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WATER AS A RESOURCE FOR FOOD PRODUCTION

THE IMPORTANCE OF WATER IN FOOD PRODUCTION

1. The countries in the region have few agro-climatic zones which can produce satisfactory food crop yields without irrigation. Some sub-humid areas produce rainfed pastures, and other semi-arid areas produce fodder shrubs and trees, and therefore concentrate on livestock production. Although many countries in the region have adequate water resources to expand the areas under irrigation, some of them have expanded to reach their maximum profitability threshold.[1]

2. About 12 percent of the harvested land or 10 percent of the farmed land in the region is now under irrigation. In 1985, 15 million hectares were under irrigation in the region, compared with 9 million in 1965.[2] In 1996 the irrigated area in the region reached 18 million hectares, 20 percent more than in 1985.[3]

3. However, world prices for basic commodities[4] are continuing their long-term decline as a result of the use of modern agronomic techniques and high-yield varieties which respond to

[1] This does not mean that they are reaching their maximum irrigation potential, but that they are increasingly less able to convert that potential to obtain a good return on economic initiatives. Other countries, such as Brazil, still have a long way to go before they can exploit the full potential of profitable irrigation works.

[2] During this period the rate of growth of irrigated agriculture exceeded rainfed agriculture as part of a production intensification programme. This growth subsequently declined due to the higher costs of the new irrigation systems, because the engineering works encountered major physical difficulties, compounded by higher interest rates.

[3] FAO Production Yearbook, vol.52, 1998

[4] Such as wheat, rice and sugar.

fertilizers and pesticides used on sufficiently humid soils. Prices and yields of irrigated products are generally higher than rainfed crop products. Irrigation is profitable for fruit, vegetables and flowers, and enhances the results of technologies to increase yields. Food production on irrigated land in the region accounts for a substantial proportion of total agricultural output.[5]

4. Over the past 35 years, consumers in the region have benefited from the positive effects of irrigation on the production and productivity of food crops whose prices have fallen without a corresponding decline in producers' incomes. Poor consumers have benefited most because they spend a higher proportion of their income on food.

5. Irrigated agriculture is gradually becoming a production subsystem characterized by a specialized crop structure with little similarity to rainfed agriculture. The most profitable crops are grown on irrigated land, and crop concentration is being encouraged by market prices, and because farmers using irrigation can better exploit government incentives.

6. Most of the poor people in the region still live in rural areas. Irrigation water is the key to dependable local food production and to creating employment in the arid and semi-arid zones.[6] Prudent water conservation and its productive use are essential to combat poverty (see Annex I, Box 1).

THE REGION'S WATER RESOURCES AND THEIR USE IN AGRICULTURE

7. Although the Latin American and Caribbean region only represents 15 percent of the world's land mass, it accounts for 31 percent of the total water discharged into the oceans.[7] But the picture is less positive when one considers water availability by country and by region within each country.

8. The large watersheds are estimated to account for 84 percent of the total area of the region. The majority of the watersheds are tropical and discharge their water into the Atlantic which receives 89 percent of all the water flowing out of the region.[8] Only 11 percent of the region's water flows into the Pacific Ocean watersheds.[9]

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[5] In Mexico's case the figure is as high as 50 percent of total production, and it is estimated that in the medium term half of the annual increased output will come from irrigated land.

[6] ILO/PREALC Employment research (23), 1984, p.61

[7] FAO: State of Food and Agriculture, 1993.

[8] From the Amazon, Orinoco, and Rio de la Plata.

[9] The high mountain systems close to the ocean create desert conditions in large coastal areas of Chile, Peru and Mexico, where agriculture is only possible under irrigation.

9. Agriculture loses out in the competition for water between different sectors because it is less productive per unit of volume of water utilized. Farmers cannot therefore afford to pay the same prices for irrigation water as are charged for drinking water, or water used for mining, industry and energy. This competition takes different forms in different countries. To avert disputes between different sectors over water-use, laws and regulations are being revised and changes are being introduced into policies and the concerns of the relevant governmental institutions.

