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IRRIGATION DEVELOPMENT OPTIONS AND INVESTMENT STRATEGIES FOR THE 1980'S

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IRRIGATION DEVELOPMENT OPTIONS AND INVESTMENT STRATEGIES FOR THE 1980's USAID/PERU

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PREFACE

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

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

For more information about the project and any of its services, contact the Water Management Synthesis II Project.

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FOREWORD

This assessment of the irrigation sector of Peru was conducted at the request of the AID Mission to that country. The report was prepared as part of AID's continuing effort to develop a consistent and effective set of strategies for its assistance program to countries in which irrigation is a significant component of development efforts. The method is to focus on private as well as public investment options for the sector. The report emphasizes programmatic rather than project level recommendations, although specific suggestions are made regarding the latter. The expectation is, however, that future projects will be developed within the context of the policy analysis so that the impact of the Mission irrigation portfolio as a whole will have a synergistic effect. The review also has implications for the process of evaluation, and specific recommendations are made for a more detailed study.

The conclusions of the team as well as its recommendations and supporting analysis are contained in the report. Due to the quantity of information obtained as part of the field study, a number of annexes are printed separately.

The review team visited Peru between March 15 and April 13, 1983. The regions visited, including the principal projects were:

1. Sierra -- Mantaro Valley and the Puno areas. In addition, Dr. Meyer visited the Cajamarca region. The projects visited included:

Plan MERIS:
Chupach Project
Chicchi Project
Sicaya Village Project

Self-Help Projects:
Micro Projects near Huancayo
Niejo La Joya Project
Nueva La Joya Experiment Station

2. Selva -- Tarapoto/Rio Mayo area. The visits made included:

International Potato Center Offices
Hullaya Central Bajo Mayo Project
Three Small Private Projects
Research and Experiment Station

3. Costal low valleys -- Chiclayo/Trujillo, Ica, Tacna and Arequepa areas. The following coastal systems were observed:

La Yarada, Caplina Valley
Zamacola, El Cural
La Joya
Majes
Lurin
Tinajones
Casa Grande Cooperative
Nueva La Joya Experiment Station

Some of the principal public and private agencies visited including the chief supervisors interviewed were:

1. Prime Minister's Office:
   Hugo Ismodes, Chief, Large Irrigation Projects
   Alvaro Salazar, Chief, Selva Projects

2. National Institute of the Expansion of the Agricultural Frontier:
   Fredesbindo Vasquez Fernandez, Chief

   Simon Lau
   Carlos M. Vallejos, Special Projects for Irrigation Technology
   German Rodriquez Velasquez, Consultant to INAF

3. General Board of Water, Soils and Irrigation:
   Luis Hudson Leon Prado, Director General

4. Agrarian Region Office of Huancayo:
   Mr. Pita, Chief
   Avilso Tovar Gorales, Administrator of the Irrigation District of Huancayo

5. Plan MERIS:
   Celso Espinosa, Director and his Senior Staff

6. Village Commission of Sicaya:
   Julio Laso Campos and his Neighbors

7. National Agricultural Research Institute (INIPA):
   Aleanader Grobman, Director
   Manuel Guardia Mayoraga

8. OSPA:
   Jaime Paredes, Director

9. Inter-American Development Bank:
   Hector Lopez

10. Ford Foundation:
    Bill Saint

11. PRIDI:
    Enrique Montoya, S., Executive Director General

12. Israeli Association for International Cooperation:
    Yoel Busel, Director

13. Technoserve, Inc.:
    Luis Vega Castro, Operations Manager

14. International Bank for Reconstruction and Development:
    Ulrich R.W. Thumm, Resident Representative

15. Plan Rehatic:
    Carlos, Alva Alvarado
    Carlos Figueroa Sifuentes

16. International Potato Center:
    Orville T. Page, Director of Research

17. Renato Rossi L., Assistant to Presidency of the Senate

18. La Molina University:
    Alvaro Ledesma

19. Ica Agricultural Association:
    James Molatesta Spalding, Executive Director

20. USAID/Lima:
    George Hill, Deputy Director
    David Bathrick, Chief, Office of Agricultural and Rural Development
    David Flood, Economist, Office of Agricultural and Rural Development

In addition to those listed, senior directors of all of these agencies were interviewed. Also, a large number of regional officials were interviewed from the Regional agrarian offices and irrigation districts in Huancayo, Puno, Arequepa, and Chiclayo. Finally, interviews were held with farmers in all of the regions visited.

The team received special help from three individuals. Mr. German Rodriguez provided the team with logistical support and technical suggestions. His kind assistance was made possible by the support of INAF. Also, Mr. Renato Rossi L. acted as a consultant to the team and made visits with the team to the Tacna Arequepa area. He provided valuable insights to the problems and potential of coastal irrigation. Mr. Hector Soto provided crop production and other statistics utilized in the annex of this report.

Review drafts of the team's report were provided to USAID/Peru in May and July, 1983.

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PART A
CONCLUSIONS AND RECOMMENDATIONS

Main Findings

The basic purpose of this report is to assist the U.S. Mission to Peru plan its response to any near term request from the Government of Peru for financial and technical support for development and expansion of irrigated agriculture. What follows illustrates a framework for planning as obtained by a rapid reconnaissance survey. Survey conclusions are based upon field testing of assumptions and interdisciplinary perceptions of the Peruvian irrigation scene.

A set of recommendations follows directly from such conclusions. For the near term they emphasize the Sierra Zone, however, the other regions of the nation are not ignored.[1]

Part B of this Volume incorporates findings of certain related studies and the main arguments supporting the WMS-II team's recommendations. Discussions with farmers (conducted in Quechua) and operating level Peruvian Agency personnel, plus inspections in the field, form the backbone of the team's conclusions. Fuller details of the team's research, the issues raised, practical answers, and calculations in enough precision to support the various critical points of emphasis are contained in the Annex to this report.

Assumptions

Historically, many public and private irrigation schemes have not been well thought out in terms of goals, design, construction or operation. As a consequence they do not always live up to expectations. Some projects stagnate over a long period of time while a few recover. More often than not, however, a decision is made to commit additional resources to rescue projects with little potential. As each new problem surfaces there is a hasty effort to come up with another and often more costly fix. In worst case situations entire developments are viewed simply as engineering challenges with little apparent regard to ultimate cost.

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[1]The general impact of these recommendations on the Mission's experience with Plan MERIS as well as upon the emphasis given irrigation in the recent Report of the U.S. Presidential Agricultural Mission to Peru (p. 14) is made explicit in this summary. Additional discussion is included in Part B.

In such cases water development and control is perceived as though subsidies, which must be borne by third parties, are not costs. The irrigation systems of Peru encompass this entire range from naturally beneficial to economically questionable projects.

Actually, successful projects obey the dictates of a very simple hierachy of requirements.[2] In their most abbreviated form these are: a) assuming no serious engineering mistakes; b) assuming reliable water delivery and reasonable farm production costs; c) assuming increased labor demands are acceptable to farm families; then d) good markets are enough.[3] All permutations and combinations of factors that are contrary or contradictory to this set reduce or eliminate the possibility of success.

From the farmer's standpoint success of an irrigation project is measured two ways. First is a net increase in household income from irrigation driven production and/or productivity increases. The second is an increase in family wealth due to windfalls in land values caused by the overlay of an irrigation structure and increased accessibility of water on his land. However, satisfaction of either or both of these measurements is possible even under conditions of extreme subsidy. Society may be willing to bear some amount of subsidy for some amount of time to achieve non-economic goals. But over the long-run economic success of a public investment is measured by an increase in value added at the GDP level. This means that in the long-run economics cannot be ignored.

An irrigation sector assessment is useful as a planning tool to the degree it can:

a. Induce planners to think about irrigation investments not as merely the technological means to mate land, water and man in a more productive way, but as a tool for farmer incentives within defined macro and micro constraints;

b. Delineate some acceptable near term investment possibilities; and

c. Highlight considerations that must be taken into account to remove barriers to greater success.

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[2]To say the hierachy is simple is not the same as saying it is easy to satisfy. In practice it is quite difficult to locate good additional irrigation opportunities in a country such as Peru.

[3]In Peru the current incentives for milk (pasture/alfalfa) and rice create, from the farmer's standpoint, conditions approaching the requirements listed.

To satisfy these requirements in Peru the WMS-II team has identified a "workable" irrigation program under current conditions as well as ways to improve the future environment for irrigation farming.

Conclusions

The main conclusions based upon observation of systems operation and utilization in various zones of the country and consideration of other studies which have been done for the Mission are as follows:

a. From an engineering perspective the irrigation systems of Peru range from relatively good to very bad. The same can be said for their day-to-day management. This means that there is technical latitude to increase efficiency from existing works, in some cases with little or no alteration of physical facilities. On-farm water management ability also varies considerably although there are undoubtedly some knowledge gaps that might be filled. There is one constant, however, at this level of water control. In situations where farmers were faced with strong market prices (real or subsidized) the team observed good on-farm water management practices and no apparent need for anything beyond a minimum of governmental support services.

b. Emphasis on market size is important because there have been obvious secular gains in rural well-being, including food availability. Therefore, the short run opportunities for large numbers of farmers to sell increased output is relatively limited. The rough calculations of future demand/supply balances detailed in the annex volume and summarized in Part B of this report suggest the possibility of shortfalls for some major crops, i.e., potatoes and rice. Of course, whenever there are shortfalls, market forces will tend to push output in the direction of satisfying secular growth in demand to the degree resource endowments, cost structures and government policies will permit. Just what role automatic supply adjustment will play relative to apparent need for direct intervention will itself be influenced heavily by Government policy.

   It appears that higher yields could satisfy increased demand forecasts for some crops, such as potatoes; whereas for others such as oil seeds, fruits and rice additional land must be brought under cultivation. Presumably there will have to be significant expansion of cultivated lands in the high Selva. The Sierra oriented crop "shortfalls," such as potatoes, cannot be made up through extending the margin of cultivation, except in the sense that some dry farmed lands might be irrigated, the alternative is yield increases.

c. These assertions, while based on crude calculations, point to the need for serious planning and efficient programming for the agricultural sector. Unfortunately, an accurate picture of the real capabilities of Peruvian agriculture is difficult to create because any field observations are biased by "distorted" price signals and subsidies (9, p. 7). Where comparative advantage begins and ends for major products trading in domestic or international markets, among regions or between rainfed and irrigated techniques, is open to conjecture. Consequently, the need for public intervention and its specific design is not immediately obvious.

d. Given Peru's macro-economic[4] situation it would be illogical to complain about GOP price and subsidy policy that discriminates against the agriculture sector, while recommending Mission involvement in construction and support programs that may have the inevitable effect of locking the GOP into situations where continuing subsidy is necessary. Any recommendations should encourage investments in activities with the ability to operate without subsidy. Otherwise, the result may be to discriminate against the non-agriculture sectors.

e. For the nation as a whole, the cost of increasing benefits from resources already committed to irrigation should be weighed against subsidy of new irrigation projects. Reported costs of recently constructed and proposed projects are above \$2000-\$3000/ha in many cases. This is a danger signal where international cost competition is a requirement and domestic costs need to be low to diminish the attractiveness of food imports. Of course, improving the performance of existing coastal zone systems where much irrigation infrastructure is concentrated is not costless or riskless. There is a possibility that the annualized costs of reconstruction (or new construction) will exceed the value added to GNP (9, p. 15). Since water users are not required to bèar a large proportion of project social costs, even a rehabilitation program might involve unacceptable subsidies.

f. Current Peruvian agricultural policy contradictions put pressure on farm profit margins.[5] High production costs in some of the

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[4]See (7) for a long description of the "current macro-economic crisis" (p.i, et passim).

[5]According to Orden et al., food import and exchange rate policy in addition to domestic agricultural price policies, "result in rather serious discrimination against the agricultural sector" (7, p. iii, iv; 9, p. 7). World Bank observers have made the same point. See sources A & J in Appendix Volume literature cited.

irrigated farming areas and in other zones add an additional negative element to increased production.

g. Despite donor pressures revision of sector programs and policies and rationalization of production are not going to occur for some time. Thus, in the short run, there is a need to identify some development situations which are insulated from expensive resource and complex institutional support requirements. Emphasis should be on private initiative, self-sustaining, no-frills projects that are politically acceptable. According to the PPC evaluation of Plan MERIS, government institutions cannot be relied upon. Every time there is a bad year the financial support for extension and many other services are withdrawn (8). Therefore, it may be gambling with farmers' interests to create a project (program) design that stands or falls upon availability of such support. To the degree possible system owners (water user groups) should be able to weather swings in price policies and macro-economic instability (cf. 7, p. i), as well as other disincentives because their own investment carrying costs are very low.

h. If small irrigation projects are not low cost they benefit too few farmers for the money spent. In addition, the actual production might not be able to compete with the cost of rainfed alternatives.

i. These conclusions lead directly to the WMS-II team's delination of a specific near term irrigation program that will meet most of the requirements listed in the previous paragraph, but does not ignore or totally divorce itself from the existing Mission committment to Plan MERIS.

