officials working with rural peasant organizations and their members should first gain group confidence and trust, then work to maintain them. This is an attitude of friendship, of sensitivity to local conditions, and of sincerity in service. Field personnel should demonstrate that they want to help. This will give the assistance agency much needed credibility with recipient organizations.

Past experience, worldwide, has shown that government assistance programs in rural areas are consistently more successful if the above types of considerations are followed in project planning and execution. They delineate a philosophy more conducive to success, one which can be applied to any program of extension or technical assistance. Unfortunately, it is often not recognized or is ignored by those offering the assistance.

One of the key ingredients to success is to find, and lock into, the local, and oftentimes informal, lines of communication and authority within the recipient group or impact area. This may require that an agency recruit and employ individuals in key supervisory and field positions who are sensitive to this issue and who have had past successful experience in interacting with campesino level groups.

Another key ingredient is to locate an individual in the client group who has the confidence of his neighbors or fellow organization members. Once identified, this type of person can be a great ally to the project. This individual, or one selected by the group at large, may even be utilized as the primary contact person (local promoter) for formal interaction between the assistance agency and the group.

The preceding scheme, with its primary points, can be followed regardless of the type of organization one is dealing with for irrigation development or system modernization, whether it is a traditional Indian comuna in the Sierra, or a new production cooperative on the coast. It is equally applicable if working with an existing organization or if creating a new one. The same philosophy is at play. The only difference may be that in the latter case more time and work may be required at the outset, as the new group is formed.

APPENDIX E

AGRICULTURE SECTOR STATUS SUMMARY

APPENDIX E

AGRICULTURE SECTOR STATUS SUMMARY

NATURAL RESOURCES

Topography

Ecuador is divided physically into three distinct agricultural regions. Of the 280,000 Km^2 of land area, 25 percent is in the Costa (the rolling western Andean foothills and Pacific coastal lowlands). These range from arid desert areas to tropical rainforests and mangroves. The Sierra consists of the mountain valleys and peaks of the parallel mountain ranges which cut the country from north to south, representing 22 percent of the land surface. The floors of the intermountain basins range from 2000 to 3000 m altitude. The remaining 46 percent is in the Oriente or eastern expanse consisting of the tropical rainforests of the upper Amazon basin.

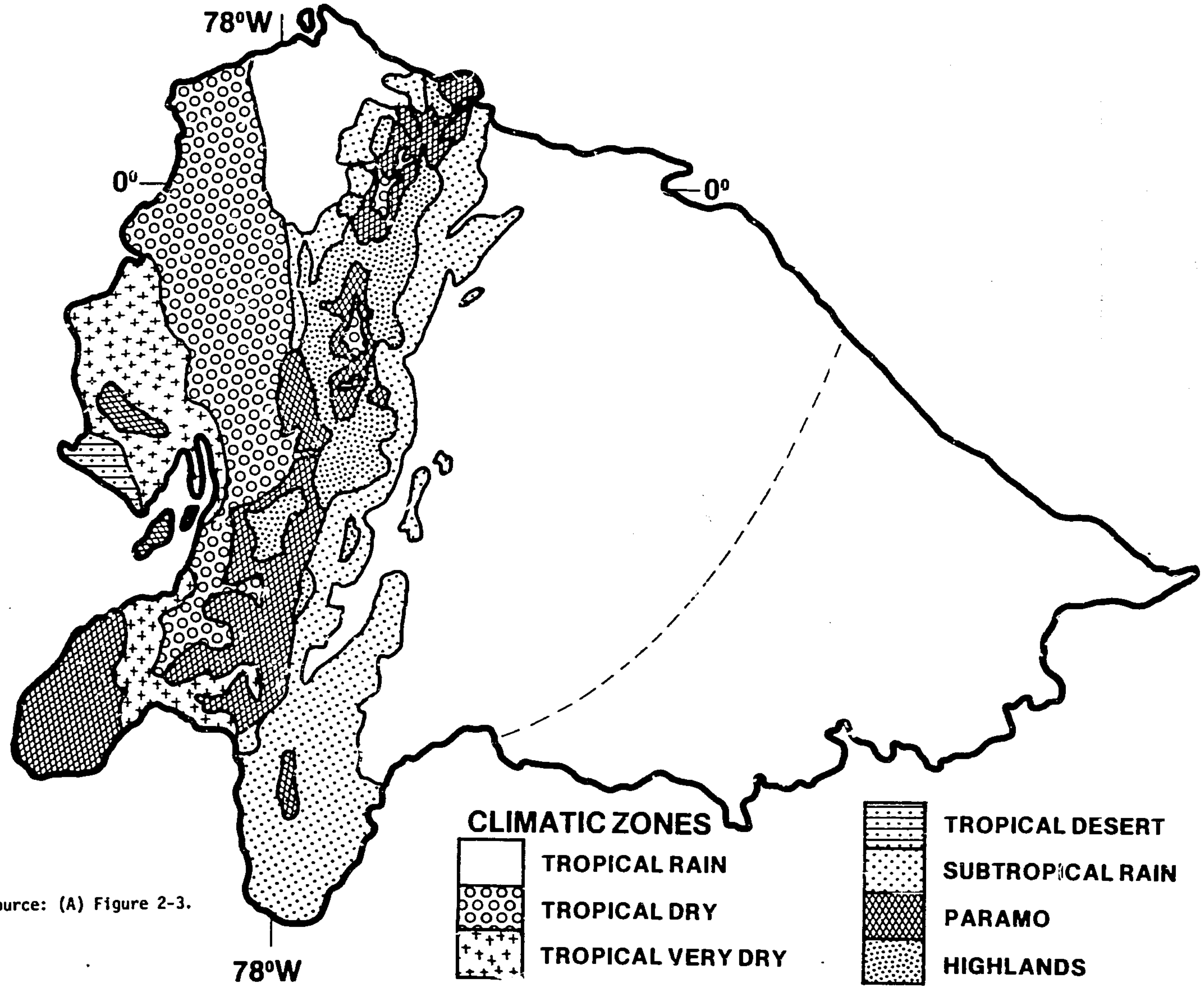
Climate[1]

The topographic features of the country are complex and this creates very diverse climatic conditions with many microclimates, particularly in the Sierra. The climate of an area is dependent on the wind exposure in the Andes, the equatorial location, the Humboldt and Nino currents, altitude, and local factors. In general, there are two seasons in the Sierra and Costa--the dry season or "verano" and the rainy season or "invierno." The Sierra has has a "normal" temperature range of 10° to 18°C except for the "Paramo" or highest altitudes where the normal is less than 10°C. The rainy season is a bimodel distribution from October to May with the highest precipitation occuring in October in the northern hemisphere and in March in the southern hemisphere. Precipitation ranges from 300 to 3000 mm with sporadic frosts and drought being the major constraints.

The Costa has a "normal" temperature range of 24° to 26°C. The rainy season is from December to May with precipitation of 4000 mm to 80 mm in the wet tropical north to the desert southwest. A major constraint is the flooding of portions of the Guayas Basin.