STRATEGIC GUIDELINES AND MODERN IRRIGATION PRINCIPLES

STRATEGIC GUIDELINES FOR A WATER POLICY

10. Irrigation policy has frequently focused on building infrastructure to capture and store water in reservoirs and dams, for later transport and delivery to the end users. With this policy approach the design of other relevant mechanisms are related to a secondary plane, together with an appreciation of the economic and environmental effects.

11. In many countries in the region the idea is now emerging that the delivery of irrigation water is an indispensable service to transform and modernize food production, to enhance the productivity and the competitiveness of crops with a high economic value in order to create employment and combat rural poverty.[10]

12. This change of focus affects everything that governments do in relation to the water supply, user participation in investing in and managing irrigation systems, the establishment of water administration bodies, the economic and social aspects of water demand, its rational use, regional planning and environmental conservation.

13. Water policy has a twofold character: institutional and instrumental. It is institutional in that everything of relevance to water has always had a marked institutional character.[11] Major institutional changes are taking place in different countries in the region, easing long-standing restrictions and facilitating the effects of market mechanisms.

14. The instrumental character of water derives from the need to ensure that it serves economic planning for different areas of production, regional land-use planning, and water and environmental conservation and protection. This means that water policy cannot be autonomous or independent, but must be designed and implemented to coordinate and harmonize multiple interests.

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[10] Emphasis is placed on the fact that this service should influence the behaviour of the users and that water supply should be adjusted both in tems of the demand and its efficient use.

[11] Water has been highly regulated, special legislation has been enacted for it, and regulations and administrative structures have had a much greater influence over water use much more than private enterprise or market forces.

15. In short, the countries in the region are taking a fresh approach to the concepts guiding economic, technological, water, environmental and social issues, using as their benchmark the fundamental principle that water must be used consistently with the legitimate interests of all users, who are under an obligation to look after it and conserve it in terms both of quality and quantity, and to use it as efficiently as possible.

THE LEGAL FRAMEWORK

16. In policy-making, the facts are based on ideas and concepts governing action by the public and the private sectors. Both must have a legal and administrative basis that makes it possible to fully implement water policy. When designing this legal basis and establishing the instruments required to ensure that it is known and implemented properly, three fundamental issues are considered.

17. Firstly, legal security must be granted to the persons vested with water rights.[12] Secondly, the water regulatory authority must be given a certain margin of flexibility to be able to adapt decisions to technological, economic and social changes taking place nationwide and appropriately protect private interests.[13] Thirdly, there must be information on water quantity and quality which must be understood by the population.[14]

18. As pressure increases on water resources and on public funds available for water, the legal and administrative systems are obliged to meet new demands. This process includes legal and institutional issues that will have to be tackled in virtually every country, and are set out in Annex 1, Box 2.

ROLE OF THE STATE AND INSTITUTIONAL ISSUES

19. For decades it was assumed that there was a direct relationship in the region between the implementation of large-scale public works and the greater prosperity of the national community, since large-scale public works were seen as the driving force behind economic and social development. Within this context, powerful arguments were used to justify the adoption and implementation by the State of ambitious and vigorous irrigation policies. Higher yields, the introduction of high-value crops, the need to reduce the harvest uncertainties due to climatic risk and its potential contribution to modernizing production have been the most common arguments to justify and legitimate irrigation investment policy.

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[12] This is an indispensable guarantee for productive activities to be implemented and for medium- and long-term investment.

[13] The way in which security and flexibility can be guaranteed and both of these often contradictory objectives can be pursued together will largely depend on ensuring that the legislation can be effectively enforced.

[14] This entails measurements being taken, analytical and interpretive studies being conducted, and people being duly educated in concepts and data.

20. By giving pride of place to transferring investment resources towards deprived areas, resources have been allocated on the implicit assumption that the beneficiaries would be entitled to use the infrastructure that had been built. These decisions prevented the possibility of setting the true economic value of the transferred resources, and this has led to the idea that water to be used for irrigation is a public asset of little value which can be squandered.

21. One of the measures adopted by the institutions responsible for modernizing the use of irrigation systems has been to cover the value of the water supplied by applying various systems of water rates and tariffs. When these are transferred to water users' associations, the question that arises is the recovery of management, operational and maintenance costs for the large structures or facilities, and the cost of the land-use management of the watersheds by charging tariffs proportional to the volumes of water supplied, measured at the point of delivery. This is a means of setting and collecting water charges that forms part of modern irrigation principles.