Recommendations for Near and Long-Term Mission Strategy[6]

Recommendation #1: AID should assist in the development of community initiated micro-scale irrigation systems in the Sierra Region. The foundation of any USAID commitment to a physically enlarged irrigation program should be supportive of necessary extension of Peruvian capacity to respond to requests for technical and administrative assistance in planning and constructing small-scale community irrigation systems. This focus will be mainly, but not necessarily exclusively, in the Sierra Zone. USAID participation, directly or indirectly, should be designed to maximize social benefits per unit of capital input, whatever its source.

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[6]These recommendations are in harmony with the spirit of those contained in sources 9 and 7 and complement them in many ways.

In effect, the Plan MERIS concept is enlarged geographically but scaled back in scope.[7] The program should embody the following characteristics:

a. Development opportunities should be prioritized with first consideration given to those projects where the following factors are present: i) the community has initiated the assistance request,[8] established a local structure to operate and maintain the system and made the commitment for the required labor and materials to construct it; ii) an engineering inspection of the site suggests little or no technical difficulty; and iii) there are no problems with water rights, delivery, and institutional interfaces with existing systems. The resulting system will be the sole property of the community and its ultimate utilization is strictly a matter for community decision, as long as the rights of other user groups are not impaired, and the water is put to reasonable use.

   Second priority will be given to community initiated projects that can meet all of the above requirements except a lack of ability to overcome some structural or physical barrier which a feasibility study indicates can be surmounted at an incremental cost of no more than $25-$50/ha. The community should be granted a reasonable time period to repay these special capital costs (a system of payment-in-kind should be considered). Ownership (etc.) is as before.

   Community initiated requests that involve somewhat more complex construction should receive commensurately higher engineering study and supervision. Again, the village(s) must bear the entire capital cost at reasonable interest rates even if it is necessary for the GOP to accept partial repayment in-kind. An upper limit on special costs should be about $200-$500/ha. Both the commitment for any public support as well as user repayment should be based upon a careful feasibility study of ability-to-pay.

   The lowest priority should be given to sponsorship of additional projects approaching the current Plan MERIS criteria, i.e., where construction is subsidized. Any exception should be grounded in significant overriding social/political considera-

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[7]This priority recommendation takes for granted that the USAID Mission to Peru will attempt to lift the current Plan MERIS projects to a better performance level by adopting some version of "Phase II" effort, as suggested by Anderson (2).

[8]Beneficiary involvement is also stressed by the PPC Team (8, p.25).

tions. Project initiated on such considerations should not be made the object of subsequent evaluations stressing economic tests.[9]

Where communities must shoulder the great bulk of the social, as well as capital costs of irrigation system development, they will only initiate requests for systems they intend to put to productive use. It would be expected that all the usual crops, including dairy products, potatoes and some meat, the very items subject to constant, steady growth in demand, would be produced. The created systems will help move more and more communities into greater degrees of marketed production, which is the only way to improve cash incomes. Individual farmer cultivation plans would not be required since this would be done at the community level. The cornerstone of this recommendation is the historic Indian community structure, cohesion, and social control. Individual water allocation as well as land utilization decisions are pushed onto the community, thus, maximum flexibility is retained for some members to pursue off-farm employment. New diversion and conveyance systems, enlargements and/or rehabilitations involving individual or inter-community initiated actions are all modes that can be accommodated.

b. A USAID created "revolving" investment fund should be created to support the repayable expenditures necessary on more complex projects. Value of in-kind repayments collected and utilized (or sold) by local Peruvian Agency personnel, plus cash collections, should be credited to the revolving fund by actual build-up of "counterpart funds" or in any other manner agreed by GOP-USAID.

c. Other USAID initiatives might include:

i) Assistance to Insituto Nacional Ampliacion de la Frontera to pre-plan "on the shelf" designs for simple structures and to create systematic "rules of thumb" for their selection. Standardization of prefeasibility study formats to be utilized in categorized situations to support requests for "special" T.A. experience and revolving finance requests. Build on Plan Meris or similar expertise.

ii) Assessment of the need to give budget support to certain backup functions other than engineering, such as "facilitators" or "promotors" to aid communities in affirming water rights, to arbitrate inter-community squabbles, and in smoothing out relationships with existing water delivery systems, etc. Community members need to see how their input

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[9]The recent "PPC" evaluation (8) errs in conside ble degree in this apparent basic intent. (This is not a criticism of that review per se.)

has been incorporated into feasibility studies, what the studies accomplish and exactly what cost and fund replacement commitments are implied with each decision.

iii) Shifting technical design and construction responsibilities from the public to the private sector, whenever possible. When a group of small systems are involved a list of pre-qualified consulting firms should be established, and the work divided among them on an equitable rather than a competitive bidding basis. The private consulting firms would have the responsibility of supervising appropriate portions of the community construction efforts in consultation with the community committee or to carry out some of the work in more complex systems. All designs should be approved by a core INAF staff before construction begins. To ensure that the private firms provide proper supervision of their own as well as the community work activities during construction, a substantial portion of payment for services should be withheld until after INAF has inspected and given final approval to the finished system. Contracts should have cost escalation clauses in more complex situations.

As part of the initial start-up phase and as the program evolves, attention should be given to the development of model demonstration irrigation projects to assess the application and integration of appropriate technologies into Sierra farming systems and demonstrate the benefits of improved farm (community) system management. A careful adaptation of the Plan MERIS experience can be transferred by core people. Budget support for this transition should be made by GOP (USAID) along the lines and for the reasons detailed. This activity should be coordinated with other research oriented development efforts.

<u>Recommendation #2: Incentive policies and services for Sierra agricultural development[10] should be supported. Policies and related services should be tailored to support and reinforce</u> production increases of major commodities which such small systems would produce, especially potatoes and dairy products. USAID should support the government in its efforts to remove barriers to efficient production and marketing of domestic agricultural output. Specific items might include:

a. The International Potato Center should be asked to evaluate the most limiting constraints to higher potato yields and the information should be disseminated by the extension services in the Sierra and into any incentive schemes CIP feels will work.

b. The GOP and USAID should encourage the expansion of potato

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[10] Cf. recommendations for market incentives in sources (7) and (9).

storage facilities by private firms, cooperatives, and public entities as a method of facilitating a long-range marketing strategy by farmers. All existing legal restrictions to storage of potatoes should be eliminated (7, p. xi). The GOP should create and enforce grading standards of potatoes for major urban markets and provide marketing news by radio direct from Lima and regional markets.

c. Any milk purchase subsidies should be kept under continual review as to purpose and accomplishment. The long-term aim should be to have only commercially viable processing plants serving farmers and consumer markets. USAID could help private entrepreneurs or groups carry out feasibility studies to determine the demand for specific plants. The studies could be linked with capital sources that would be interested in financing such operations.

Recommendation #3: Technical studies to support and promote commercially viable irrigated agriculture in the coastal region should be undertaken. Irrigated agriculture in the Coast should be increasingly transformed into wholly commercial farming enterprises which are concentrated as far as possible on high value crops capable of bearing any economic cost of upgrading technology and lowering unit costs of production. The Coastal Zone must supply some of the grain and specialty crop needs of urban areas and be cost competitive, if possible, in foreign sales. Farm prices must be high enough to cover the nation's resource cost of production.[11]

To support the development of this policy thrust, USAID should provide assistance which lays the technical foundation and generates some data that are lacking. An important strategy should involve an emphasis on increased conjunctive use as a key method to boost irrigation water supplies in the least cost, most economically viable manner. Needed technical studies to support a coastal irrigation program should include the following components:

a. To ensure the commercial efficiency and long-term viability of coastal irrigated agriculture that is based somewhat on conjunctive use, USAID should sponsor a study of the future strengths and weaknesses of coastal agriculture, emphasizing export potentials and internal demand for rice and sugarcane. The study should evaluate the effective tariff protection impact as well as the impact that phasing out direct and indirect subsidies would have on the commercial viability of farmers in the coastal region (Cf. recommendations in 7, pp. xi-xiii).

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[11]This is the substance of a major part of the Orden Group's recommendations, (7).

b. A study should be made to delineate a cost effective role the public sector might play in rehabilitating (where necessary) or easing structural adjustments for the very important traditional export crops. As things now stand, the apparent mismanagement of the sugar estates precludes very much public intervention until a somewhat new production climate can be created.

c. If the results of such investigations affirm that irrigated crops can be economically produced without subsidies and/or there is an expanding market for high value crops, then USAID should support the completion of hydrological modeling studies to identify optimum conjunctive use of surface and groundwaters. These studies should include intentional water spreading for recharge, the use of temporary and night storage, and maintenance of low pumping lifts for new lands or as supplemental water in existing irrigated areas. An interesting approach to carrying out the needed modeling of each of the 52 coastal valleys would be to integrate this effort with the proposed five year $3.5 million build-up of the agricultural engineering capacity at La Molina University, as recently recommended by the USAID Policy Analysis and Manpower Team study. This would not only help develop the institutional capacity to carry out the needed studies with a minimum of expatriate assistance but also go far in providing meaningful and needed strengthening for the University. The effect could be similar to that achieved through federal research grants to U.S. land grant universities.

<u>Recommendation #4:</u> <u>AID and GOP support of private sector irrigated commercial farming on the coast should be supported.</u> If a long-term agricultural policy can be adopted on the basis of the findings of the "subsidy" study and the technical data has been generated, then USAID and the GOP should develop specific programs to strengthen private irrigated commercial farming on the Coast. Such programs should include the following:

a. USAID should support a program to strengthen the Peruvian private sector capacity in optimizing well design, drilling, development and services, along with the maintenance and operation of pumping plants.

b. If there is a lack of adequate private capital to finance, without any subsidy element, the development of groundwater resources by private commercially viable farmers, then AID should carefully study the advisability of financing a credit program at commercial rates to encourage groundwater development in a systematic manner. If it appears that groundwater demand will outrun supply the GOP should establish laws and regulations which give priority legal use of groundwater to commercial farmers or cooperatives that have proven their ability to run economically profitable operations. This will require an assessment of the farm management skills of applicants. USAID and the GOP would have to insist that inefficient cooperatives did not get priority access because of their political power if demand is greater than water supply.

Recommendation #5: On-farm water management training[12] should receive greater emphasis. If the country can create an agricultural incentive system and eliminate serious constraints which have a depressing effect on profitable, commercial, agricultural production, it would be advisable for USAID to invest energy in facilitating the development of extensive, improved on-farm water management training program. Such a program should consider the following:

a. Both INIPA and DGAS have on-farm water management activities which need to be folded into a single program. Related activities by other offices within these agencies as well as INAF should be integrated to avoid further duplication. The use of video/TV technology in the DGAS program should be given the central focus as the training component of the extension program. The current materials of this high-tech approach, however, need to be reviewed and upgraded. Video segments seen by the team were of such a general nature that it is doubtful that a farmer would receive enough useful and applicable information to justify the cost of such a program. What is needed is creation of tapes teaching the results of applied research, illustrating practical techniques for technician and farmer use.

b. An on-farm water management program should also include a component which provides radio and TV news and interview broadcasts covering technical information and demonstrations of successful on-farm water management techniques being employed by progressive farmers as well as other useful information.

c. Water management needs to be taken up as an "adjunct commodity" along with the research currently being carried out for the five major crops by the INIPA in its extension research program.