The Oriente has a "normal" temperature range of 23° to 26°C with an equatorial precipitation pattern of 3000 to 6000 mm. The major constraints are excessive rainfall and soil characteristics. See Figure E-1.

[1] The bulk of this sub-section is quoted from source (A).



Source: (A) Figure 2-3.

Figure E-1. Climatic Zones of Ecuador.

Good, extensive, and reliable historical and current meteorological data is essential for technology transfer and rapid agricultural development. The data is essential for good system design in irrigated agriculture. It is also, however, equally important in rainfed agriculture for crop zoning and matching agronomic inputs to probable production. Rainfall probabilities also allow for better selection of planting dates, harvest date, and crop varieties. The requirement for manpower and equipment is high. As with other governmental institutions, INAMHI is under severe budgetary and personnel constraints. It is imperative that INAMHI and INERHI have a close working relationship, particularly at the field level. INAMHI must be fully supported in order that the data necessary for good water management be available and reliable.

Soils

Because of the many types of climate, different parent materials and ages of formation, Ecuador has a wide range of soils. In general, these resources are excellent if properly managed. There is need for more detailed soil mapping and study. No irrigation project should be initiated without a detailed soil map being developed with agronomic interpretations. Close working relationships between INERHI and the Soils Department of INIAP are required.

Sierra. The soils in the Northern and Central regions are generally of volcanic origin. The higher altitudes have soils with high organic matter but are seriously limited for production because of the low temperatures and steep slopes. The lower altitudes are more favorable for production but are subject to serious erosion because of the slopes. The valleys are formed from colluvial-alluvial materials with a more coarse texture and lower fertility.

The soils of the southern Sierra are formed from metamorphic or sedimentary materials rather than volcanic. The higher altitudes are clayey and have good physical characteristics but are limited because of low fertility, aluminum toxicity, and steep slopes.

The lower hills have productive soils with good physical characteristics and fertility. The lower slopes and alluvial valleys also have quite productive soils.

Costa. The soils of the rolling plains north of the Santa Elena peninsula are generally developed from sandstones and shales except for hill tops. Going from the dry south to the wetter north the soils become more acid and lower in fertility. Soils on slopes are frequently shallow because of erosion. Many of the soils in the intermediate precipitation range are quite productive.

The soils of the Guayas Basin are excellent and very productive. They are some of the best soils in Ecuador.

The soils of the southern coastal plain are recent alluvial origin, deep, very productive and have enormous potential. Limiting problems are excessive water in the rainy season and drought during the dry season.

Oriente. The east lower slopes of the Andes and rolling hills of the upper Amazon basin have clayey, shallow soils with low productivity. The soils are in a fragile ecological balance and require extensive study. There are some very productive soils in some plains and alluvial terraces. In some cases there are problems with flooding and drainage.

Erosion

Ecuador has very serious erosion problems in almost all areas of the country because of its geography, climate and soil characteristics. Overgrazing, deforestation, and improper soil and water management have made major contribution to erosion magnitudes. There are many examples of lands abandoned because of erosion and the possibility of a potential catastrophe in the Oriente should not be minimized. There are examples of up to 3 m of soil being lost in Sierra fields and reservoirs losing more than 20 percent of their capacity in five years. This illustrates the importance of INERHI paying more attention to the protection portion of its mandate. It is imperative that INERHI work closely with the new soil conservation unit being developed. Soil conservation should be involved from the beginning in any irrigation project.

Water

Ecuador has an abundance of water resources. In fact, during the rainy invierno, too much water is often the problem. In addition to the abundant rainfall there are a number of lakes located in the Sierra region whose resources have been relatively untapped to the present.

Eighty-four separate river basins have been mapped in Ecuador, the majority of which flow westerly into the Pacific Ocean. A few of these are only small intermittent streams. However, the 11 most important rivers flowing into the Pacific discharge some 107,039 x 10^6 m^3 yearly, while the three large rivers flowing east to the Amazon have an annual flow of 98,245 x 10^6 m^3.

Few dams of any consequence have been constructed in the country, although CEDEGE (Study Commission for Development of the Guayas River Basin) is currently developing the Daule-Peripe Project which will consist of a large multi-purpose dam in the upper end of the Guayas Basin. Another large project is presently under construction at Pisayambo in the Sierra but will be used primarily for the generation of electrical power.

Agricultural Regions and Products

The ecological conditions (climate and soils) of the three natural regions determine the distribution of crops. The main crops in the Costa are bananas, cocoa, rice, coffee, cotton, sugarcane, soybeans, and oil palm. A wide variety of crops are grown in the Sierra: corn, potatoes, wheat, barley, tubers and roots (oca, melloco), lima beans (habas), and some fruits. With the exception of tea, cincona and oil palm, the Oriente of Ecuador produces few crops (Figure E-2). Agricultural production can be generally classified as either "commercial" or "subsistance." Irrigation and improved technological practices are mainly visable at the commercial level.

Animal husbandry is important in all zones. In fact the demand for meat and dairy products has induced considerable technological improvement among larger commercial operators. These improvements include more productive breeds and pasture upgrading based on new forages and fertilization as well as irrigation.