22. When addressing the fundamental relations that exist between each watershed and its water resources, many countries in the region have wisely instituted water authorities with jurisdiction limited by watersheds. They have acknowledged that work carried out in a watershed, such as deforesting its upper reaches, has direct repercussions on the water resources. These effects include changes in river flows during the year, which a higher flow than before in the rainy season and a lower flow than before in the dry period; the water tables are replenished more slowly, there is increased silting of reservoirs, lakes, lagoons and river banks and channels, and a greater risk of flooding; the water is more contaminated by solids, chemicals and organic matter from the eroded soil.

23. In some cases land ownership includes rights to water for irrigation or ownership rights over groundwater. But while there are many countries where government, technical experts and the private sector are seeking to link watershed land-use management to benefits accruing in terms of water quantity, quality and availability, this linkage has not yet been legally sanctioned. Some countries have determined that water prices should include the cost of the sustainable management of the upper part of the watersheds. A few isolated cases exist where charges are made for water coming from large national parks in the upper part of watershed. There are other cases of private corporations (hydroelectric companies) which financially support the forestation of the upper watershed, even though it is not their property, in order to reduce silting and extend the useful life of the reservoirs.

PRIVATE PARTICIPATION IN MANAGING IRRIGATION SYSTEMS

24. In recent years there has been a gradual change in the way irrigation systems are run and maintained in many countries in the region. The causes of this change include:

i) the abolition of programmes to attain food self-sufficiency in which irrigation projects were a major component of the agricultural development strategy;

ii) the persistent shortage of public funding for different irrigation systems. Some of them have had to manage with serious shortages of government funding for investment and operating costs, while others have been over-budgeted;

iii) the increase in the costs of marginal irrigation projects. In previous decades, various irrigation projects were implemented using the best water resources and the most

appropriate sites.[15] The new irrigation regime enjoys less public funding and uses less appropriate sites, requiring more complex civil engineering works and in many cases is designed to enhance the production potential of agricultural zones with a lower production potential;

iv) the *ex-post* analyses carried out by international lending institutions concluded that the irrigation projects implemented in the 1980s and earlier had failed to achieve satisfactory results because of the poor management of the systems, causing serious deterioration, inefficient operation and inappropriate agricultural use of irrigation water.

25. The pilot cases in which the water authorities involved water-users in the operation and maintenance of the systems were successful. Drawing on these successes, the officials of these authorities decided to adopt a new institutional approach and to implement a policy to transfer the management of irrigation and drainage systems to the users, organized in the forms of irrigation Boards or Associations.

26. They relied on the fact that this change would make it possible to make irrigation more efficient, that the land would be more intensively and profitably used, that the agricultural production potential would be better exploited, and that the cost to the public sector for operating and maintaining the irrigation channels would fall. It was found that when the users take responsibility for operating and maintaining the systems, there is generally a considerable increase in private sector interest in directly taking part in operating and maintaining the service they control. Gradually, such motivation not only acts as a powerful incentive to pay the water charges punctually, but it also encourages people to pay more for the water they use. It has been shown empirically that when systems are managed by the users themselves, they have more equitable access to irrigation water. But there are also cases in which users are unwilling to take charge of operating the systems, particularly when this is not financially sustainable. For this reason rules and regulations are always necessary to clearly allocate responsibilities.

27. In some countries in the region, the institutional and legal aspects of the irrigation associations as organizations of users responsible for managing irrigation systems have also been examined. This examination has been used as the basis for drafting proposals for regulations setting out guidelines and basic rules with which associations must comply when taking over full responsibility for administering, conserving, operating and maintaining irrigation systems. By promptly implementing regulations of this kind, the legal, institutional, managerial and administrative capacity of the irrigation associations will be greatly improved.

28. There are numerous examples of the way in which irrigated agriculture has had positive spin-offs in terms of profitability as a result of transferring irrigation systems to the users. Their associations have contracted-in skilled technical and administrative personnel who provide timely, efficient and effective services to the members, paid for from the revenues collected for the water, charged not only in terms of the volumes of water delivered but also the volumes of water discharged into the rivers, and also from local taxes levied on the proprietors and other taxes, according to circumstances. The State maintains the necessary degree of control over the regulatory and statutory issues, and monitors the professional experts to make sure that they comply with their contractual obligations.