Recommendation #6: Technical studies and research to support Upper Selva development should be expanded. As a subsequent priority area, USAID should support the rational development of irrigation in the Upper Selva

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[12]This recommendation is a special aspect of all the many recommendations for greater emphasis on Research and Training that have been well stated in other studies of Peru's Agriculture sector (7, p. ix; 2, pp. 14-22; 9, p. 40).

should support the rational development of irrigation in the Upper Selva by assisting in the formulation of policies and the financing of research activties which will be important to the long-term success of irrigation in this region. An Upper Selva irrigation study would need to include the following topics:

a. An overall regional agricultural strategy needs to be formulated which examines the tradeoffs between colonization and negative ecological impacts. The strategy analysis needs to simulate the potential impact of terminating cocoa production and other policies such as subsidized crop production and transportation (rice). Finally, policies need to be defined with regard to public subsidies for new lands development in the Selva. It may be more advisable, for example, to subsidize new lands development through construction of penetration roads rather than through public irrigation investment. Such tradeoffs need to be carefully studied before USAID agrees to support investments in public irrigation projects.

b. USAID might also sponsor incremental planning of agro-hydraulic resources to guide future water development in the Upper Selva. It should treat water resources as a system, not necessarily with a view to total manipulation of all water, but to assure that all large and small diversions are compatible with staged development, linked to long-term environmental goals.

c. In the area of research USAID should continue to support INIPA in a rice research program which anticipates potential pest and disease problems, especially in view of the widespread tendency to double crop rice on rice. In addition, research on upland rice and other rainfed alternatives, as well as irrigated upland crops and pastures, should be implemented to find viable second season cropping and animal production packages. Furthermore, the important and possibly necessary potential of the Selva to support sugarcane production should not be overlooked.

Recommendation #7: Near term follow-on strategic planning data activities need to be undertaken. Several earlier recommendations have called attention to the need for certain types of technical information that only can be obtained through an organized approach. Other data needs have not yet been mentioned. Needed water resource management information falls into two categories, each of which suggests the general outlines of continuing data assessment and research.[13]

There is a need for semi-technical engineering reconnaissance,

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[13]Orden's group has pointed out some ongoing data requirements (7). Additional discussion of follow-on study recommendation will be found in the final sections of this report.

analysis, and programming of what water is being diverted to agriculture and higher uses. An assessment of the physical appropriateness of diversion structures should be combined with cataloging where changes need to be made and an estimate of the amount of water available for additional non-agricultural/agricultural purposes. The entire question of new water source development vis-a-vis public (subsidized) investment should be the focus of a policy paper with the central idea being to maintain and protect the physical resource.

A review of the role of rights and obligations linking private users and public authorities and how those roles are impacting current and future resource use should be undertaken to complement the above effect. Water law as written and as practiced should be harmonized. Anomalies in Peruvian water law should be studied with intent to remove them. Experiences of economic and social benefits of irrigation investment should be brought together, reviewed and correlated with current national priorities and policies.

PART B
IRRIGATION DEVELOPMENT CHALLENGES IN PERU

Agricultural Objectives in Irrigation Sector Assessment

A rational irrigation strategy in Peru must be designed on the basis of two overall goals. First, irrigation must serve the efficiency objectives of the agricultural sector. To accomplish this there must be a clear definition of production objectives, an analysis of rainfed versus irrigated methods to achieve those objectives, and an evaluation of alternative irrigation programs to meet the sub-set of objectives best achieved through irrigation. Second, irrigation might serve social goals in the rural sector where the problems are enormous. There should be a clear delineation of the social objectives that irrigation can reasonably support, an identification of those groups that can best be served, and design of applicable irrigation "systems" (and corollary subsidy).

While both goals and their support elements are found in irrigation development in Peru, they are mixed in a somewhat unbalanced combination for several reasons. First, it is not clear in the minds of policy makers how to weigh these elements within the focal points of the decision-making process. Second, there is a lack of basic technical data on which to define production goals or social objectives and make reasonable estimates of the probable impact of alternative irrigation strategies on such objectives. Last, irrigation planning is greatly influenced by the political process through the relative influence of regional interest groups.

This study is a general analysis of meeting production and social objectives in the Peruvian context with corresponding recommendations. The nature of a sector assessment and the need to rely on existing data places some limitations on the depth of the analysis that can be corrected only through subsequent studies which generate more technical information. The analytic process is complicated by the fact that Peru is characterized by very substantial regional differences which are reflected in economic, social, and physical variety. To the degree possible the WMS-II team compared and evaluated irrigation utilization and benefits on the basis of these regional differences and opportunities. A careful review of a set of documents supplied by the Mission subsequent to the team's in-country visit helped clarify some conclusions and added force to all of the team's recommendations.

In its trips to the three regions of the country, the team saw a variety of irrigation strategies being pursued. These strategies could generally be grouped as follows: (1) consolidation and provision of management control structures for existing systems; (2) developing off-season storage; (3) constructing canal systems along higher contours to command greater areas; (4) strengthening diversion structures to withstand flood flows and provide better silt removal; and (5) complex inter-basin and transmountain diversion works for augmenting coastal water supplies. Groups 1 and 4 strategies are the most important for current program support because they fit the objective of raising already existing systems to higher performance levels at reasonable marginal cost.

The principal irrigation characteristics which the team observed in each of the three regions of the country are first described. In each instance, possible USAID program strategy criteria are defined and evaluated in terms of the team's point of view. Rainfed strategies are examined and their importance explained. Trends in agricultural production are estimated to identify where irrigated agriculture can best satisfy future need. Land use patterns and yield factors are examined to identify the specific commodities that need central attention in agricultural policy. The reasonable way to increase production of these crops, whether through rainfed or irrigation strategies, is also considered. Finally, social and administrative issues are examined to link strengths in zones and areas with compatible strategies.

Zonal Assessment of Irrigation In Peru

Most of the irrigation now in place in Peru was privately developed by individuals and groups. These numerous, relatively small developments were considered sufficiently economic by farmers to call forth construction investment without direct government subsidies. Undoubtedly, indirect subsidies such as extension services, water allocation institutions, or support prices have played and continue to play a significant role in the private irrigation development process.

In recent years, public projects have been initiated to expand the country's irrigation capacity. Most of these projects overlay the existing private systems although a few involve development of considerable amounts of previously unirrigated new land. Some of these projects appear to have potential economic viability but others are based entirely on geopolitical or social reasoning. The great bulk of these projects as measured by capital commitment have been in the Coastal zone and are frequently large scale.

USAID'S Non-Coast Strategy

Modern concentration of public and private irrigation development in the accessible Coastal zone resulted in observed payoffs to the national economy through export crop production and good yields in domestic agricultural products. There is a natural tendency to repeat this process if "funding is right," since unirrigated or underexploited irrigation potentials still exist. Some of Peru's most knowledgeable farm owners and operators are on the Coast and they would always welcome additional water supplies. Regional leaders always want development and will not refuse public works subsidy. In addition, most agriculture research has emphasized the Coast (4, p. 1).

As of the mid-1970's USAID/Peru was faced with the question of where or how the Mission should structure any program of activities in the irrigation sector and could have chosen the Coast. As early as 1970, however, the Mission had sponsored studies discussing a Sierra emphasis and advocating concentration on small projects and USAID chose to go this route. During the second half of the 1970's, the Mission made its commitment to Plan MERIS, hoping to lay a foundation for better farmer incomes and productivity in the Sierra by means of small-scale irrigation projects (8). In 1978, Mann added his endorsement of a Sierra strategy (4). Most recently, the question of "relative efficiency" of investment in Selva versus Costa agriculture projects has been argued in favor of the former by Adler (1).

In general, the focus of the WMS-II team recommendations are in harmony with these earlier arguments. The team places short-run emphasis upon the Sierra, mainly because of the possibility of immediate social and political benefits and the probability of greater overall agricultural production in the future. The details of how the WMS-II team would design a Sierra irrigation program no doubt differ from recommendations the Mission might receive from the consultants named (or from any others).

Sierra

Lessons from Small-Scale Sierra Irrigation Project Experience

Before undertaking further investment in small scale Sierra projects, USAID must necessarily take into account its own post-1975 experience along with that of the Inter-American Development Bank since 1970. Evaluations of both experiences are available (3; 8). Together, the two programs have involved 29 projects, most of which were small-scale. Eleven of these have been studied in considerable detail.[14]

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[14]The IDB evaluation of four subprojects included extensive farmer surveys and recalculation of feasibility indicators, assuming certain production levels and cropping patterns. Internal ratios of return were above the 12 percent "minimum" on two of the projects; one was near the minimum and one was below. It should be noted, however, that many program costs were omitted from these calculations. Even allowing for this warning these results _seem_ to be more positive than early indications from the seven Plan MERIS projects evaluated.

In both evaluations, the basic conclusion is that project success has been retarded because economic viability was not defined in advance (3, p. 26; 8, pp. 4, 46, 48, 50, Appendix B-18). Lack of institutional capability and poor coordination have also been important negative factors (8, Appendix F; 3, p. 15-23). Incomplete designs and various other shortfalls are cited, some of which were also noted by the team during visits to part of the Plan MERIS group (3. pp. 14-15). It appears, for example, that physical characteristics formed the principal basis for site selection (11, personal conversations; 8, Appendix F-24).

To these assessments the WMS-II team would only add that the Plan MERIS and IBD projects are expensive if they are made to bear the total program costs as part of any reevaluation of feasibility. Average information reported from feasibility studies is compared with realized investment experience in Table 1.

In relation to the well-known high per hectare costs of some of the large coastal projects, the 1981 (IDB) and 1983 (Plan MERIS) projects costs may appear relatively cheap. However, a simple way to keep per hectare costs in perspective is to relate improvement costs to land values. In 1982 the selling price of irrigated Coastal Valley land was reported to lie between \$1,500 and \$3,000/ha (9, p. 15). This makes \$1,000-2,000 improvements on Sierra lands seem expensive. Nevertheless, as noted, some of the IDB projects appear to be an economic success.[15]

Therefore, even if the ex-post evaluations of small-scale projects are interpreted as being somewhat inconclusive, the Mission is faced with a clear choice for a Sierra strategy: either the current system requiring a fairly high investment cost per family (per hectare) coupled with uneven return in social benefits or a new strategy impacting on a far larger number of participant families for the same budget, with the bulk of any problematic results voluntarily absorbed by the beneficiaries, and at little cost to society (per family). The WMS-II team recommends the new strategy.[16]

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[15]Although Table 1 is not complete, it may be observed that other types of ratios help create a fuller impression of relative wisdom of investments even if little or nothing is known about benefits. For example, the amount of money (subsidy) per family must be kept within reason. Again, we note that for the small-scale IDB projects, the average amount was not insignificant. There is also some upper limit upon the worth per job of new employment generated.

[16]Where projects are loan financed, the donor (World Bank, IDB, USAID, commercial banks) may not agonize over the outcome since the bottom line is the nation's ability to repay. Arguments of the WMS-II team focus on allocation of scarce resources to help poor people improve their position, regardless of funding sources, obligations, or donor policy objectives.

Table 1. Some comparisons of average expected versus average actual program costs of various irrigation projects in Peru.

Item	Feasibility			Post-Audit[c]	
	1972	1977		1981	1983
	Mainly Coast	Coast	Sierra	Sierra	Sierra
No. of projects	11	15	20	12	17
Est. Invest. Cost($$10^6$)	4,036M	21,093.4M	17.5M	31.3M	21.0M
No. Ha.	195,926	--	--	26,280[a]	13,443[b]
Cost/Ha. ($)	2,060	3,684	725	1,189 (1,786)[a]	1,562[b]
No. Families	--	--	--	7,295	11,261
Cost/Family	--	--	--	4,306	1,865
No. ha/Family	--	--	--	.6(2.4)[a]	1.2
Cost/Job Created ($)	--	13,304	2,292	--	--

Sources: 1972 (5); 1981(3); 1983 (8); 1977 (Peru, Agricultural Sector Survey Report [Quoted in 4]).

[a] Only about 65 percent of project lands utilized.

[b] Includes improved as well as new lands. Three small Sierra projects in the list have a program cost of about $450/ha. In some cases considerable on-farm investment must be added to these figures.

[c] The data for the post-audit reports are for total program costs, not merely construction. The construction costs for the 1983 report (Plan MERIS) would be about 33 percent less than the values shown. The 1981 IDB data would be about 20-25 percent less.

This point of view is not a rejection of the Plan MERIS concept, or of what has been accomplished thus far.[17] Except for a philosophical

[17]As recognized earlier in this report, the AID Mission is devoting additional resources to "finish off" the existing Plan MERIS projects, but a fresh look is being taken at a number of issues in project execution.

preference for "spreading the benefits" as widely as possible, the team would have no objection to Mission support of the design and execution of relatively higher cost investments if the net social payoffs looked promising. We do not see that promise, however, in total program benefits for any additional expansion of the current program to new sites. As far as near term geographic expansion is concerned, the team's priority recommendation advocates a substantially modified Plan MERIS both operationally and philosophically.[18]

Typically proponents of irrigation projects argue that "sooner or later the investment of public revenue will pay off." What tends to get overlooked in situations analagous to Andean valleys is that expansion in market demand or improved prices first impact upon existing, better situated, and often well operated irrigated farms. These farms, generally occupying lower elevations in the valley, will capture Ricardian Rents, and the induced supply response will satisfy part or all of the new demand. In this sense the outlying projects such as Plan MERIS are always marginal, no matter how well designed and executed. This is another reason why people-oriented projects often should be very small in scale, very low cost, and be founded mainly on community/group (i.e., private) supplied capital and human resources.