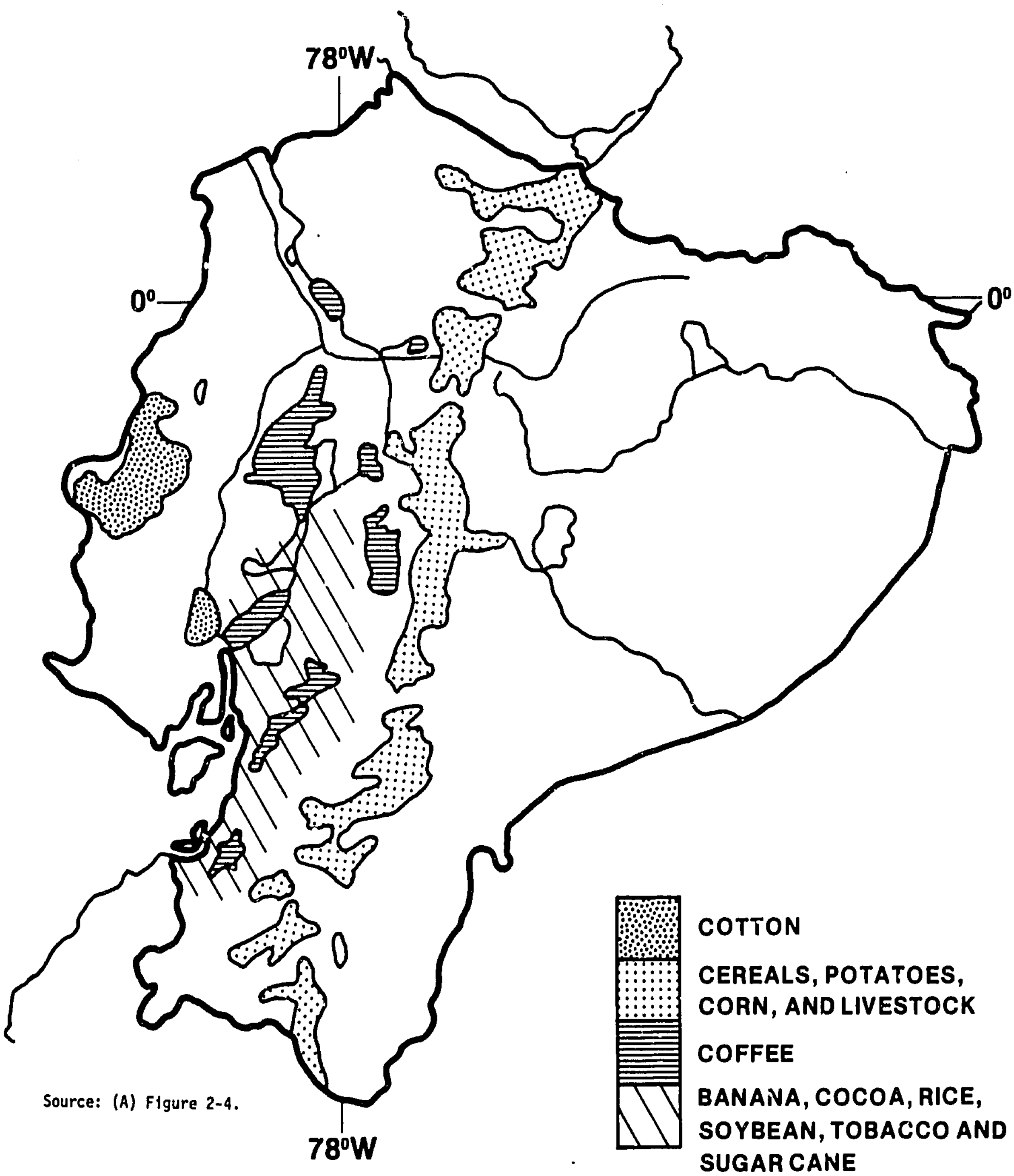
LAND TENURE

Table E-1 indicates there are approximately 7,657,196 hectares of farmland in Ecuador and some 638,989 individual farm units. The most striking feature of the table is the inequality of land distribution by farm sizes minifundios, those farm units of less than 10 hectares each, which comprise 80 percent of the total number of farms yet account for

TABLE E-1. Farm Size and Number of Farm Units in Ecuador

Size of Farm (ha)	No.	Farm Units Percent	Total ha	Area Percent
Less than 1.0	173,710	27.2	72,969	1.0
1.0-4.9	260,050	40.7	564,841	7.4
5.0-9.9	77,510	12.1	513,410	6.7
10.0-19.9	48,987	7.7	644,887	8.4
20.0-49.9	49,586	7.8	1,505,656	19.7
50.0-99.9	17,066	2.7	1,076,860	14.1
100 or more	12,140	1.8	3,278,573	42.7
TOTAL	638,989	100.0	7,657,196	100.0

Source: E, P. IV-32 & 33; cf. N , Table 3.17



Source: (A) Figure 2-4.

Figure E-2. Distribution of Major Commercial and Subsistence Crops in Ecuador.

only 15.1 percent of total farmland. In contrast, the medium and large multi-family farms (50 hectares and above) occupy 56.8 percent of the land but are only 4.5 percent of the total farm units.

The real problem areas of minifundio are concentrated in the traditionally populated Sierra, especially in the provinces of Cotopaxi, Chimborazo, Tungurahua, Canar, and Azuay, all centers of Indian habitation. The Costa, a relatively newer agricultural area, is characterizied by slightly larger average-sized farm plots, although many small farms exist there as well. (E, p. IV-30)

AGRICULTURE ROLE IN ECONOMY

Contribution to Gross Domestic Product

Table E-2 indicates that agriculture (including forestry and fishing) accounted for 14.5 percent of GDP in 1981, down from 24 percent in 1970. This reduction occurred because other major economic sectors had real growth rates of 8 to 10 percent per annum while agriculture grew much more slowly. Viewed in isolation, the sector had real growth of roughly 2.3 percent during the 1970-80 period. This is shown in Table E-3. The largest subsector gains were made in forestry and fishing. Livestock also grew at a substantial rate. During the years mentioned, crops declined in relative importance to overall GDP (Table E-2.); this trend included the main export crops.

Taken together, Tables E-2 and E-3 reveal that the agricultural sector picture in Ecuador has turned somewhat negative. The rate of growth in value for rice has been high but for other non-export crops the rates have been well below zero. In consequence, the non-export crop sub-sector has had a negative rate of growth in real terms of -4.2 percent since 1975 (column 2, Table E-3).

In 1972, before petroleum became an important export item, the agricultural sector accounted for over 75 percent of total commodity exports. The export data, in terms of $US are shown in Table E-4. Cocoa, bananas and coffee are the main agricultural exports. In 1970 these exports (in raw and processed form) were valued at $US 155.5 million (coffee, $US million; cocoa $US 22 million and bananas at $US 83 million). By 1978 these values had risen to $US 266, 50, and 151 million respectively. However, in real terms the value of these exports to the domestic economy (as a component of GDP) was unchanged during the entire 11 year period 1970-81 (see Table E-3).

Imports of products of agriculture origin, as indicated in part by import licenses, are estimated by World Bank experts at $US 56.7 million in 1972. By 1981 the value had risen to $US 117.3. (P) The general

TABLE E-2. Agriculture Subsector Contribution to GDP 1975 Prices (Percent)

ITEM	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
AGRICULTURE GDP	24.0	22.8	22.4	18.1	18.8	17.9	16.9	16.0	14.9	14.4	14.1	14.5
BANANAS, COFFEE & COCOA	5.4	5.4	5.1	3.9	4.1	3.5	3.1	3.3	3.3	3.1	2.7	-
OTHER CROP PRODUCTS	10.0	9.0	8.5	6.9	7.2	7.3	6.9	5.6	4.7	4.3	4.2	-
LIVESTOCK	7.2	6.9	6.9	5.6	5.5	5.5	5.2	5.3	5.3	5.3	5.4	-
FORESTRY	2.8	0.9	1.0	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0	-
FISHING & HUNTING	0.6	0.9	0.9	0.7	0.7	0.8	0.8	0.8	0.7	0.7	0.8	-
NON-AGRICULTURE GDP	76.0	77.2	77.6	81.9	81.5	82.1	83.1	84.0	85.1	85.6	85.9	85.5

SOURCE: Based on Appendix Table A.1

TABLE E-3. Real Growth within the Agriculture Subsector

	1970-75	1975-80 (81)	1970-80 (81)
Ag Sector GDP	2.3	2.36	2.34
Bananas, Coffee, Cocoa	-0.7	0.7	0.00
Other Crops	1.9	-4.2	-1.4
Livestock	2.67	6.156	4.49
Forestry	22.96	7.22	10.2
Fisheries	12.52	6.52	9.9
Non-agriculture GDP	10.07	6.82	9.0
Overall GDP	8.40	6.08	7.8