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[15] ROURA, H. and CEPEDA, H. Manual de identificación, preparación y evaluación de proyectos de riego. Santiago, Chile, ILPES, 1997.

MODERN IRRIGATION PRINCIPLES

29. One of the innovations of recent years in the science and art of irrigation has been the introduction of localized irrigation systems using techniques relating to high-frequency low-volume applications of water (and nutrients) as a specific and appropriate way of responding to changes in crop requirements. The introduction of comparatively low-cost water application systems, installed permanently or on a seasonal basis and the perfecting of auxiliary self-regulating devices have eliminated some of the economic constraints that formerly hampered the widespread adoption of high frequency irrigation.[16]

30. On the other hand, there has been a proliferation of digital models, methods and techniques for the mathematical simulation and optimization of irrigation systems. The development of computerized systems is making it possible to successfully undertake these commitments. They improve the efficiency of irrigation systems and minimize the costs of the water required for crops.

31. Correctly applied, the new irrigation methods can raise yields while minimizing losses (due to run-off, evaporation and excessive seepage), reducing the need for drainage and promoting the incorporation of irrigation into simultaneous operations (for example fertilization, ploughing and pest control). The use of salt water has become more viable for certain crops and under certain soil conditions, as has the irrigation of coarse soils and sloping, sandy or stony soils which were previously considered to be totally unproductive.

32. Irrigation has a greater impact on the rainfed agriculture practised by small farmers, even where irrigation is only used on part of their small plots. It enables them to diversify production, produce marketable surpluses and reduce the risks and uncertainties that threaten their harvests. It has been shown that small-scale irrigation plays a major part in improving the food security of the small farmer population.

33. 'Irrigation culture' is the expression used to describe familiarity with the importance of water to life and production and its gradual declining per capita availability. It is on the basis of this culture that people can become committed to improving the effectiveness of water-use. When the users are trained and apply simple techniques (irrigation scheduling, furrow widths, seed bedding, contour furrowing, etc.), they can enhance the effectiveness of the irrigation water they apply. It has been shown that efficiency can rise from 30-40 percent to 60-70 percent, which is very difficult to exceed because when using these methods water is always 'lost' whenever irrigation is applied. The danger with interpreting water tariff and market factors to enhance water-use efficiency is that the training required to know how to achieve it may be neglected.

34. Another problem that is typical of surface irrigation methods is that they have to be applied by experienced personnel who often cannot easily be found in the rural areas, and they are methods that are generally only used during the daytime. This produces huge water losses if there are no water storage facilities at farm level or for a community of farms.

35. Most pressurized irrigation delivery and application methods are costly, but can be economically justified for crops with high commercial value. Under certain conditions, however,

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[16] WORLD FOOD SUMMIT, Rome, Italy, 13-17 November 1996. Technical background documents 6-11. 2(7) pp.37-46.

these methods are essential, as in the case of extremely fragile soils, or where there is a risk of salination, or the water is of poor quality, or on hillsides or for other reasons which make it necessary to have almost total water control. In these circumstances the use of irrigation can be justified more in terms of the sustainability of agricultural production than on account of the economic aspects involved.

36. Despite the great progress that has been made, in many irrigation areas largely inefficient methods are still being used. Modern technologies are being applied in only a small percentage of the irrigated area in the region. Barely 2.5 percent of the areas have micro-irrigation systems and only 10.8 percent use sprinkler systems. There are many places where over-watering perpetuates inefficiency, and is consequently uneconomical. But the inertia of the institutions and conservative attitudes are only part of the problem. Some of the new irrigation systems designed in the developed countries are highly mechanized, highly complex, use too much energy and are of such large dimensions that they cannot be used without adjustment in countries with little capital and low technology where labour costs are low and capital costs high.

37. Applying rainwater capture (sometimes called ‘harvesting’) methods focusing on run-off in small areas or storing the water in small reservoirs, ponds or tanks can considerably improve both yields and the stability of food production in semi-arid lands. International experience suggests that it is possible in these cases to increase the yields of rainfed crops threefold or even fourfold. The costs of harvesting rainwater vary, but it is estimated that it takes about 70 to 150 days’ work per hectare. The annual maintenance of stored water requires between 20 and 40 days’ work per hectare.