Irrigation in Mountain Valleys

The Andean highlands cover about 27 percent of the total land area (33 million hectares). This zone contains about 44 percent of the population, 70 percent of the farm units, and 83 percent of the land in farms. It consists of steep mountain ranges reaching over 5,000 meters above sea level and high valleys located between the mountains. Although over half of Peru's cultivated areas are in the Sierra (about 2.2 million hectares), this represents only about 7 percent of the Sierra's total area. About half of the remaining area (14.3 million hectares) is used for grazing or natural pastures on steep slopes at high altitudes. Annual cropping predominates and is limited to one short cropping season from about November to March. While there is little scope for bringing new land into production in the Sierra, there is some potential for improving productivity through intensification of land use by reducing fallow time and increasing production inputs.

The Sierra region produces most of the nation's small grains, a third of the corn and 90 percent of the potatoes. Almost all Peruvian alpaca, goats, llamas, pigs and 80 percent of all cattle are raised in the Sierra. The region accounts for about 42 percent of the gross value of agricultural production.

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[18]Nunberg asks, "Whether [the existing] model [MERIS] should be institutionalized...?" (8, Appendix F-13).

In the Sierra crop and livestock production problems are complex due to high man/land ratio, low soil fertility, adverse climatic and topographic conditions, inadequate research information, primitive water control systems, seriously inadequate services and infrastructure, and sociological factors. Yields are quite low. Although about 500,000 hectare (including fallow land) are nominally supplied with water, only about 340,000 hectares are irrigated in a given year. This latter figure is roughly one-third of the irrigated land in the country. Currently many water sources within the zone are underutilized.

In view of the low yield levels, significant increases in overall production from the high valleys can be achieved through improved irrigation and by application of available technology. This is demonstrated in Table 2 which shows estimated yield improvements in the Tarma, Junin area of the Sierra for 1972, with application of modern inputs plus irrigation.

Table 2. Yields of selected crops with relatively high and low input applications under rainfed and irrigated conditions in the Sierra.

	Yield (tons/ha)					
	Unirrigated		Irrigated		Ratio Irr/Unirr	
Inputs	Low	High	Low	High	Low	High
Sweet Corn	0.7	1.4	1.7	8.4	2.4	6.0
Artichoke	1.7*	1.7	2.5	3.6	1.5	2.1
Green Peas	0.6	1.8	1.0	2.7	1.7	1.5
Potatoes	1.9	6.4	2.4	9.6	1.3	1.5
Garlic	1.8*	1.8	4.4	8.0	3.0	4.4
Corn	0.7	1.4	0.8	2.2	1.1	1.6

Source (4).

*Sierra unirrigated average--none produced in Tarma without irrigation

The data indicate that very substantial increases can be achieved utilizing purchased inputs as well as through irrigation. The combination of the two, of course, generates the greatest production increases. However, implementation of such a program faces a number of related constraints. These range from poor access to credit for purchase of modern inputs or to finance on-farm irrigation systems, all the way to legal restrictions against potato storage and marketing systems which can discourage farmers from increasing their total production in the first place.

Credit and some other constraints of agriculture sector policy can be sidestepped to some degree in irrigation development by tapping the human resources and social characteristics of the region. Although there is considerable emigration to the Coastal towns and newer Selva settlements, traditionally the peasant communities are still well organized, integrated, and cohesive in comparison to those in the Coast and Upper Selva.[19] An abundance of underutilized human resources are available in the Sierra that could be harnessed to develop low cost, very small-scale irrigation systems. Table 3 indicates the wide variety of costs that may be encountered, depending on how financing is arranged. The low cost

Table 3. Selected cost indices for several Sierra small-scale irrigation systems.

Project	Total Cost ($)	Unit Cost Design Area ($/ha)	Approximate Amount Developed (m^3/sec)	Development Cost ($/$m^3$/sec)
Chupaca	272,000	280	2.90	94,000
Apata	303,000	930	0.40	758,000
Yanucancha	138,000	330	0.53	260,000
Sincas	138,000	550	0.34	406,000
Collano-Sorasa	12,000	631	0.30	40,000
Cahualla	15,000	375	0.35	43,000

Source: Plan MERIS Project reports.

[19]This statement might not hold for indigenous "amazon" groups in the Selva.

examples do not include an allowance for donated labor or labor payments made with community food.

Evaluation of these same or similar systems demonstrates that community involvement in construction, operation and maintenance is high. (See Table 4.)

Table 4. Extent of community involvement in selected small-scale irrigation systems in the Sierra.

Project	Community Input			No. of Committees	Development Cost ($/m^3/sec)
	Construction	Operation	Maintenance		
Apata	Earthwork*	na	yes	na	758,000
Chupaca	Earthwork*	To main canal	yes	na	93,000
Chiche	Earthwork*	yes	yes	na	---
Sicayo	Earthwork	yes**	yes	3	---
Collano-Sorsa	All	yes	yes	2	40,000
Cahulla	All	yes	yes	1	43,000

Source: Consultations with PPC Team (8).

* Labor paid for in food (approximately 3.6 kg/day).

** Proposed

na = data not available

These data suggest that labor intensive irrigation system construction can potentially increase output with moderate capital inputs. Due to topographic and physical constraints, individual irrigation systems would have to be small with many involving only a single community. Logistics for providing technical services are difficult and experience has demonstrated that support information disseminated diminishes as the distance from the agency headquarters increases. Thus, a development system which puts the initiative on the community would be most practical.

Most irrigation development in the Sierra will be rehabilitation, extension and/or modernization of some existing irrigation infrastructure. The main needs may be technical assistance for planning and supervision, some heavy earthwork, cement and reinforcing steel, turnout gates, and training of farmers. Farmer training is needed in the arts of simple leveling, some rocking of channels and related structures, and concrete construction using as many local materials as practical. Design would have to focus on improved canal alignment and stability, reduced seepage in porous zones, reduced channel erosion, and improved diversion structures which can withstand floods, reduce silt intake and be shut off to protect the canals during floods.

While it is well understood that irrigation projects have both social and production objectives, the importance of each is typically confused. Some projects clearly have the potential to be oriented toward commercial production and economic goals. Such projects must basically involve medium or larger farm units which are managed by farmers who have easy access to markets, credits, and the needed infrastructure plus the knowledge to begin using high yield varieties materials, inputs and techniques. Even under such an environment, however, projects which cost more than $2,500/hectare for all needed infrastructure, land, and other capital inputs can hardly reach hoped-for returns (benefit/cost ratios above unity) with discount rates of about 6 percent when producing basic commodities under single cropping.

Irrigation projects in the Sierra which are designed predominantly to serve small community units should clearly be based on social as well as drought avoidance criteria rather than to achieve standard economic objectives. Where many small farm units are involved the gap between existing and needed farming capacity, labor, credit, technical knowledge transfer and marketing arrangements is simply too great to overcome abruptly. Furthermore, subsistence farmers are in no position to accept production or financial risks. For all these reasons the team's recommendations stress assistance in situations where group actions and risks can be pooled and the group believes it can shoulder any outcome as evidenced by a willingness to pay the capital and other ownership costs.

Costa

Lessons from Coast Experience

The WMS-II team's priority recommendation involving very small-scale irrigation development farmers and little subsidy per family has important political, institutional and market consequences. The USAID Mission strategy should not, however, overlook the team's recommendations (#3 and #4) involving the Coastal zone. It will be recalled that these recommendations call for a "staged" approach. Thus, depending on goals for use of Mission resources, a complementary Coastal program might be appropriate.

One of the chief reasons for caution is made abundantly clear by Orden, et al (7). They describe in detail negative impacts of current agricultural sector policy upon coastal agricultural production. The President's Mission on Agriculture to Peru reached the same conclusions. (9). This latter report also discusses the problems of many of the large coastal producer co-ops in terms that totally coincide with the WMS-II team's findings.

While government policies are undoubtedly important, they do not form a complete explanation of the declining crop production efficiencies in some parts of the coast. For example, sugar co-ops should be able to increase production if they would rehabilitate the many tubewells that are now below par; instead, these groups are mining existing capital to maintain benefit levels to co-op membership and are avoiding the cost of new capital formation. What may be expected is a gradual increase in political pressure to provide a capital infusion into these groups. Any future subsidy to co-ops must be well thought out given these internal attitudes, government policies, and international marketing conditions.

Irrigation on the Coast

The Coastal Zone in the west of Peru is a narrow 3,000 km long belt of desert alluvial plains and dry, heavily eroded Andean foothills. The climate is ideal for a wide range of crops such as sugarcane, rice, cotton, corn, potatoes, citrus, olives and grapes. Most of the existing irrigation systems, however, are old, inefficient and poorly drained, and land loss to waterlogging is serious. Although the Peruvian Government is taking steps to rehabilitate and renovate existing systems, this is a slow and costly process.

Most of the land is concentrated in 52 valleys formed by rivers originating in the Sierra. From 150,000 to 250,000 hectares of the 800,000 hectares commanded by the coastal systems suffer from poor drainage and salinity problems. The mean annual runoff is estimated to be on the order of 40,000 mcm, a volume of water sufficient to irrigate 2 million hectares, employing an average application of 2 meters per hectare. When rainfall in the Sierra watershed is adequate, the maximum total harvested crop area is only 645,000 hectares of the approximately 800,000 hectares which can be potentially irrigated. Thus, approximately two-thirds of the annual discharge (approximately 26,000 mcm) is lost to the Pacific Ocean as little is needed for aquifer recharge at present. Unfortunately, surface storage sites are limited to about 2,500 mcm, in part because the development of additional capacity would be expensive.

The groundwater reservoir, however, could be used much more effectively. Therefore, in most cases conjunctive use of surface and groundwater offers the optimum means for realizing the full irrigation potential of the various valley basins and the completed irrigation infrastructure investments.

Currently, groundwater resources are used sparingly in most valleys to complement surface supplies. There are an estimated 10,000 wells in the coastal region (perhaps only half are in operation) which are used to pump 2,500 Mcm annually. About 65 percent of this amount goes for agricultural use and the remainder is devoted to industrial purposes. The amount pumped has been estimated to be approximately 10 percent of the exploitable groundwater resources in coastal valleys. In certain valleys such as Ica, Nazca, and Tacna, the groundwater is fully exploited and groundwater overdrafts are occurring. Most other valleys, however, have groundwater resources that are available near the surface (10 to 100 meters) yet are not fully exploited. Information obtained from AFATER revealed that in over half of the valleys along the coast, insufficient hydrogeologic data are available to evaluate groundwater resources and recharge capacity and to outline options and alternatives for groundwater use.

Water use on the coast is not excessive considering the area being irrigated. More than 98 percent of the land on the coast is irrigated using traditional gravity methods. On-farm gravity application efficiency is in the range of 40 to 60 percent, which is good by world standards. Production per unit of water applied is low for some crops, however, because of the relatively low uniformities of application, especially in view of the general salinity problems and rather high salt content of much of the well water. Average fields of major irrigated crops along the coast are shown in Table 5.

Table 5. Reported yields of important crops grown on Peru's coast (m.t./ha).

	1964	1974	1979
Seed cotton	1.6	1.7	1.8
Sugarcane	115.0	168.0	131.0
Rice	4.3	4.8	5.5
Maize	---	3.5	3.4
Alfalfa	---	---	54.0

Source: Appendix I

Sugarcane yields are good by world standards while cotton yields are only about half those obtained in California and Arizona under irrigated conditions.[20] Similarly, the yield of maize is only about half that obtained in California.

Rice is the only crop showing appreciable output gain over time. With HYV seed and other needed inputs, world class production of 6, and even up to 9 tons per hectare of paddy rice per crop are being obtained. The countrywide average for rice is 5.9 tons per hectare, the best in Latin America. This pattern is due in part to the fact that good water management for paddy rice is considerably less demanding than for non-flooded crops. (See Table 6.) Rice is continuously flooded and small variations in land surface elevation do not adversely effect application uriformity. Furthermore, salinity is usually not a problem with rice.