Source: Calculated by WSM Team

TABLE E-4. Exports of Banana, Cocoa, Coffee and Petroleum, 1967-1980

Year	Banana		Cocoa		Coffee	
	Kilos	U.S.$ FOB (1,000)	Kilos	U.S.$ FOB (1,000)	Kilos	U.S.$ FOB (1,000)
1967	1.131.844	67.158	42.208	23.497	56.694	38.871
1968	1.597.684	92.219	67.202	38.883	49.560	34.667
1969	1.198.571	66.175	32.413	24.240	37.363	26.045
1970	1.246.332	83.299	36.491	22.188	52.286	50.002
1971	1.179.680	88.157	48.750	24.322	45.943	36.100
1972	1.726.095	130.991	46.669	23.628	61.022	46.990
1973	948.496	74.126	32.767	26.016	75.414	65.427
1974	1.525.059	126.723	69.314	102.613	59.574	67.756
1975	1.384.486	138.652	38.392	42.165	61.047	63.472
1976	937.259	103.224	21.864	31.461	86.427	192.793
1977	1.317.733	148.260	18.621	59.954	53.950	175.006
1978	1.223.785	150.935	16.274	50.093	98.474	265.719

Source: K, p.131

TABLE E-5 General Pattern of Agriculture Produce Imports

	1972	1976
	(CIF Prices - U.S.$ Million)	
Consumer Goods		
Foods	2.1	11.1
Beverages	2.4	7.9
Tobacco	8.6	-
Inputs for Agriculture		
Animal Feeds	0.2	1.8
Inputs for Industry		
Edible Agri Products	17.9	67.0
Non-edible Agri Products	25.6	59.8
TOTAL	56.8	147.5

Source: C, p. 141

pattern of such imports through 1976 were as shown in Table E-5. The main import items are wheat, fats and oils, and dairy products.

In terms of 1974 sucres, there has been a significant uptrend in the annual average wholesale price of many farm products. The percentage jumps through 1978 were quite large, on the order of 20 percent for the previous three years. In 1979, the index stood at 215.5 and rose further to 244 by mid-1981. (L, p. 177). How much of this overall increase reached the farm gate level is unknown; however, farmers probably benefitted to a considerable degree.[1]

In contrast to domestic food price movements the indices of real export price movements of coffee and cocoa and associated labor costs have varied a great deal during the 1970-80 decade (the labor index jumped in 1979-80 due to government decreed rise in minimum wage. This is shown in Table E-6.

Trends in Crop and Livetock Production

Tables E-7 and E-8 illustrate trends in Ecuador crop and livestock production. The data shown are a composite of information from several sources, not all of which are in agreement. The incomplete estimates as shown, however do not indicate any strong upward trends in any crop output except for rice and African palm. Growth in production of export crops appears to have been nil, or as shown in the right side of Table E-7, the long run linear trend is negative.

The data for livestock products do not cover the most recent years so the indicated trends may not be very accurate. They show growth in beef and milk only, (through 1977). However, it seems probable that all livestock, plus poultry, would have increased in output during the past few years for which data are not included. Again calculated trends are shown on the right side of the table. (No values are shown for mutton, lamb and pork because the linear trend is negative.)

The linear extrapolations shown in Table E-7 and E-8 are the best estimates given the variability in the data, but the results are only useful as examples of what might occur by the year 2000.

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[1] See Appendix Table f-3 for index of price movements of selected crops at the wholesale level, through the year 1977.

Table E-6. Ecuador: Indices of Real Price Movements of Coffee, Cocoa and Labor, 1970-80

	Coffee[1] Price	Cocoa[1] Price	Labor[2] Cost
1970	100.0	100.0	100.0
1971	88.9	88.7	91.3
1972	85.2	83.1	84.7
1973	77.8	120.1	75.7
1974	71.2	151.5	89.8
1975	61.6	97.0	82.4
1976	113.2	118.0	89.6
1977	140.4	224.8	79.3
1978	115.3	192.1	70.0
1979	94.8	159.3	93.8
1980	73.8	109.4	168.0
Average 1970-80	92.3	131.3	93.2

[1] Average export price adjusted for export taxes and credits and deflated by Ecuadorian CPI.

[2] Minimum wage adjusted for fringe benefits (13th, 14th and 15th month additional pay) and deflated by Ecuadorian CPI.

Source: K, Table 38.

Table E-7. Trends in Agricultural Production of Major Crops - Ecuador (MT)

EXPORT	1970	1971	1972	1973	1974	1975	1976
Sugar Cane	2,806,008	3,235,796	3,387,312	3,290,020	3,457,996	3,680,188	3,765,588
Coffee	72,053	62,252	71,386	74,980	69,638	76,437	87,101
Cocoa	53,584	70,800	67,784	63,374	91,039	75,272	65,192
Bananas	2,911,342	2,742,948	2,581,639	2,495,927	2,676,411	2,544,327	2,570,925
INDUSTRIAL							
Cotton	7,552	10,714	11,556	19,549	41,899	30,270	27,000
Hemp	1,387	1,968	2,691	4,585	8,688	10,425	13,852
Tobacco	2,160	1,665	1,166	1,286	2,251	2,000	2,256
African Palm	21,140	31,484	44,528	58,358	75,846	94,512	111,587
Soy Beans	600	1,087	847	1,538	4,378	12,324	15,035
Peanuts	5,270	9,838	10,788	12,541	17,180	11,424	21,180
Sesame	2,256	1,890	2,090	893	1,673	2,832	3,454
Castor Bean	16,518	34,704	23,152	51,708	39,057	3,385	17,737
DOMESTIC							
Rice	158,500	135,900	172,700	204,300	112,853	194,768	198,663
Wheat	81,000	68,493	50,640	45,189	54,986	64,647	65,000
Corn	269,506	260,913	271,390	253,688	255,780	273,027	274,987
Barley	110,000	68,700	73,400	79,400	56,148	62,801	62,872
Potatoes	541,794	680,740	473,348	539,198	503,340	499,371	532,770
Cabbage	77,968	81,294	61,583	45,933	40,980	43,407	49,577
Tomatoes	24,186	24,435	26,556	24,486	33,327	37,243	42,552
Cassava	266,251	274,686	270,334	354,905	403,319	353,517	377,813
Plantains	464,359	437,500	411,771	398,100	426,887	405,820	410,062
Oranges	152,904	172,864	153,060	143,698	174,487	250,000	300,000

Table E-7 (continued)