38. The increasing availability of cheap and reliable engines and pumps, with low lift capacity, coupled with increased fuel and electric power availability, have facilitated the implementation of irrigation more than other technological or administrative innovation. In many areas that are suitable for irrigation in the countries in the region, cheap gravity offtake projects cannot be implemented. Typical cases are the lands on the edges of large slightly sloping rivers. Many of these lands can now be irrigated using cheap pumping systems if the water only has to be lifted a few metres.

39. The extraction of water from shallow aquifers offers numerous advantages for small-scale irrigation: the water is easy to access thanks to the low installation costs, which encourages private investment, either individually or by small groups of farmers; it is not necessary to channel the water over large distances; nature is responsible for renewing, storing and delivering the water because there is little need to use other types of intervention; shallow aquifers are plentiful, even in semi-arid zones, mainly in the alluvial deposits in the valleys. Seasonal rainfall and flooding replenishes these aquifers, and this replenishment can be artificially increased by building small structures to help the water seep into the aquifers.

40. Surface water can be used in conjunction with groundwater to minimize undesirable physical, environmental and economic effects and maximize the balance between the water supply and demand. The main factors to be taken into consideration here are: the underground storage capacity and the possibility of absorbing large volumes of floodwater quickly, the production capacity of the aquifers, the possibility of recovering the water stored in wells with a high flow rate, the availability of excess surface water to replenish the aquifers, and the economic and environmental benefits from this option in comparison with the alternative of surface water storage.

41. To improve the sustainable, participatory and integrated management of renewal natural resources, three strategic elements must be borne in mind: the first is to strengthen the

institutional capacities to design, promote and implement public policies and the institutional procedures required to ensure the sustainable use of renewable natural resources (RNR); secondly, to guarantee the timely and appropriate transfer of RNR integrated management technologies; and lastly, to be in possession of the information, and the data and communications systems needed as the basis for effective RNR use planning.

42. In this latter case it is vitally important to have, and to apply, a sound public policy requiring the relevant institutions to take responsibility for generating data and information for later analysis of the state of the RNRs (national accounts). This examination must include a careful review of the monitoring system to which they are subject, to be used as the basis for the adoption of sustainable development policies.

43. When considering issues relating to sustainable development and information, particularly the sustainable management of the RNRs, it is not enough to have scattered, piecemeal and partial data and studies. It is essential to have integrated data systems on the geographical areas in which the resources are located.

44. It should be noted that traditional data-processing techniques do not provide a holistic view of the state of resources, neither do they make it possible to efficiently process and manage huge volumes of territorial information. These traditional techniques are therefore not a good basis for supporting efficient decision-making, and they are now being replaced by remote sensing (RS) and geographic information systems (GIS). These were developed over two decades ago but they have only recently been brought into general use both because of their lower costs and the increased processing capacity and output of computers, as well as a widespread professional familiarity with these subject areas. However, water quality and flow studies and data remain necessary, and in certain cases can be incorporated into localized territorial data bases, so that they can be used with other computerized mapping or GIS data.

45. When RS and GIS techniques are integrated, available information can be appropriately complemented and provide a holistic overview of all the problems, in terms of both time and space, incorporated into sustainable RNR management. These tools make it possible to generate territorial information systems integrated at the watershed level which can be exploited by multidisciplinary teams responsible for the country's land-use planning.

REDUCTION OF ENVIRONMENTAL IMPACT

46. As occurs in the developed countries, in the areas in the region practising intensive agriculture, fertilizers, pesticides and other agro-chemicals are major general pollutants of water. Most agriculture is not input-intensive but the poor watershed management encourages frequent flooding and the deterioration in quality of water due to the increase in its content of suspended solids and chemical elements and compounds from eroded soils. The suspended solids silt up reservoirs, rivers and canals and affect the mechanical equipment in the irrigation systems, increasing the need for de-silting facilities. at the same time, activities connected with forests, the growth of towns, mining and other human activities, are also interfering with the quality of the water used for food production. These consequences must be borne in mind when policies are designed, and when the institutions are overhauled and new legal provisions adopted.