Table 6. Reported irrigated hactares and annual water requirements by crop, Peru.

	Thousands of hectares 1975	1979	Typical allocation mm/yr
Cotton	124.6	131.3	710
Maize	98.8	90.5	710
Rice	77.0	69.4	1,400
Sugarcane	74.6	53.9	2,000
Fruit Trees	47.6	27.5	1,080
Alfalfa	18.5	40.6	1,200

Source: Appendix I

Referring to hectarage in 1979, one observes that sugarcane, cotton and rice utilize about the same gross quantity of water. On a per hectare basis sugarcane is the large consumer, requiring 30 percent more than rice and 60 percent more water than maize. However, to infer that any improvement in water use efficience on the coast must place primary focus on sugarcane may be incorrect. Since productivity levels

[20]Poor management has cut yields in many plantations.

for sugarcane (and rice) are already at world levels, such a strategy does not deserve high priority.

Greater benefits might be obtained by increasing cropping intensity through conjunctive use, as previously suggested. Very few farmers on the coast have the opportunity to obtain more than one crop per year from their lands since surface water is generally not available year around and groundwater supplies are not well developed. Figures for 1971 revealed that about three percent of the overall area was double cropped. Of the 52 coastal rivers and small streams, half of these produce no water during the period from June to December and two-thirds of the cumulative annual discharge is concentrated in a three month period from January through March. Since it is already known that the creation of storage facilities is very expensive, a study of conjunctive use of surface and groundwater may reveal a potential alternative. Expansion of existing systems without augmenting water supplies is a dubious strategy, given the costs involved and the fact that in the average year only four hectares are planted out of the five that could be planted within the existing irrigation infrastructure.

Large and costly projects requiring many years before there is any water delivery, represent one of the most serious financial drains affecting the Peruvian irrigation sector. One study revealed that the average time for completion of construction of major irrigation projects was in excess of 11 years. Since the early emphasis is almost entirely on civil works construction, many years may pass before significant benefits from these investments can come on-stream. Yield estimates are too high, especially when water is not provided in adequate amounts. Financial benefits are projected to occur well in advance of their actual realization, and are sometimes based on specialty crops which have a restricted market. In general, cost overruns are common, projects do not stay on schedule, and hoped for social gains are not forthcoming. The MAJES project affords an exaggerated example of this situation. Thus, the team has serious reservations concerning providing USAID support to new or current large projects.

Alta Selva

Lessons from the High Forests

Other donors are already sponsoring irrigation investments and USAID could certainly stay on the sidelines in this region. Recommendation #6 is all that the survey team feels is justified at this time.

Considerable spontaneous colonization is occurring in an environment that may not be well adapted to atomistic development. There will be obvious ecological problems if people are allowed to pursue their own economic goals in an unrestricted manner. USAID might help study some long-run, sensible, identification of areas that can withstand settlement with the least damage. Spontaneous movement is so great it may already be too late for part of this region. The Government of Peru should handle the infrastructure development itself without USAID assistance.

Any direct irrigation emphasis by USAID could take the form of assisting the GOP to conserve and protect water resources and limit any trends toward chaotic development. There is need for regulation and control of existing diversions from the rivers and better design of attendant structures. Also, from a long run planning standpoint it is necessary to obtain good data on markets and production costs.

In summary, the Selva is already developing very rapidly. Part of this development is based upon subsidies that USAID should avoid supporting, given the speed and direction of what is already happening.[21]

Irrigation in the High Forest

The tropical forest zone east of the Andes mountains covers about 63 percent of the total land area (about 81 million hectares), but only contains 10 percent of the total population. It comprises two sub-zones: the eastern slopes of the Andes at medium altitudes, called the Upper Selva, and the Amazon jungle, called the lower Selva. Although most soils in the lower Selva are classified as marginal and suitable only for grazing and forestry, soils in the Upper Selva are generally of better quality. They are concentrated primarily in four river valleys that have been gaining economic importance over the last decade. The related migration of experienced, commercially motivated farmers from the Sierra to the Upper Selva has provided considerable impetus to agricultural development. The Upper Selva is bound to be an important new agricultural frontier with potential to help meet the rapidly rising food needs of the large urban populations along the coast.

In the Upper Selva rainfall is not dependable at any time during the growing season. In the Baja Mayo area, for example, there is a 20 percent probability that rainfall will be over 50 mm short of crop requirements during any month except April and May, when it is only 20 mm short. Thus, irrigation of most crops will usually double the average rainfed yields plus provide assurance against unusual droughts. In the Bajo Mayo area astonishing rice yields of two crops each of five to six tons/hectare of paddy are typically obtained on new lands under

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[21]The rapid economic development occurring in the High Selva is an outstanding example of the role of markets in agriculture sector development. The WMS-II team could not ask for a better demonstration of its principle thesis (pg. 2 of this report) than what is being offered by the explosion of cocoa leaf traffic on the east side of the Andes.

irrigation. This potential for high yields, coupled with subsidized and dependable markets, has stimulated considerable private irrigation development in the region wherever access roads have been provided. The area currently being irrigated has been reported at 32,000 hectares, and the potential is estimated to be over 150,000 hectares.

Private developments include small diesel pumping plants serving 5 to 25 hectare parcels, simple surface diversions serving a few farmers and/or hectares, and relatively complicated systems where groups of farmers have joined efforts and constructed canals several kilometers in length serving 500 hectares or more.

Naturally, the valley sites with the best soils which are easy to command and put into productive rice paddies are being developed first. Due to topographic restraints, further totally private development of irrigation in the accessible areas is limited to perhaps a 50 to 100 percent increase, over the existing 32,000 hectares, even in view of the high rice subsidies which include a special extra $46/metric ton plus transportation to the coast. To reach the full increase in irrigation potential of 120,000 hectares will undoubtedly require direct public subsidies of the irrigation infrastructure, assuming, of course, that careful feasibility studies indicate high B/C ratios.

It is. interesting to note that the cost of developing rice paddy land adjacent to natural surface water sources is in the neighborhood of $1,200/hectare (based on current data from private experience). Potential underdeveloped paddy land sells for about $200/hectare, and fully developed land for about $1,400/hectare. The cost of a pump set suitable for 20 hectares is in the range of about $8,000 and can be obtained on credit at favorable (actually negative) real rates of interest.

The first Selva irrigation project to be funded by a donor agency is the Cumbasa Project which is under construction near Tarapoto under Agencies of the Inter-American Development Bank (IDB). It will serve 6,500 hectares and was initially estimated to cost approximately $8 million; but due to unforeseen construction difficulties and inflation it will cost considerably more. Other major irrigation projects in the region which have recently been funded include: the set of 18 IDB subprojects in the vicinity of Jaen-Bagua which are designed to serve a total of 25,000 hectares at an estimated cost of $36 million; and the 17,000 hectare Sisa Project located in the Huallaga Central area, which is estimated to cost $24.5 million and is being funded by Spain. The average cost of these projects is estimated at $1,440/hectare for the irrigation infrastructure. The feasibility documents for the 14,000 hectares of new projects now under consideration in the Huallaga Central area, however, show an average cost of $2,600/hectare which is too high for obtaining commercially profitable returns with basic food grain crops.

In spite of the utility of irrigation, respectable average rainfed yields also can be obtained in the Upper Selva for such crops as corn, beans, upland rice and sugarcane. These lands are predominantly low fertility ultisols with slopes less than 5 percent and average rainfall in the neighborhood of 1,500mm/year.

Rainfed Alternative

Equity Considerations for Non-Irrigators

Obviously even the very small scale irrigation development program advocated for the Sierra--no matter how widely applied--will never reach all farm families. Many are limited to rainfall to raise crops and livestock[22] and more emphasis on improved farming for this segment of Sierra society might produce good results at low cost. Better family nutrition and cash crop sales from widespread improvement in rainfed yields have to be weighed against the social benefits of an irrigation oriented program.

The technical importance of considering "irrigated versus rainfed" agriculture is discussed in the annex volume. Although no formal recommendation is included in the WMS-II team's prioritized list, the arguments in these sections deserve careful consideration.[23] It is recognized that the USAID Mission to Peru already has research, extension and education interventions in progress that may reach this rural category (11).

Rainfed Strategy

Irrigation is often a very costly, capital intensive means of substituting for other inputs. In much of Peru's Sierra production, for

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[22]Once the conception is accepted that in a country like Peru the overall market for food production might not grow too fast, an equitable conclusion is that all farmers should share in that growth as much as possible. Practically any project which establishes a certain group as beneficiaries necessarily selects out a group of nonparticipators. This tendency is probably reduced to a minimum with a "general" rainfed emphasis and raised to a maximum in integrated rural development projects.

[23]The report of the U.S. Presidential Agricultural Mission to Peru contains somewhat negative implementations for the role of rainfed agriculture. The statement is made, for example, that "the higher productivity of irrigated land explains. . . .why Peru has placed such heavy emphasis on irrigation" (9, p. 15).

example, increases from irrigation with traditional cropping practices are about the same as could be expected from using improved seed and fertilizer under rainfed conditions. (See Table 2 above.) This is to be expected when water is supplied "free" or improved seed and fertilizers are not available. 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 crop inputs (seeds and fertilizers) under rainfed conditions or by opening new lands to settlement. The settlement of new lands in the Upper Selva appears to substantiate this. Input costs are still low as plant diseases have not become established and the soils have high native fertility. Yields are reasonable for rainfed conditions and irrigation is giving a considerable additional increase. It is questionable, however, whether the management level is as high under rainfed conditions as it appears to be for the irrigation situations.

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 issue on a regional or country-wide basis.[24] There is considerable evidence, however, from other countries with similar conditions that indicate rainfed yields can be doubled if inputs, training, and assistance are provided to farmers. Given the current average national yields of 0.8 to 1.0 T/ha for grains and 6 to 7 T/ha for potatoes, improved agronomic practices should provide a two-fold increase under rainfed conditions with irrigation providing an additional two-fold increase, for a total four-fold increase at the minimum. Therefore, it would seem wise not to begin new projects until the existing ones are brought up to this standard.

An indication of what productive potential might be locked up in current cultivated rainfed hectarage, is revealed in Table 7. This shows rough estimates of the "equivalent" amount of new, irrigated land that would be required to produce the same output of crops that could be obtained if yields on current rainfed lands were to be increased from present levels to what might be attainable with better technique.

The example includes most of the important crops, nevertheless, viewed in irrigated terms the hectarage is significant: 225,000 ha in Sierra, 175,000 in Selva and 4,000 on the Coast.

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[24]At the very least enough research and support service attention (including marketing potentials) should be given to rainfed agriculture as to ensure steady output increases at a pace that will cover agricultural needs of an ever growing rural population.

Table 7. Savings in "required" irrigated hecta-age if current equivalent rainfed lands are producing at potential by year 2000.

Crop	Coast	Sierra	Selva
Pasture		10,259	55,574
Cotton	3,982	---	---
Softcorn		50,991	
Hardcorn		1,793	32,201
Wheat		25,640	
Sorghum		57,459	
Potatoes		77,965	
Rice			2,081
Cassava			10,648
Dry Bean		9,195	4,324
Coffee			52,535
Bananas			20,189
Oranges			1,800

Source: Appendix V-A

Assuming that new irrigation development in the Selva costs about \$2,000/ha and that the "cash" cost of new irrigation in the Sierra is \$500/ha, the gross "savings" on capital investment, for the examples shown would be \$310 M in the Selva and \$115 M in the Sierra (by the year 2000).

The general objectives for improving rainfed agriculture in Peru should be:

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

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

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

To achieve these objectives and improve "actual" yields with known production techniques involves essentially a double focus. First, systems that are more effective in storing the rainfall that reaches the earth must be developed and used. This may be achieved by management practices that increase infiltration or reduce runoff or evaporation losses. Secondly, cropping systems that optimize the cutoff water to improve production must be selected, tested and applied. This can be achieved by agronomic management practcies that are tailored to the available and expected moisture supply.

Agricultural Production Policy

The agricultural sector of Peru is characterized by a general insufficiency of production in relation to requirements both for domestic consumption and possible export. These situations have prevailed in both good and bad climatic years. On a cumulative basis, this situation not only has created an adverse impact on the total economy but also has reduced opportunities for a considerable segment of the economically active population to engage in agricultural and related employment.