	1977	1978	1979	1980	1981	Trend	Linear Projections of Supply Trends (1,000 MT) 1990	2000
EXPORT								
Sugar Cane	3,760,000	3,924,480	3,825,440	3,861,518	3,938,700	+	4,861	5,747
Coffee	82,680	75,447	89,728	69,530	74,200	+	89	98
Cocoa	72,120	72,085	77,407	91,219	91,700	+	107	130
Bananas	2,450,690	2,152,192	2,031,559	2,269,479	2,258,100	-	1,578	960
INDUSTRIAL								
Cotton	26,900	26,565	25,167	39,806	41,000	+	62	87
Hemp	16,550	10,690	10,690	11,046	-	+	27	39
Tobacco	1,890	2,511	3,464	3,277	-	+	4.6	6.3
African Palm	124,801	124,801	164,712	244,930	-	+	381	568
Soy Beans	19,270	25,391	29,903	33,549	-	+	63	104
Peanuts	8,400	9,257	17,130	13,645	-	+	22	28
Sesame	708	454	553	532	-	-	(1)	(2)
Castor Bean	1,810	-	-	-	-	-	-	-
DOMESTIC								
Rice	327,622	225,273	318,471	380,614	394,300	+	568	798
Wheat	39,800	28,903	31,248	31,113	31,800	-	(8)	(48)
Corn	218,450	275,760	217,868	241,884	250,100	-	(22)	(198)
Barley	40,776	21,760	20,718	24,350	24,700	-	(0)	(10)
Potatoes	417,000	343,195	254,507	323,222	325,000	-	(30)	(261)
Cabbage	43,282	-	-	-	-	-	-	-
Tomatoes	33,056	-	-	-	-	-	-	-
Cassava	-	-	-	-	-	-	-	-
Plantains	215,782	-	-	-	-	-	-	-
Oranges	519,794	-	-	-	-	-	-	-

Source: B, C, L.

TABLE E-8. Livestock Production Trends - Ecuador (1,000 MT)

	Average 1961-1965	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	Linear projections of supply trends: Trend	1990	2000
Beef & Veal	33	41	42	44	47	60	62	59	67	58	61	+	102	129
Mutton & Lamb	3	5	7	7	8	7	7	4	5	3	4		-	-
Pork	14	24	24	27	24	26	28	18	16	13	15		-	-
Milk	376	458	475	492	510	529	549	544	580	590	590	+	828	962

Source: C, p. 549.

IRRIGATION

Recent Growth of Private and Public Irrigation

Since the pre-colonial period Indians of the highlands have practiced irrigation. Nearly all the old canals and ditches were later destroyed so that the irrigation works in operation today have been constructed in the post-colonial and modern eras. It has only been during the last three or four decades that irrigation has been utilized in the coastal area. Part of this recent development has been supported by public funds, but private initiative has played a big role through simple pumping diversions along rivers.

Until 1944, irrigation development in Ecuador was entirely dependent upon the private sector. However, in August of that year an autonomous government entity called the National Bureau of Irrigation was created to construct irrigation projects with public funds. This action satisfied the Water Law of 1936 and the Irrigation and Drainage Law of 1944, both of which placed certain obligations upon the state to develop irrigation. Prior to its demise in 1966, the Bureau of Irrigation constructed six irrigation projects, four in the Sierra and two on the coast. The Ecuadorian Water Resources Institute (INERHI) was created on November 10, 1966. This new entity assumed the role of the old NBI.

Comparison of the current roles of the public and private sectors in irrigation delivery and use is quite difficult due to the lack of data. As shown in Table E-9, irrigated area was estimated at 176,700 ha in 1971. But INERHI did not really begin its investigations of irrigation systems until 1972. As of 1977, planners in MAG's national regionalization program estimated only 167,000 ha (public and private) irrigated. According to INERHI's most recent estimates the total area irrigated is about 427,000 ha. It may be possible that the 1971 and 1977 data underestimated the true size of private works, if the 1981 figures are accurate. Another explanation for at least part of the discrepancy is that the private sector placed a large quantity of land under irrigation during the decade. (However, it should be noted that the implied rate of expansion is about 20,000 ha per year for 10 years.)

The data for public works are no doubt the most accurate. INERHI has 93,000 ha in projects at the moment. Of this total roughly 30,000 ha actually utilize the available water. Allowing for about 10,000 ha irrigated by other public entities such as CEDEGE, CREA, PREDESUR, etc., current water deliveries on public projects serve 40,000 ha. Meanwhile, some publicly financed projects, inherited by INERHI from the NBI, have fallen into disrepair so that the net annual increase in public water deliveries during the 1970-80 decade may have been about 1,000 ha per year.

TABLE E-9. Estimated Irrigated Cropland
(1000 ha)

Sector	Coast	High-lands	Total	Coast	High-lands	Total	Inuse	Unused Capacity	Total
	1971			1977			1981		
Public	29.9	10.7	40.6	35	16	51	40	63	103
Private	52.5	83.6	136.1	86	85	171	323[e]	0	323
National TOTAL	82.4	94.3	176.7	121	101	222	363	63	426

Source: (M) p. 90 for 1971; (N) Table 2.16 for 1977; (G), (R), and (E) for 1981. e = estimated by WMS team.

Therefore, as indicated, the greatest share of increase in irrigated area is the result of private sector activity during recent years. The main developments have been concentrated in the coastal zone, but the true amounts, on the coast or elsewhere, are not really known.

Estimated Irrigated and Non-irrigated Area by Crop and Zone

In order to gain a better understanding of the role irrigation plays in the agricultural sector, it is useful to describe irrigation's contribution in terms of its relationship to overall area and output of various crops by zone.

A relatively small amount of Ecuador's land area is cultivated. A more substantial amount is categorized as formal pasture. Over 80 percent of the land area is in forest, grasslands, or rough lands that may or may not be utilized for agricultural purposes. The division is shown in Table E-10. The backbone of current Ecuadorian agriculture is the cultivated and pasturelands of the Sierra and Costa (16 percent of all land). The cultivated portion of these two zones can be subdivided further into irrigated and non-irrigated shares. Based on scattered evidence, study team estimates of these shares are shown in Table E-11. (Some pastureland is also irrigated, but the amount is unknown.)

TABLE E-10. Current Ecuador Land Resources by Area, Type and Use (1,000 ha)

	Costa	Sierra	Oriente	Total
Land Resources	6,937.8	7,292.3	13,704.2	27,434.3
Cultivated				1,627
Utilized	115.5	425	47	
(Irrigated)	(368)	(58)	-	
Pastures				3,191.5
Utilized	924.4	1,873.1	394	
(Improved)	(799.0)	(402.3)	(160.9)	
Forests Managed	2,720.2	3,596.6	9,300	15,616.8
	901.4	(23.2)	-	
Other	2,138.2	1,397.6	3,963.2	7,499.0
(Private)	(3,845.4)	(3,066.3)	(1,579.1)	(8,490.8)
% of Total	45.3	32.1	18.6	

Sources: (C) p. 177; (N) p.28; plus WMS adjustments for steady changes in amount cultivated, amount in pasture, and forest clearing, as well as for tremendous increase in irrigation in the <u>Costa</u>.

TABLE E-11. Main Irrigated and Non-irrigated Crop Area by Zone (1,000 ha)

	Sierra	Percent	Costa	Percent	Total	Percent
TOTAL	425	100	1155	100	1580	100
Irrigated	58	14	368	32	426*	27
Non-irrigated	367	86	787	78	1154	73

*Includes total area "commanded" by public irrigation projects.

Table E-12 carries the breakdown of irrigated and rainfed lands to the crop level. The estimates are a composite of information from many sources, including conversations with knowledgable people in various organizations. The range of information obtained indicates a serious lack of uniformity and coherence in the data used by various organizations for planning and suggest that a uniform, reliable data base would be of great benefit to public and private entities as well as to international lenders.