47. Irrigation water can also become a vector for spreading bacteria and other disease-transmitting pathogens and is a habitat for parasites and other disease carriers. Malaria is the most serious of these diseases, both in terms of the number of people infected each year, whose quality of life and working capacity is impaired, and mortality rate. Now that the negative effects are

better known, measures can be adopted to remedy their causes. Combating disease transmitted by irrigation water includes four types of measures: i) controlling pathogens by immunization, prophylaxis or the use of curative drugs; ii) reducing the density of the carriers or their life-span; iii) preventing contact between humans and carriers or pathogens; and iv) protecting people and homes from mosquito attacks.

48. Inadequate irrigation methods raise the groundwater level which causes waterlogging and drowns the plants, or produces secondary salination in the arid or semi-arid zones. In arid zones under surface irrigation, the rising movement of water by capillary action and evaporation frequently exceeds the seepage of rainwater and irrigation. Both irrigation water and groundwater contain salts, and although they are present in only small quantities, they accumulate on the soil surface until it makes it difficult for the plants to absorb water, and can reach toxicity levels that reduce or prevent the productivity of the plants.

49. Rising groundwater levels can be reduced and controlled, and the resultant salination curbed with two types of measures: preventing over-replenishment of the aquifer and facilitating the evacuation of the ground-water. The first type of measures adjust water deliveries to crop requirements, plus the minimum requirements for leaching the salts, preventing losses through seepage in the fields, reducing losses in the canal system or changing the irrigation methods to pressurized irrigation systems, which are more efficient. The second type of measures include pumping wells to lower the groundwater level and installing drainage systems comprising ditches or pipes to be able to control the groundwater level and evacuate excess underground water.

50. The concentration of salt in the water gradually rises from the upper to the lower reaches of large rivers because of the concentration of salts caused by the reduction in water volume in the irrigated fields as a result of water consumption or evapotranspiration.

51. In areas where irrigation is controlled by the private sector and short term economic objectives take precedence, drainage is frequently neglected. To guarantee the sustainability of irrigated agriculture it is vitally important for the drainage system to function properly. Drainage costs must be included in the normal operating and maintenance costs of the irrigation system, which must cover the payment of drainage charges. It is obvious that farmers who replenish the aquifer are also liable for any damage caused by the rising groundwater level on their own fields or on other farms on the same aquifer. However very rarely are they held liable for any damage they cause.

RECOMMENDATIONS

52. Traditional irrigation policy is changing and moving towards other more desirable methods. This change of focus involves moving away from the narrow concept of irrigation policy towards another more global and complex multi-sectoral water policy, viewed not only as a series of actions by government relating to water delivery but which includes management by local participatory associations, taking into account the economic and social aspects of water demand, rational water use, land-use planning, and environmental conservation.

53. Water policy must have an administrative legal basis making it possible to be comprehensively applied, with effective procedures to ensure compliance with the law. When designing this legal basis and deciding on the instruments for it, account must be taken, firstly, of the fact that legal security must be given to water right-holders in order for them to make the necessary productive medium- and long-term investments. Secondly, the water management

authority must have margins of flexibility and the wherewithal to adjust its decisions to technical, economic and social changes without neglecting private interests.

54. The most rational proposal, which has proven successful in some countries, even though the structure varies, would seem to be to promote local watershed management organizations run by representatives of users in all sectors. It would have to be administratively and financially autonomous, based on tariffs calculated not so much on the volume of water delivered as the volume of water discharged into the rivers, with land taxes levied on proprietors and other parties, depending upon the circumstances. The implementational aspects of management, such as the water volume distributed, its timeliness and quality control, can be left to technical groups or companies supervised by representatives of the users and the Government, thereby protecting their interests and ensuring compliance with the law.

55. The design and implementation of water policy makes it necessary for government institutions to become modern, well-organized, competent and effective institutions. They must design and implement renewed institutional and administrative mechanisms and then ensure that these function properly. This reform process implies acceptance of the fact that it is no longer a matter of priority or essential to have institutions to promote engineering works, but it means that the time has come to provide appropriate technical services for water-users, to resolve disputes within and between sectors, to submit their activities to economic evaluation and appraisal, to ensure that irrigation water does not go to waste, to safeguard the environment, and to monitor the national water assets.