Economic Performance of Agriculture Sector

Peruvian agriculture's contribution to gross domestic product (GDP) has declined almost continuously, from 25 percent in 1950 to 12 percent today. Traditional agricultural exports have not performed well. Sugar value is down a great deal from where it was 10 years ago. Ignoring a slight resurgence in 1962, cotton is off by a factor of four. Coffee may be holding its own, more or less unchanged for 20 years. Wool exports seem to oscillate between 3.0 to 7.5 thousand metric tons. There is little to indicate an improving trend in increased foreign exchange earnings from these traditional exports.

On the other side of the ledger, Peru has a long history of substantial food imports. The value of such imported goods has consistently equalled about 30 percent of the value of domestic agricultural production. Generally speaking there are indications of declines or leveling off in trends for a number of imports during the latter part of 1970's. Although 1981 and 1982 data are not available it is possible that dry milk imports, for example, are not higher than in 1972-74. In this case as in others, domestic production seems to be substituting for some imports that have been substantial over the years. Rice production, for example, has certainly increased due to attractive farm prices to some degree, and the rice imports of 1979 and 1980 were connected to poor crops, not a weak growth trend. Wheat import trends are generally up, as would be expected, since it is difficult to increase domestic production. Possibly the strongest upward trend is visable in hard corn. This trend is due to the rapid growth of chicken meat sales and a heavy requirement for imported chickenfeed.

Current data imply that food imports have either declined or leveled off during the latter part of the 1970's which do not appear to be compensated through a corresponding increase in domestic production. Unless a significant amount of domestic food production is not entering national statistics, the figures would suggest that per capita food consumption has been decreasing since the early 1970's.

The overall impression one obtains from Peruvian agriculture is one of subsidy at the farm level, price controls at the retail level, and considerable government intervention in general.[25] As a consequence it is difficult to know how much falling exports are the result of a basic weakness in competitiveness or whether domestic policies are making export production less attractive. For many years, at least in the cases of cotton, sugar, coffee, and certain wools, the nation was cost competitive in international markets. This may still be true for some products, but in the cases of sugar and cotton, two important export crops, export supplies appear to be falling off. While this is due in part to the current drought, the rest might be due to reduction in hectarage as cooperatives look to the higher returns available in government subsidies through the production of rice and milk.

Preliminary analysis of trends in agriculture in Peru suggest that there is a serious need to get far greater results out of the sector than what has been attained in the past. Peru's irrigation strategy must be linked to whether policies will be altered along the lines suggested by Orden, et al., (7 Summary). The nation is already intervening in many important sector functions in order to subsidize urban consumption, or to tax some of what is exported. Such programs involve price supports and cost controls that drain the economy. It is extremely unlikely that there is any way the country can proportionately carry the same or an even greater subsidy level into the next century. Extremely tough decisions about the whole agricultural sector, and the people dependent upon it, are going to be forced onto Peruvian society as a whole--these issues cannot be avoided.

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[25]An accurate, detailed, analysis of inconsistent macro-economic and agriculture sector policy is contained in source (7).

Needed Production Increases[26]

Production requirements can be discussed in terms of the team's rough projections of demand/supply gaps of major crops in the year 2000. The demand projections were made on the basis of current consumption patterns and then allowances were made for population growth and the influence of rising incomes on the future pattern of consumption. For the supply projections the question asked was: could existing lands reasonably satisfy the food and fiber demands in the year 2000 with little or no change in current land use patterns, except for application of better technology and farm management? Estimates were first made which assumed that current yield trends and hectarage levels continued, and then projections were made of supply on the basis of higher yield levels that might be attained by modern farm operations. This shows in a rough way the relative importance of the expansion of land and the increase of yields to fill any demand/supply "gap". The results for some of the more important crops for domestic consumption are given in Table 8.

The "trend" for virtually every product is for a short supply by the year 2000. If "possible" yield increases can be achieved, however, a mixed picture emerges with some shortfalls persisting and some surpluses being indicated. Potato possibilities are a good example of this. Without yield or cultivated land increases, there will be a significant potato shortfall in Peru by the year 2000. If, however, reasonable yield increases can be achieved then a surplus could be produced. This does not mean, of course, that the outlook is necessarily sanguine. Potato yields have been stagnant for some time. Apparently government policies are at least partially to blame (7, p. v) since demand appears to be strong.

Rice, on the other hand, is projected to have shortfalls, even allowing for maximum yields. Thus, it will be necessary to allocate more land for rice production in order to keep pace with demand. Similarly, wheat will be imported at the rate of about 1,500,000 MT annually by the year 2000 unless Peruvian tastes and preferences are shifted to maize or other alternatives. As mentioned, Peru will never be self-sufficient in wheat under current state-of-the-art knowledge because too much land and water would have to be diverted from other crops. Assuming seven tons/ha yields, wheat growers would require 215,000 "new" hectares of land and water to meet the shortfalls, based on one crop per year. It might be technically possible to raise wheat on the coast during the off-season, but it would require pumping, and the result would be a high cost crop.

Even employing good technology the area devoted to sugarcane will need to be doubled to meet projected shortfalls. It is very unlikely

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[26]See annex volume, Appendix V-B

Table 8. Year 2000 indicative supply/demand balances for selected agricultural products: Peru

Product	Consumption	Seed & Losses	Demand at Farm Level	Supply Trend	Supply Possible[B]	± Balance ± Trend	Possible
Rice	931	46.5	978	938	821	- 40	- 157
Wheat	1,730	10.0*	1,740	100*[A]	353	- 1,640	- 1,387
Soft Corn	308	37.9	346	300*	622	- 46	+ 576
Potato	2,378	238.0	2,615	1,874	6,715	- 742	+ 4,100
Sweet Potato	234	23.0	257	146	957	- 112	+ 700
Cassava	684	68.0	752	373	982	- 379	+ 230
Olluco	--	--	--	102	168	--	--
Choclo	235	12.0	247	102	243	- 145	0
Tomato	129	19.0	148	113	169	- 35	+ 21
Onion	297	30.0	326	250	245	- 76	- 80
Oranges	352	52.0	404	56	333	- 349	- 71
Apples	202	30.0	332	78	155	- 254	- 177
Plantain	1,240	186.0	1,426	1,194	1,818	- 232	+ 392
Beans	71	4.0	75	51	97	- 24	+ 22
Sugar Cane	(All uses)		19,895	7,384	9,697	- 12,510	- 10,198
Coffee	32	(60 exports)	92	143	184	+ 51	+ 94
Sorghum			--	101	119		
Hard Corn			--	688	1,087		
Barley			--	130*			
Mutton	37			20.5		- 17	
Pork	137			73.7		- 65	
Beef	278			111		- 167	
Poultry	433			295		- 138	
Milk	3,754 (Fresh equiv.)		3,757	1,129	--	- 2,628	
Eggs	139		139	112	--	- 27	
Oils (All)			--	209*	231	- 261	- 240

A. Trend for national crop. B. All data from Table V.17. C. Estimated growth in fish oil extraction and african palm production.

* Estimated trend.

that the probable shortfalls in sugarcane can be met simply through more intensive cultivation of existing areas (returning to former yield levels on the Coast). The well-known shortages of meat and dairy products are projected to get worse, not better, unless yields go up. This would require more animal feed and larger national herds. The trend in the demand for milk is towards deficits of over two million metric tons per year on a fresh equivalent basis. Filling this gap would require an increase in the national milking herd of 325,000 animals averaging 22 liters output each per lactating day.

There seems to be no technical reason why Peru should continue to be short of fats and oils. If the African Palm plantations now in prospect prove insufficient, or the average anchovita catch is not great enough, new lands will have to be developed. Otherwise the nation faces a 50 percent shortfall in its domestic requirements at year 2000. (Fats and oils can continue to be imported if increased domestic production is not internationally cost competitive.)

The magnitude of such numbers suggest that it may not be possible to "force" the kind of rapid development and recuperation necessary to head off shortages and dislocations by means of the subsidized approach now being applied in the Selva, as the localized requirements are too massive. Careful investigation might show that the amount of new subsidy required would be so large that greater social gains would be obtained by putting the resources into a different sector. The best first step to obtain all around better agriculture performance from <u>all zones</u> would be for the government of Peru to institute the policy reforms recommended by Orden, et al. (7) and the Presidential Agricultural Mission (9).

Needs, Technology and Zones

Matching regions having the most profitable production efficiency with these indicative and particular shortfall estimates suggests a number of conclusions. Expansion of crop production on the Coast via opening up new lands may not be very practical since most low cost irrigation opportunities have been exploited. Nevertheless, considerable output increases are possible because all production has not reached good yield levels; some former yield levels are no longer achieved and groundwater resources could be utilized.

One Coastal crop that potentially may be in short future supply is sugarcane. Even if all current plantations were achieving good yields, as many as 85,000 <u>new</u> hectares would be required to cover the indicative shortfalls. Thus, sugarcane increases might be most easily obtained in the Selva, possibly under rainfed conditions.

Considerable amounts of rice and alfalfa are produced on the coast and it would be technically possible to obtain increases. To a considerable degree, however, current output and good yields are being induced by strong markets for grain and dairy products that are somewhat artifically founded on subsidy and price controls. If this artificial element were to be removed by changes in policy, rice and alfalfa emphasis might not be very profitable. Indeed it is possible that in the longer run, production of rice under rainfed conditions would look attractive.

The zone of the country best suited to meet the potato shortfalls is the Sierra. The amount of land cultivated in potatoes would not need to be increased. Substantial increases in production could be achieved through the use of modern inputs and better arming practices. The zone is also well adapted to meeting dairy and meat shortfalls. Some farmers are quite progressive and operate on a fully commercial basis. Others tend to emphasize alfalfa and cattle so they can minimize their concentration on farm production and work elsewhere. The majority of the families probably are not endowed with very good land, but they operate in a social system based on kinship, group, and community support that seems to help stretch what resources and reserves are available. The WMS-II team's discussions with small farmers indicated ample interest in improving family welfare if more cash sales could be made.

The main challenge is to find a clear-cut and effective method to increase potato yields in this zone. One approach might be to concentrate on a program to develop better water management practices and greater use of modern inputs. The team observed widespread practices which were highly inefficient. It appears to the team, however, that improving water management may be premature until more fundamental marketing constraints are removed. There are currently several barriers which restrict the profitability of commercial potato production, and until these barriers are removed additional training of farmers in better farming practices will produce few results. The whole situation is brought into sharp focus in several areas located in both the Sierra and the Coast where the team observed very efficient water management practices. These were areas where clear and substantial profits were to be made from good practices, and this was achieved with relatively little outside training or other public support services.

Once potato marketing barriers are removed, it would make sense to develop the micro-scale community initiated irrigation systems recommended in this study because increases in potato production could be achieved with reasonable capital costs to farmers in the Sierra. In fact, irrigation improvements, even in the absence of modern inputs, will be able to make significant inroads on any potential shortfalls in potatoes. Yield increases of just 4 or 5 percent per year would be sufficient to increase production to the level of projected year 2000 demand.

Thus, it is possible that just the removal of marketing constraints and the installation of low cost irrigation systems (and better rainfed yields) would be sufficient to meet market requirements. Also, it should be recognized that considerable social benefits could be achieved, quite apart from production objectives. With new or improved irrigation systems farmers may increase output somewhat just to improve their diets for themselves and their animals. The increased protection against frost gained by irrigation would also provide additional security against poor crops for the poorest segment of the Peruvian society. And, most important, if the new irrigation systems are not utilized to capacity, it will be cause for relatively little complaint since the public will bear only a fraction of the cost of self help projects.[27]

Somewhat more assured and regulated small scale water supply systems in the Sierra would also confer other important advantages. Any Sierra community that receives more water is almost certain to increase or intensify its area of managed or improved pasture. This not only allows animal herds to increase, but families can better use child labor. More milk cows would mean more milk for poor Sierra farm families and help fill the shortfalls in national production.

In summary, it may be difficult to incresase the average incomes of poor farmers in the Sierra until some fundamental alterations are made in incentives for productivity and strong prices appear in a freer market place (Cf.7, pp. v, xi). This is true even though output of important

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[27]Note that this discussion is not about "maximum" production from irrigation, it is about what might better be termed "sufficiency" or "break-even" increases. In this sense, additional water is a "sufficient condition" for irrigation success, and the PPC Team is incorrect in its opposite conclusion (8, p. 25). Despite common sense notions about the synergistic effects of modern inputs in combination with assured water supplies, the general rule that the marginal value product of each new, separate factor should be able to equal or exceed marginal input costs, is something to bear in mind. At the very least the water input should be able to pass that test.