Table E-13 translates the areas shown in Table E-12 into estimated production and yields of the major crops. The data are again a composite of various sources. Yield estimates are based on total production and harvested areas. The data reflect the extremely low yields and the lack of reasonable response to irrigation. Similar responses could easily be expected in many instances simply from improved delivery of technology and inputs to rainfed agriculture.

The estimates of Table E-13 suggest that by increasing current rainfed yields by merely 20 percent, the expected increases in production would be the equivalent of the production that could be obtained from 77,000 ha of new irrigated lands (at current irrigated yields). But, as noted in Section IV and Appendix A above, 77,000 ha of actual new irrigation might require considerably more project area, since Ecuador's current experience shows that not all farmers within project boundaries actually utilize available project water. Finally, an imaginary comparison may be made of the costs of constructing 77,000 ha of new irrigation projects with the costs of the 93,000 ha of current public projects.

PUBLIC POLICY

Prices and Taxes

Official prices are enforced through price controls, supports and various regulations. Although producer interests are taken into account, the key objective is to maintain consumer prices as low as possible. Certain controls extend well beyond the main domestic food products to include even export crops. However, it is claimed that enforcement is a problem (D, p. 77) (except in the case of wheat and milk products). In addition, a system of export taxes on cocoa and coffee constitutes an important element of central government finance. These latter taxes range from 20 to 35 percent of the FOB value of commodity shipments.

Extension Research and Marketing

The national extension service has been criticized for

TABLE E-12. Area of Major Crops by Zone

	Sierra		Coast	
	Irrigated	Rainfed	Irrigated	Rainfed
Cereals				
Rice			60*	70
Wheat	0	36		
Barley	0	52		
Corn	23	170	10	55
Other		4		
Legumes				
Beans	5	50	5	10
Peas	2	13	1	1
Oil Seeds				
Cotton			6	20
Soybean			5	20
Palm			3	20
Peanut			8	9
Roots and Tubers				
Potatoes	21	17		
Yuca	0	5	0	20
Fruits				
Plantains			25	25
Other	5	11	30	10
Vegetables	3	3	3	2
Export				
Bananas			60	60
Coffee			0	272
Cocoa			95	137
Sugar Cane			60	40
Subtotal	58	361	371	771
Other Crops	6		13	
TOTAL	425		1155	

* Est. Av. 1.5 crops/year

Sources: Adapted from (C) and (E) and Tables E-9 and E-10 of this report.

TABLE E-13. Estimated Production and Crop Yields*

	Current Production	Yield		Production Increment Based on 20% Yield Increase (Rainfed)	Irrigation Equivalent Assuming 20% Yield Increase
	(1,000 MT)	(MT/ha)		(1,000 MT)	(1,000 MT)
Cereals					
Rice	350	3.2	1.2	28.0	5.1
Wheat	32		0.97	7.20	3.6
Barley	25		0.48	4.99	3.3
Corn	250	1.6	0.85	38.25	19.5
Legumes					
Beans	30	0.9	0.35	4.2	4.7
Peas	7	0.7	0.35	0.98	1.4
Oil Seeds					
Cotton**	41	2.5	1.3	5.2	2.1
Soybean	33.5	2.4	1.08	4.32	1.8
Palm	245	19.0	9.4	37.60	2.0
Peanut	33	2.7	1.27	3.0	0.9
Roots & Tubers					
Potatoes	342	11.0	6.5	22.18	2.0
Yucca	255		10.2	51.0	2.0
Fruits					
Plantains	865	19.0	9.5	20.9	1.1
Other	600	16.0	8.0	40.0	2.5
Vegetables	138	14.7	10.0	10.0	0.7
Exports					
Bananas	2250	23.5	14.0	168.0	12.0
Coffee	81		0.3	16.32	1.0
Cocoa	90	0.66	0.2	5.48	8.3
Sugarcane	3950	49.0	25.0	200.0	4.1
TOTAL					77.00

Source: Adapted from (C), (E) and Tables E-7 and E-12 of this report. Yield estimates by WMS Team.

* Table E-12 and this table attempt to relate yield, production and harvested area figures from various sources. In some cases, area and yield data are completely at variance with published total production figures.

** Data mixed seed and lint cotton.

fragmentation of effort, lack of staff, and failure to deal with farmers in a context of total "business" units (D, p. 81). The same World Bank source notes a need for marketing facilities, and the absolute size of distribution margins. Storage space, public markets, slaughterhouses, cold storage and better livestock marketing facilities are needed.

Agricultural Credit

The amount of available credit has grown rapidly but the bulk of it reaches relatively few operators who farm about 17 percent of all land. Most credit goes to rice, cotton and corn growers, i.e., it is concentrated in the coastal area (D, p. 82). In an earlier study, it was reported that 75 percent of farmers had never had credit (I, p. 103).

SUMMARY

A recent World Bank review of the status of Ecuador's agriculture sector sums up the situation as follows:

> ...realization of Ecuador's considerable agricultural potential requires a coordinated systems-approach to the problems of the sector... The country urgently needs to depart from the piecemeal approach, strenthen its managerial function and improve overall integration and coordination. If the Government: (i) adopts a price support policy broadly consistent with market realities; (ii) revises export taxes so as to allow for adequate longrun profits; (iii) establishes a unified extension service with backstopping support of adequate research; (iv) improves the marketing infrastructure; and (v) expands and spreads agricultural credit so as to cover more crops and reach more farmers, agricultural output will undoubtedly grow faster than in the past. In the process, the living conditions of the poorest segments of the population will improve, thus contributing to the fulfillment of the objectives of the 1980-1984 Development Plan. (D)

APPENDIX F

SUPPLEMENTAL STATISTICS FOR SECTION II

TABLE F-1. Ecuador: Sectorial Origin of GDP.
1972 - 1980 (million sucres)

Item	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Agriculture, Livestock & Fish	17254	17261	17.160	17.340	18.894	19.933	19.982	19.981	19.687	20.077	20.585
Bananas, Coffee and Cocoa	3900	4100	3.915	3.730	4.214	3.766	3.598	4.181	4.348	4.274	3.898
Other Agricultural Products	7166	6766	6.533	6.630	7.324	7.833	8.145	7.040	6.132	5.985	6.171
Livestock	5155	5194	5.316	5.396	5.661	5.880	6.151	6.566	6.936	7.415	7.927
Forestry*	570	660	745	861	941	1.019	1.090	1.243	1.296	1.362	1.444
Non-Agriculture GDP	54717	58320	59.333	78.527	83.152	88.407	97.987	104.993	112.139	119.391	125.344
Gross Domestic Product	71971	75581	76.493	95.867	102.046	107.740	117.679	124.974	131.826	139.468	145.929

Item	1981
Agriculture, Lovestock & Fish	22.189
Non-Agriculture GDP	131.332
Gross Domesitc Product	153.521

Source: (J) Table A-28 (the overall sector data are consistent with those given in Table 1 of (B); Table 7.1; (C) for the years 1970 and 1971).