56. There are many positive examples of the profitability of irrigated agriculture once the irrigation systems have been transferred to users organized into associations. These have contracted skilled technical and administrative personnel to provide timely, efficient and effective services to their membership, paid for out of the revenues raised from collecting water tariffs and charges. The State continues to monitor the statutory issues as well as the performance of the professional experts.

57. Over the past few years a number of technical innovations have been introduced which provide better control over irrigation water, making irrigation more efficient and improving the management of the water status of the crops, substantially increasing the quantity and enhancing the quality of the harvested products. Properly applied, the new irrigation methods raise yields while reducing losses to the minimum, and reduce the need for drainage while promoting the incorporation of irrigation into other cropping activities such as fertilization and pest control. The use of salt water has become more viable as has the irrigation of coarse soils and sloping, sandy or stony soils which were previously considered to be totally non-productive.

58. Despite the considerable progress that has been made, in many irrigation areas there are still inefficient outmoded methods being used. It is estimated that modern technologies are used on only five percent of irrigated land in the region. There are many farms where the excessive, and consequently uneconomical, use of water is perpetuating inefficiency as a consequence of inertia on the part of the institutions and ingrained habits on the part of the users.

59. Extension services can no longer evade their responsibility to transfer suitable agricultural technologies for use on irrigated land. An appropriate demonstrative appraisal of the economic benefits of irrigated agriculture will make it possible to introduce the reforms that are needed in the extension services, enabling them to compete with other alternative uses of public funds.

60. Additionally, and considering that these services have not generally been geared to irrigated agriculture, a great effort will need to be made to provide training, focusing primarily on the professional personnel, and then on ensuring the effective and widespread transfer of know-how and skills to the farmers.

61. In many countries in the region there are numerous areas suited to rural aquaculture as a productive activity that helps improve the diet of poor farmers, generates direct and indirect employment and raises rural incomes. There are numerous examples of successful freshwater fish farming, with such species as carp and tilapia, which have been gradually increasing over the past few years, offering viable medium-term development potential. But there have also been many failures largely due to shortcomings in managing the production cycle or inappropriate entrepreneurial management. Recreational fishing in inland waters, linked to the development of tourism, is also becoming important in some countries.

62. Little attention is often paid to the negative effects of irrigation on the environment, such as soil degradation as a result of salinity and waterlogging. Irrigation water can also become a vehicle for spreading bacteria and other pathogens which transmit diseases, and is a habitat for parasites and disease carriers. Now that these negative effects are better known, appropriate measures can be taken to correct their causes.

ANNEXES

Box 1 - IRRIGATION AND CREATION OF EMPLOYMENT

One of the fundamental reasons for public irrigation investment is job creation, and hence combating poverty. But the quantitative values of the effects of new irrigation infrastructure in comparison with other public investments in employment-creation schemes are not well known. The box below, based on studies carried out by ILO into job creation in selected Latin American and Caribbean countries between 1975 and 1984, shows the actual results of employment creation as a consequence of public investment in various sectors, including new irrigation systems.

Job-creation per Unit of Investment – Public Sector

	Type			
	Permanent employment		Temporary	
Sector	direct	indirect		Total
Housing	0	0	219	219
Education	1 385	0	184	1 569
Health care	658	0	133	791
Roads	0	1 685	56	1 741
Irrigation	187	1851	108	2 146
Ports and airports	60	340	75	475
Water and sewerage	64	0	147	211
Electricity	39	139	55	233
Industry and tourism	221	399	71	691
Mining/oil	48	338	49	435

Source: ILO – PREALC

These figures are employment indices. The index for permanent employment was the number of jobs created in the tenth year following commencement of the operation. For the purposes of this evaluation, ten temporary annual jobs were considered to be equivalent to one permanent job; the temporary employment index was the average of the number of jobs created during the construction stage calculated on the equivalence with a permanent job. Taking these data to indicate the number of jobs created for the same amount of investment in each sector, the irrigation subsector created jobs at the lowest cost.