The "full impact" of irrigation may require other modern input accompaniment. In this sense the PPC Team is correct. But as the main text makes clear, the WMS-II team is not very concerned about "full impact" where the communities bear the cost. Greater impact can come later. Full "impact" is an inappropriate short-term goal for additional reasons. First, mere availability of some new technological package may not induce farmer response because what is offered requires cash, or is too costly in terms of farmer time and effort. It may ignore diseconomies of scale or be unsuitable because the tenure or share cropping pattern is unsatisfactory. Finally, the most powerful results of new water plus modern inputs may still not exceed the value of the annual sum of daily wages that are available from off-farm employment opportunities. This is a possibility that must be addressed in any planned expansion of irrigation.

crops such as potatoes will undoubtedly respond to widening national demand. Meanwhile, as long as tenure questions and other policy issues are unsettled, growing pressures will be put on traditional farming systems due to a worsening man/land ratio among small plot holders.

Impact of Contrasting Socio-cultural Characteristics Upon Irrigation Strategy

Peru has sharply contrasting cultures which emerged out of its Inca and Spanish heritages. Its Inca culture tends to predominate among the peasant classes of the Sierra and its Spanish culture among the upper class and in the Coast and the Selva cities.

The Inca culture was built upon a communal system and many of its characteristics have been preserved to a significant degree by the Indians of the Sierra. Today, Indians continue to find security principally within their villages and view the outside world as a place of danger and risk. The culture also continues to place a great value on individuals in the community who make substantive contributions to the community rather than accumulate individual wealth. The members of the Indian communities are taught that independent action is doomed to fail, and only communal action will be successful. This has maintained the traditional and highly cooperative society where agriculture is still the most honored profession and dedication to communal oriented activities brings social recognition. Individualistic attitudes are still suppressed as early as possible and the household as a unit generally complies with community desires (Cf. 8, Appendix C-4, pp.5-7).

In contrast, the Spanish culture is built upon the concepts of individual achievement and non-agricultural pursuits. The Spanish conquest of Peru was carried out by knights and soldiers who drew their values from a culture that had been shaped by war with the Moslems for 800 years. This military class placed great emphasis on the concept of individualism, self-status, stratification, and economic inequality. Spain had been a country oriented toward animal husbandry, so agricultural work did not hold the same status it held in the Inca culture, which had few domesticated animals.

The Spanish colonial administration took the best Indian lands and gave them to private individuals as "estates" for service to the crown. Smaller plots were assigned to peasant families who had to pay a "labor tax" by working on the lands of the estate owner for a fixed number of days per month. Some communal lands were assigned to peasant communities in exchange for taxes paid in cash and kind, although some were subsequently converted into estates and the Indians placed into a type of labor-tax serfdom.

Independence (1824) had little effect upon a colonial social and economic structure, The system remained generally intact until the "Agrarian Reform Law" was passed in 1967. The Agrarian Reform movement returned some semblance of property ownership back to the Indians, but the reform efforts of the government to create cooperatives did not tap the communal nature of the Indian culture. The new cooperatives included people from heterogeneous backgrounds, while the Sierra Indian communities included people with a homogeneous value system. The cooperatives created an administrative class which did not do field work which was contrary to the Indian culture where everyone, regardless of social position, does field work. The Indians view the cooperatives in action as a neo-Spanish cultural hacienda system with the Spanish on top and the Indian on the bottom.

These differences in cultural values explain to some degree irrigation development in the past and support potential opportunities in the Sierra. Indians who have left the Sierra for the coast or high forests have generally lost their Incan cultural heritage over time. Irrigation on the Coast has been developed on the basis of individual efforts by private interests or through large government projects rather than through communal efforts. As a consequence the best opportunities for irrigation development on the Coast continues to be through tapping the private entreprenurial orientation of Coastal farmers.

Due to the cultural characteristics of many of the cooperatives induced by the Agrarian Reform movement, irrigation programs cannot rely on them as a vehicle for implementation. Any coastal program would have to pick and choose with great care which cooperatives to work with. Any major effort based on cooperatives will have to wait until they can resolve their conflicts and improve their management capabilities.

Sierra communities, on the other hand, offer a comparatively strong social structure for the development of community based self-help small irrigation systems. The Incan Empire itself developed substantial irrigation works and a good understanding existed with regard to the use of water for frost protection and the cultivation of improved crop varieties. Masonry skills exist in the Sierra Indian communities and can be utilized for community development of simple, small irrigation systems in the region. The Sierra Indians do not, however, know efficient methods for the utilization of water resources in situations requiring sprinklers, or special methods of water control. Training in modern water management technology along with some technical engineering assistance and the provision of construction commodities such as cement and reinforcing steel would be an efficient inducement to greater food production in the region.

Administrative Development

There are a number of public policy objectives which are factored into the design of irrigation development in Peru. These values, which underlie public policy objectives might be characterized as follows: (1) economic efficiency for food production; (2) social equity; (3) water distribution equity; and (4) political stability. These values frequently come into competition with each other when irrigation investment is programmed on both the national level and the regional level. The choice between projects with social objectives and economic objectives is one of the most frequent examples of this type of conflict. Public irrigation development normally involves subsidy to the recipients in all countries, developed or developing; i.e., political objectives tend to weigh very heavily in the decision-making process.

Planning Water Development

Currently, national planning of irrigation investments is more a goal than a reality in Peru. Large projects are planned and carried out, for example, through autonomous authorities who are under the direct control of the Prime Minister's Office (PM). While a coordinating body was created to program such investments (Consejo Superior de Aguas), it has no authority over projects by other government ministries. Within the Ministry of Agriculture (MOA) the Instituto Nacional de Ampliacion de La Frontera (INAF) has principal responsibility for medium and small irrigation project (i.e., up to about 12,000 hectares). At the same time another office at the PM carries out projects in the upper Selva, overlapping somewhat with INAF. At the local level public regional community development corporations (Corporaciones de Departmentales de Desarrollo) carry out their own agenda of irrigation and other community service projects, sometimes employing the expertise of INAF. They report to the PM, although there is not a consolidated system at that level for monitoring their activities. At a very small local level, Corporaciones Populares carry out village community service projects, including some very small canal projects.

The National Planning Institute (INP) has had a technical role in the preparation of feasibility studies of proposed projects and in trying to track their costs. At the same time each ministry has had planning units within their structures to allow centralized coordination of all activities. From a practical standpoint, however, these units such as OSPA in the MOA have not been utilized very much since the end of the military government. Recently there have been moves to create a true centralized planning unit, the Consejo Superior de Aguas (CSA), to program all irrigation investment in a comprehensive way. As yet, the CSA has not carried out any real comprehensive planning, nor has the technical input of agencies played an overriding role in policy making at the political level. While there is increasing resistance within the PM against the financing of large, expensive irrigation projects, this resistance has not been too effective against continued pressures of certain interest groups which find expression through the legislative branch among others. As yet, the planning process is still fragmented and heavily influenced by political and social considerations relative to economic efficiency.

There is a substantial need to increase the level of national programming of irrigation projects, expand the technical input into such decisions, and circumscribe, purely geopolitical factors in the final configuration of projects. This would require the functioning of a Consejo Superior composed of high level decision makers with specific power and will to program cost-effective irrigation development.

Administrative Control of Water Delivery at User Level

Peru has a well developed statutory system for water right distribution and administration which reflects its long history with irrigation development. The Direccion General de Aguas y Suelos (DGAS) through its regional offices, the irrigation districts, enforces legal norms and handles technical water matters. The districts are supposed to have an extensive system of "sectoristas" of farm level agents who reach out to the user level to enforce water distribution equity.

In actual practice there are not enough sectoristas to control water distribution at the farm level although they exercise a fair amount of control at the main canal level. The irrigation districts lack funds for employing enough sectoristas to operate as the law demands. The administrators of the irrigation districts adjust to this problem by assigning sectoristas to manage and control those irrigation systems in which there is considerable conflict because of the scarcity of water. In other systems the allocation of water is principally controlled by user organizations. When water is short certain years, a considerable strain is put on the private voluntarism of the system. Presidents of user organizations cannot handle at present the allocation abuses that take place in scarce water seasons. Equity in distribution is suffering and the whole enforcement system is strained because of the drought conditions in a number of areas of the country.

All ownership rights over water were taken from private entities and reserved to the state by the military government. The law established an orderly system of registration. However, the legal enforcement mechanism of public management of water distribution and planning is now much greater than previously required. This management system was codified through the "cultivation and irrigation plan" (plan de cultivo y riego). Under this system farmers are required to submit to the irrigation district a cultivation plan for the season in which they project the crops they will irrigate and the anticipated area of each crop. The irrigation district then makes a projection of water availabilities for the season and a seasonal plan for the allocation of water in which the quantity of water is assigned to each farmer on the basis of the water requirements of the types of crops he will irrigate. The plan thus tries to achieve a certain level of efficiency and equity by allocating water on the basis of need and production plans.

There is a serious question as to whether or not this registration system actually achieves its purposes. If nothing else, the allocation of water on the basis of area irrigated rather than cropping pattern would allow the shifting of administrative resources to enforcement of distribution rather than the determination of amounts to distribute. If the procedure would allow the informal swapping of water some efficiency gains could also be realized. Swapping would need to be informal, however, unless the law was changed, because under the current regulation a farmer will lose his claim to water use if he does not utilize it for two years in a row.

Water Charges

Another important area in which the legal system plays an important part is that of water pricing. The water law provides for the payment of a water tariff and a quota according to use. The purpose is to try and recoup some of the development costs of irrigation systems, generate money for operation and maintenance of systems, and encourage more efficient use of water. Under the current practice, the tariff varies from district to district to take into account farmers' ability to pay. The tariff is collected by the government for the public fund and the quota is collected by user groups for their own use. Currently, the levels of both the tariff and quota are so low in most districts that they are inconsequential. Collections cost more than the revenues which are generated. However, the present aim of the government is to get farmers accustomed to the concept of paying for water, so that over the long-term water charges can be increased in real terms.

Enforcement and Administration

The current tendency of the government is to push for an extension of the enforcement mechanism into systems with less tension. Because of budget constraints, however, it is unlikely there will be any significant change from the current outreach level. A revision of the water law to allow a more efficient allocation of water also appears quite difficult. There is a special commission revising the water law. However, no substantive changes are presently being considered or recommended.

User participation in the irrigation process in Peru is relatively high. By law a whole superstructure of user organizations has been created. To varying degrees these user organizations do function, even though they did not spontaneously spring into existence under local initiative. They are sustained by the private voluntariam which is characteristic of irrigation users the world over and are driven by the need of users to regulate their system to protect their individual interests. In systems where water is scarce and the tension between users is high, the user organizations are generally quite active. Likewise, in the Sierra where Indian social cohesion still persists, the user organizations serve as the basis of control over water distribution, especially where no sectoristas (government agents) are available to manage the system.

Design and Execution

The only design and construction that is carried out by public agencies is that of relatively small and simple irrigation projects. The design and construction of large public projects is contracted to consulting firms. The principal agency which carries out the design and construction of small and medium scale irrigation projects is INAF. The DGAS also provides technical input in terms of evaluation of water resources of basins which it periodically carries out, but the principal design and construction work is done through INAF.

In general, the technical capacity of INAF has been irregular, although generally capable of handling small systems. The low government pay scales make it difficult to maintain a high professional level of technical competence. After professionals upgrade their capacity through training they frequently leave their government positions to enter the private sector where pay is better. While such training subsidy is not lost to the country unless the professionals emigrate, the execution capacity for carrying out small and medium sized projects, where the government plays a central role, does not improve.

The corporaciones de departmentales, corporaciones populares and other groups carry out projects for which the expertise of INAF are employed. Several projects seen by the study team which were done by private consultants suffered from major design deficiencies which could have been avoided had INAF had some supervisory or approval role. Because of the budget constraints of the government, however, it is unlikely that the technical engineering capacity of the government will make significant improvements in the near or medium term. In fact, there is a good chance the level of talent will decrease because of the continued real decrease of public sector salaries, leading to the better professionals seeking other jobs and the less capable ones hanging onto theirs.

There is a need for the government to involve water user organizations more directly in planning and construction. Likewise, the government should modify its current administrative policies in order to give user organizations more power over the direct control of water distribution. Currently, the government is not moving in this direction. Likewise, user organizations are mainly concerned about ways of getting the government to do more for them rather than seeking ways to do more for themselves. However, a certain willingness to take the lead in developing their own systems with minimum government help was seen in several areas. User organizations do not particularly exhibit an interest in substantial amounts of time. Leaders in most systems already give significant time to the management of their systems without compensation and are not interested in increasing their time commitment. Without some government initiative, it is doubtful that any change from the status quo will be achieved. It might be cost effective, for example, for the government to compensate presidents of water user associations for some of the time they devote to enforcing water distribution rights rather than trying to hire more sectoristas.