* Data estimated for 1970 and 1971 based on trends. Note the forestry data reported in Table 7.1 of (C) is completely inconsistent with source (J).

TABLE F-2. Exports of Agricultural Produce

	1972	1974	1977	% of Total 1977
	- - - U.S.$ million (FOB) - - -			
Unprocessed	231.7	328.0	413.9	(36.7)
Processed	29.1	78.2	236.1	(20.9)
Total Agri.	260.8	406.2	650.0	57.6
Total - All Exports	326.3	962.4	1,127.3	100.0

Cocoa, coffee and bananas are the main agricultural exports. In 1977, cocoa exports (in raw and processed form) were valued at U.S. $245 million; coffee, U.S. $160 million; and bananas, U.S. $138 million. The exports of fisheries products totalled U.S. $70.5 million in 1977.

Source: (C) p. 140.

TABLE F-3. Price Increases 1970/72 - 1976/77 (%)

Rice	159	Yuca	326
Peas	170	Tomatoes	374
Lentils	157	Plantains	242
Wheat	115	Apples	117
Potatoes	372	Beans	168

Source: (B) p. 141.

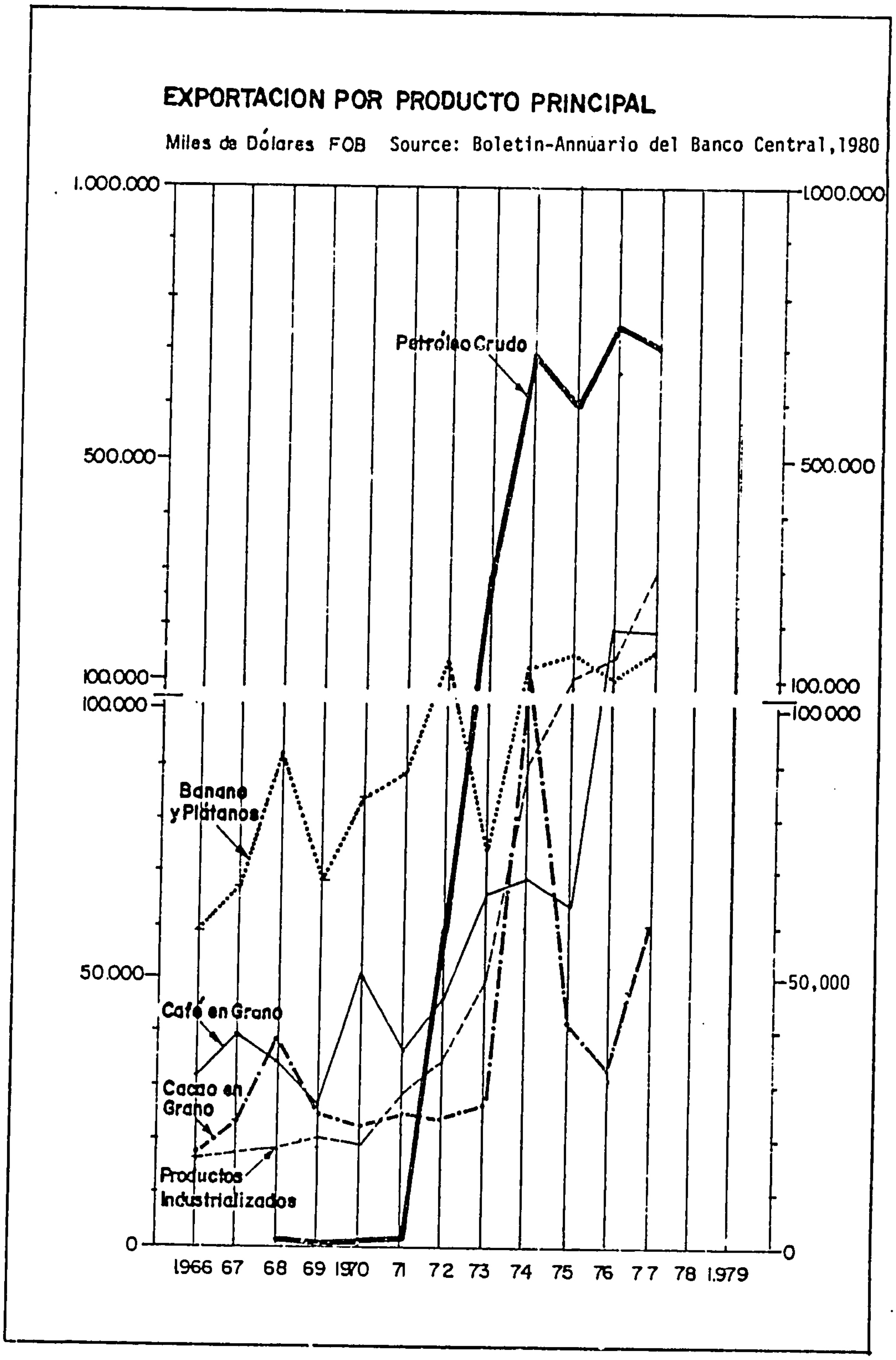

Figure F-1. Exports of Principal Products

TABLE F-4. Agricultural Supply and Distribution in Ecuador
(Date as of 4/20/82)

Commodity	Area Hvstd	Prod	Begin Stock	Import	Export	Cons	Ending Stock	Cons kg/Cap	Price S/Cwt	Year Begin
	1000 Ha*	- - - - - - - - - - - -			1000 MT	- - - - - - - - - -*			1/	
Abaca	12	11.2	0.3		11	0.2	0.3	0.024		1/81
Bananas	60	2275			1350	96		11.6	(41)	1/81
Cocoa	270	80	4.6		76.9	3.65	4.1	0.44	1944	10/81
Coffee M.Bag	261.4	1.47	0.46	0.01	1.15	0.23	0.56	1.73	1600	4/81
Cotton	18	12.6	3.7		3.2	11.3	1.8	1.36	2000	8/80
Pyrethrum	0.38	0.265			0.265					
Sugar	48.2	343.9	57.9	20*	43.3	312.8	45.7	37.7	580	6/81
Molasses		119.7	3.7		56.8	65.5	1.1	7.9		6/81
Tobacco	1.6	2.7	4.3	1.8	0.2	3.8	4.8	0.46	(5200)	1/81
Barley	40	35.8	5.9	32		69.5	4.9	7.8	320	7/81
Corn	135	238.1	47.3		10	242	43.4	3.8	280	7/81
Oats	0.5	0.5	3.5	29		28.5	4	3.5		7/81
Rice	120	201.4	63.8	7	10	218.8	42.9	23	315	1/81
Sorghum	0.5	1				1		0.1		
Wheat	23	22	14.3	315	10	330	11.3	33.8	330	7/81
Lentils	0.67	0.35		6		6.35		7.8		
Potatoes	47	500		20		520		62.7		
Castor Bean	13.5	10.9				10.3				1/82
Castor Oil		5.1			5.0	0.1				1/82
Castor Meal		5.4			4.5		0.9			1/82
Cotton Seed	25	21.7				20.5			198	6/81
Cotton Meal		7.2				7.2				6/81
Cotton Oil		3.1				3.1				6/81
Palm	27.5	96.4				95.0				1/82
Palm Oil		42.7	4			42.2	4.5			1/82
Palmiste		11.4				11.4				1/82
Palmiste Meal		4.3				4.3				1/82
Palmiste Oil		5.2				5.2				1/82
Peanuts	12.7	10.0				2.7				1/82
Peanut Oil		1.1				1.1		0.12		1/82
Peanut Meal		1.5				1.5				1/82
Sesame	1.0	0.5				0.5				6/81
Soybean	20.5	33.0		17		47.5			460	6/81
Soybean Oil		8.6		30		39.1				6/81
Soybean Meal		37.7				37.7				6/81
Fish Oil		24				24				1/81
Fish Meal		110			90	20				1/81
Lard		9.3		11		19.3		2.3		
Tallow		10.8		10		20.8		2.5		
Wool		3.1				3.1		0.37		
Hides	808	20.2		1.2	0.5	20.7		2.5		
Beef		95.3				95.3		11.5	13	
Pork		52.2				52.2		6.3	26	
Goat		4.5				4.5		0.5		
Lamb		5.1				5.1		0.67		
Milk ML	655	765		15*		574		69	8	
Eggs M	5300	1257	4.1	0.5		1217	48	157		
Poultry	24000	35.9	2.1			36.7	2	4.3		

LIVESTOCK	CROP	INVENTORY	FEMALES	SLAUGHTER	DEATHLOSS	INVENTORY	
Cattle	704	2451	1430	567	241	2348	1/81
Pig	3384	3961	705	1534	1630	4181	1/81
Sheep	896	2335	914	597	290	2341	1/81

1/ Official exhange rate for exports 30 s/$, for most imports 28 s/$, free market exchange rate 42 s/$ in April 1982.

Source: U.S. Embassy, Quito Ecuador, Doc. 0044A

Commodity Notes:

Bananas - Supply does not equal demand because waste (829,000 MT) is not included in consumption. Export price $178.50/MT. Ref price $3.20 per box.

Cocoa - All data on a bean equivalent basis. When export tax on beans was removed proportion beans/product changed from 18/82 to 50/50. As a producer of aroma type cocoa Ecuador's cocoa exports are not limited by the International Cocoa Agreement export quotas.

Coffee - All data on a bean equivalent basis; while about 82 percent are exported as beans, 18 percent are exported as soluble coffee. Production includes 1.03 M bags arabicas and 0.44 M bags in the Septembei 1981 meeting of the ICO.

Cotton - Data for cotton. The area recorded for cottonseed in the oilseeds section includes area growing criollo, short staple cotton. The medium fiber crop is harvested in January while the criollo crop is harvested in October, November. Medium staple crop 11.8, short staple 0.8. Ginning rate is 36 percent. Seed cotton price 800 sucres/cwt.

Pyrethrum - All data on a dried flower basis. However, no exports of dried flowers are permitted; all exports are concentrates of various percentages.

Sugar - Area represents only cane devoted to the production of centrifugal sugar. Area devoted to agua ardiente and panela is estimated to include another 80,000 ha. Cane prod approx 3.6 million MT. Imports of 20,000 MT announced in April to cover for unexpected shortfall in harvest. Ecuador's ISA sugar export quota for CY 1982 is 78,784 MT. Sugar export earnings: CY 80 $42.9, CY 81 $13.9.

Tobacco - Production includes blond types (2,545 MT) and cigar wrapper (133 MT).

Barley - Area has dropped from about 110,000 ha 10 years ago.

Corn - Area has been about stable since 1974. There are two crops per year: Aug-Dec 30,000 ha and Jan-Aug 105,000 ha market price $/220 gal.

Rice - Area has varied from 80,000 to 125,000 ha per year since 1965. There are two crops per year: Aug-Dec 40,000 ha and Jan-Aug 80,000 ha market price $/430 gal.

Wheat - Area has dropped from about 75,000 ha 10 years ago.

Oilseeds- Consumption figures refer only to crush.

Palm - There are very large palm plantations being developed in the Oriente between Baeza and Lago Agrio. Currently about 10,000 ha are under development but the plan permits expansion to 50,000 ha. A surplus of 3,000 MT of red oil appeared in March-April of 1981. The local industry eventually bought this as part of the deal that led to the prohibition of choice white grease imports.

Soybean Complex - Harvest is in November. Area and crop are much smaller than expected, therefore imports may be authorized around April-May 1982, June 81, May 82 import quota 26.7 but industry estimates almost 40 needed.

Lard - Imports were exclusively choice white grease. These imports were prohibited in August, 1981.

Livestock & Products - Slaughter is recorded under the livestock population supply and distribution table at the bottom of the page.

Beef - Price given is official price, liveweight, farmgate. retail official price is 32-34 sucres per pound.

Pork - Price given is contract price, liveweight, delivered to slaughterhouse.

Hides - The 808 is the sum of 241 deathloss plus 547 slaughter.

Milk - All data are recorded as million liters with the exception of imports which are 15,000 metric tons (1981) and 5,000 MT (1982) of full fat dried milk.

Eggs - All data are recorded in millions.

Poultry - Is recorded in thousand metric tons. Slaughter is 24 million birds per year.

Cattle - Most of the approximate 630,000 milking cows are in the Sierra, particularly the valleys of Cayambe, Machachi, Lasso, and Cuenca. Most beef cattle are on the coast.

TABLE F-5. Estimates of National Demand for Products for Human Consumption in Year 2000 (based on 2.500 calories/day)

Products[1]	CEDEGE Estimates of Annual Consumption Per Capita Kg/year[2]	Net Demand in year 2000 (1000 MT)[3]	Losses %[4]	Internal Demand at Farm Level Year 2000 (1000 MT)[5]	Estimated Exports (1000 MT)[6]	Total Demand at Farm Level Year 2000 (1000 MT)[7]	M.A.G. Estimates of Domestic Production 1977 (1000 MT)[8]	Surplus or Deficit in Year 2000 (1000 MT)
Cereals	34	551	30	716	160	876	628	-248
Legumes	22	358	22	437		437	40	-397
Tubers	41	659	33	876		876	652	-224
Vegetables	27	435	15	500		500	167	-333
Fruits	51	823	37	1,127	1,525	2,652	4,170[9]	+1,518
Cocoa-coffee-tea	6	97	6	103	169	272	161	-111
Sugar	38	616	32	813	98	911	511	-400
Beef	21	341	-	341	42	383	82	-301
Mutton/Lamb	4	65	-	65		65	10	- 55
Pork	15	243	-	243		243	41	-202
Chicken	4	65	-	65		65	42	- 23
Fish	27	433	10	476		476	216	-260
Milk	244 Lt.	3,954,686	10	4,350,155		4,350,155	847,850	-3,502,265
Eggs	9.5	154	5	162		162	30	-132
Fats-Oils	13.5	217	-	217	30	247	72	-175

Source (R), Table V-5.