Training Deficiencies

The administration of on-farm water management training is plagued by overlapping responsibilities and duplication of effort. Under the current structure the primary responsibility for agricultural research and technical assistance (extension) to farmers is assigned to INIPA, an autonomous institute under the MOA. INIPA has several programs financed by international donors which are aimed at increasing research and extension capacity. INIPA has established 18 regional research and extension centers, called CIPA's, which are carrying out research on a commodity (crop) basis and building the skill level of extension agents to reach farmers. Experiment stations for five major crops exist in many of the regional CIPA's but relatively little irrigation research is done in relation to these crops. Furthermore, the extension component isn't as well organized, which is not to imply that the research component is functioning at a highly professional level. Israeli experts through a World Bank program are providing training to extension agents under the Banor training and visitation system. At present, however, the technical competence of extension agents is low and there are too few agents in the field with too few resources to have a very great impact on farmers.

Among the proliferation of efforts in this area, including another one within INIPA itself, is another major program for on-farm water management within the DGAS. The DGAS training program, which is being financed by a loan from the Inter-American Development Bank, is similar to the INIPA program but with significant differences. The program has a component for training engineers and for training farmers in on-farm water management. The first component trains engineers within the DGAS through a system in which the trained become the trainers. Under the program 24 high level engineers in the DGAS were sent to Mexico where they received technical training in such subjects as conservation, irrigation technology, drainage, etc. Upon returning, they were assigned to train mid-level staff within the regional offices.

The goal of the second component of the project is to train 14,700 farmers in on-farm water management techniques. This is being done through the use of demonstration plots which are used for the application of principles the extension agents wish to convey. The farmers who show the best capacity to learn and apply the lessons are expected to teach others within their community. The extension agents also use video cassettes and portable TVs to show farmers specific irrigation technology practices.

The overlapping of INIPA and DGAS programs is obvious. Furthermore, there are other offices doing similar things; but these are the two major programs. The existence of the INIPA/DGAS duplication is understandable for several reasons. First is the fact that the DGAS program was started in 1978, which is several years before INIPA was created. Likewise, although the research and extension function in agriculture has been assigned to INIPA, the law and regulations of the government still clearly stipulate that the DGAS is responsible for on-farm water management. Thus, there is a duplication of legal authority.

Peru seems to be moving forward in its efforts to substantially increase its capacity to deliver on-farm water management training to farmers. Before the Agrarian Reform movement under the military government the country possessed a fair capacity in agricultural extension and on-farm water technology training. The innovative features of the DGAS/IDB program would seem to offer real opportunities for making substantial strides again in this area. However, INIPA should recognize the superior elements in the DGAS program and be willing to adopt them into an integrated effort. But it will take some time before the research capacity reaches a level in which an understanding of the inter-related impacts of water and other agricultural inputs is achieved.

Administrative Analysis

The analysis of the current state of administrative capacity in irrigation supports the team recommendations. Because of the preponderance of geopolitical considerations in public irrigation investment decisions, USAID would be wise to continue to avoid involvement in some of the more prominent coastal projects which are in need of money for completion. They were undertaken for political reasons, are not economically justifiable, and the social return for the level of investment is very small. If anything, a USAID program should seek to compensate for the disproportionate benefit which has historically flowed to coastal irrigation systems. This should be done through a funneling of assistance, on a non-subsidy basis to the Sierra. With its lack of political weight Sierra interests would be less able to promote a subsidy oriented program, yet the social returns would probably be considerably higher than for a coastal program.

Because of the lack of insufficient public control of water distribution equity through sectoristas, USAID programs should favor simple systems which do not depend on them. For very small-scale Indian community based irrigation systems the necessary social cohesion exists for achieving a reasonable degree of equity in water distribution without sectoristas.

When Peru is able to develop an effective video backed extension system which is expressly designed to reach large numbers of farmers at low cost, then extension can be factored into irrigation projects. Until that time the irrigation strategy should not rely on it. The absence of effective extension does not pose a particular problem for a small-scale irrigation development strategy, however, since few public funds will be expended and immediate productivity increases would not be expected anyway.

It is questionable whether small Indian community based systems would enforce water allocation on the basis of annual cultivation plans. This is probably another reason why a small-scale Sierra strategy is desirable. Because of the small size of such systems they could bypass this government program without impairing its implementation on larger systems. Since the allocation scheme is of dubious efficiency and administratively cumbersome, the result would be a plus for the small-scale strategy.

Finally, small-scale systems would not be highly dependent on the sophisticated engineering capacity of public institutions, which seem to be declining with the erosion of public sector real salary rates. Since the development of micro-systems would rely on less complex engineering skills, the level of public sector engineering sophistication would be less important than under an alternative strategy.

On-Farm Water Management

Whether the topography is relatively flat or steep has a major influence on the possibilities for water management. This is in addition to whether a basic watersource must be pumped or can be tapped by gravity flow. In Peru some assistance with water management technology transfer in both flat and steep situations has the potential to help farmers control their water resources better and increase production or alter cropping patterns in a beneficial way. Many Andean farmers are forced to irrigate on hillsides or live with the rainfed alternative. In some cases they resort to terracing and have devised elaborate schemes (mainly effective) to shift the runoff of irrigation water from terrace to terrace.

Steep topography (not involving terraces) may be mentioned first. Such situations include those where farmers already have access to some irrigation water as well as situations where irrigation will be a new experience. Sprinkle irrigation offers a promising technical solution as a means for achieving high application efficiency, minimizing erosion, increasing yields, and reducing the human toil of spreading the water on steep slopes. Sprinkle irrigation requires pressurized water supplies. This in turn requires piped distribution systems from outlets along canals constructed on high contours in order to command as much area as possible with the capital and physical resources availabile.

Projects on relatively flat lands suitable for ordinary surface methods are obviously easier to deal with. Of course, there is always some slope and men, women and children expend tremendous effort to lead the water around to where they want it to go. (This may explain why experienced farmers tend to be careless even when water is in short supply.) As Anderson has pointed out in his review of Plan MERIS projects, better land leveling would be the single most useful recommendation (2). In addition, improved water courses and field distribution channels would also improve water application efficiency. In general, Anderson's suggestions indicate the sort of on-farm water management interventions that would be appropriate for flatter areas. In certain situations another promising technique is surge flow irrigation utilizing small controlled water releases from gated pipe supply lines.

Engineering design experience with pipe sizing, pressure control, and optimum layout techniques for sprinkle and gated pipe surface irrigation is limited in Peru. It is also possible that some of the main channel engineering techniques commonly required in such situations may be lacking. In any case it can be said that irrigation projects on sites that exceed a maximum slope for open channel surface water management are going to require a great deal of training and technology transfer for both the technicians and farmers.

As mentioned in the recommendations and highlighted earlier, the small-scale projects given priority recommendation will involve a range of simple to complex water handling situations and Indian community members will require some help with on-farm water management. This will be especially true where they elect to irrigate steep terrain. For the present, however, it is probably not necessary to anticipate much desire for complex systems assuming the communities must pay for them.

Water Pricing

In the report of the Presidential Agricultural Mission the claim is made that "the most important single deterrunt to more rational use of water is the lack of incentive to do so" (9, p. 16). Presumably this refers to situations involving sheer carelessness or where "excess" quantities are being applied. However, if "incentives" are thought to lead or force learning or adoption of better techniques, then the statement might refer to cases of poor leveling or other field preparation or to incorrect head ditch placement, etc.

If we suppose irrigation water to be in short supply, it is logical to expect farmers to "stretch" it as far as possible (although application efficiencies may still be low due to poor techniques). Water tariffs may only make a tight situation worse. If the short supply is ulilized on high valued crops, farmers may switch techniques to get better application -- a tariff may not be necessary to push them across this decision hurdle.

Generally, therefore, statements relating tariffs to efficiency in water use must be taken to refer to situations of relative abundance. Such situations are not unknown in Peru. Even in such cases there is more than one way to discuss efficiency and tariffs may not lead to the straightforward result implied by the Agriculture Mission.

A less obvious concept is that water which is not consumed by plants or evaporation moves overland or via aquifer to downsteam locations where it may be reused by other farmers. In typical Peruvian situations, the "same" water may be used several times, the only reduction being for overall consumptive use. Therefore, pricing on-farm water use may have less aggregate effect on total river system efficiency than expected. In an extreme case all that would happen is that the water "not used" upstream would arrive at downstream locations more directly. (Depending on the flow hydrograph this may or may not be desirable.)

Some engineering/hydrologic information is usually necessary before pricing impacts upon use efficiency can be thought out. Another point that might get overlooked is the interrelationship between efficient on-farm water management and efficient main system management. Whether achievement can be simultaneous is dependent on the actual situation.

Whether tariffs will induce farmers to use more or less water on their fields and whether any "waste" is involved depends upon all kinds of factors in addition to the complexities already mentioned. Some of them are: how water fees are collected; whether water can be stolen; if the marginal value really exceeds the marginal costs of utilization, etc.

Finally, there are other reasons for collecting tariffs that may override any efficiency goals. These reasons include the need for O&M funds, to recoup the social cost of investment, or to generate resources for other purposes. Once these goals are overlaid upon notions about "incentives for better use," a complicated mix of ends and means is created. The right set of policy instructions (including tariffs) has to be designed in the light of the paramount objectives in each case.

Follow-on Research and Needed Data

It is unusual for "experts" to recommend any major investments without noting the need for special or additional planning information. Recommendations #3, 4 and 6 of this report, for example, suggest data gathering and analysis to some degree. A similar recommendation is found in Orden, et al., which emphasizes further information as far as longer-term policy planning for the agriculture sector is involved. A number of relevant irrigation studies are also proposed in the Phase II Mission support of Plan MERIS (2b).

While it is wise to be cautious about insufficient information, it is not efficient to recommend unnecessary data collection and analytic efforts. Many agriculturally oriented studies and reports already exist in Peru and knowledgeable persons possess important information. So it is possible that a good review of existing irrigation experience would be worthwhile and highly supportive of further Mission planning efforts. Such an exercise would expand and improve some of the documentation in the annex volume to this report. Here is one example of an apparent data conflict that needs to be resolved: Indications of leveled off food imports, reported leveling off or falling production and claims of reduced per capita consumption do not square with crop price trends, relatively little urban food price pressures (few apparent shortages) and clearly higher levels of rural consumption. This apparent inconsistency points directly to under-reporting of domestic production. It may be that more complete analysis will reveal that no inconsistency exists.

Pricing Policies and Macro-Economic Studies Related to Agriculture

The President's Mission on Agriculture to Peru is correct in stating that government policies are the most important constraints to improved agriculture sector performance. The necessary studies to support better policies have already been outlined by Orden, et al. (7): a) price analysis for certain aspects of the cotton industry, sugarcane and many specialty crops, and for livestock as well as various cash inputs; b) establish a desired effective protection framework; c) analysis of the marketing and transportation system; and d) design of a targeted food subsidy program. These suggestions are well thought out and require no elaboration from the WMS-II team.

Irrigation Sub-Sector Studies

Some specific follow-on studies have already been mentioned in the summary sections of this report.

For long run planning of coastal zone irrigation, the studies to obtain technical information about surface and underground hydrology require direction from qualified engineers and an organized system of monitoring, collection and modeling. Much of this can be put under the direction of the La Molina University. See Recommendations #3 and #4.

Recommendation #6 emphasizes conservation and wise development of the water resources of the high forest of the Eastern Andes. Again, the main need is for civil and agricultural engineering talent, assisted by soils and range/forest management experts.

The technical information of most use to achieve better irrigation in the valleys of the Sierra has recently been outlined by Anderson in consultation with USAID/Peru (10). Considerable emphasis is placed upon social science disciplines and engineering. The suggestions are focused on better operation of Plan MERIS projects, but may of them would have wide applicability to other small-scale irrigation projects:

1. Problems in main system management involve water scheduling, movement and canal losses due to seepage, weeds and phreatophytes.

2. On-farm water management as affected by soil conditions, farm water distribution, water quality, irrigation timing and return flows. Other studies are proposed to help to identify better varieties, input needs, including appropriate machinery.

3. Economic and social factors which affect farmers' production decisions are also recommended for study. Land tenure and relationships to government organizations, markets and off-farm employment are examples of factors that need to be better understood.

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