Even though some of the conditions have changed since the time these surveys were conducted, the background information clearly shows the effectiveness of irrigation works in rainfed agricultural or desert areas in terms of creating new jobs, provided that the projects are economically viable.

Box 2 –LEGAL AND INSTITUTIONAL FACTORS IN WATER MANAGEMENT

i) In order to encourage irrigation, rights must be guaranteed over a sufficient and stable volume of water of the right quality. Legal security makes it possible to resolve disputes using the legal procedures established specifically for the purpose. Legal security is also necessary in commercial situations other than disputes, such as when yielding or assigning private water rights or when water rights are offered a collateral for borrowing. Ownership of or rights in rem over water use must be set out in clear and unambiguous legal instruments to prevent disputes and promote market mechanisms which will improve the efficient water management.

ii) In many countries, legal practices and rules based on custom are important in resolving water-related legal issues. Traditional unofficial methods, particularly in the rural environment, are very important for conflict resolution, whereas the official resolution of disputes by filing suit in the courts is often risky, costly and alien to the local culture.

iii) The issue of licences must also be sufficiently flexible to prevent or to reduce to the minimum water-related conflicts. When water resources for which licences had previously been issued are redistributed to uses with greater value (when water is preferred for industrial rather than for agricultural use) legal procedures should be adopted that regulate or at least provide information on the way it is redistributed and compensation should be given to the licencees who are deprived of the water. It is important to ensure that water-use rights are transferable, particularly in the case of irrigation, in order to encourage investment in water-saving practices and to make it possible for the water thus saved to be put to other valuable uses. Transfer systems based on the market have evolved in some countries, but not in others. There is still a prevalence of transfers between different sectors under the direct control of the authorities.

Box 2 (cont'd)

iv) In order to reduce government powers over water, some countries have set up institutions and tribunals to make it possible for those powers to be transferred to the users. This involves regulating the legal system governing the ownership of irrigation facilities and the degree to which these facilities must be transferred to the users or remain in government hands, the conditions for their use and in many cases the rehabilitation and modernization of the systems in order to improve their efficiency. In many countries in the region, water management functions have been or are being transferred to users, irrigation organizations, mining companies, drinking water supply companies, energy producers, manufacturing companies and so on. There are however few cases in which representatives of the users of water for human consumption take part in this form of management, and there is also generally little intersectoral coordination between users, which is the main potential source of conflict. Local watershed management entities, run by representatives of the users from every sector (which means virtually all the people living on the watershed) would seem to be the most logical approach, even though various alternatives might exist in terms of the structure. Administrative autonomy detached from the central government, and financial autonomy based on charges for water use and for permits to discharge effluent, are essential factors in the successful cases that currently exist. The implementational aspects of management, such as multisectoral distribution in terms of quantity and timeliness, and water quality control, can be carried out by groups or technical firms supervised by the representatives of the users and the government, to look after their interests and ensure compliance with the law.

v) The regulation and implementation of compensation and restrictions on water-use rights imposed on users who damage other users, or the environment, landowners, buildings, natural vegetation, plantations, water bodies, etc., are at a very elementary level in the region. The most common damage is water contamination by industrial and mining effluent, municipal waste water and by agriculture, and the waterlogging and salination of lands as a result of over-irrigation replenishing the water tables, leading to losses in plant and livestock production, and damage to buildings. In many cases the usual ways of ensuring compliance with the water law in the countries in this region are proving ineffectual.

vi) Better land tenure systems and greater security of ownership rights will contribute to the efficient and sustainable use of irrigated land. In order to encourage the transition from traditional to more modern agriculture, legal mechanisms must be put in place to make it possible to replace customary rights with written title deeds, which are modern and marketable.

Box 3 –AGRICULTURAL AND FORESTRY PRODUCTION BASED ON RAINFALL

- Most of the area used for agricultural and forestry production in this region, as throughout the world, is based on the direct and natural supply of water to the land by rainfall. These productive activities are major sources of food of plant and animal origin. The semi-arid zones which only manage to maintain bush vegetation or dry woodlands are used for livestock production. The sub-humid and humid regions produce crops, grazing lands and humid forests which produce food products of animal and vegetable origin, as well as timber and fibre.

- The use of rainwater, and not irrigation water alone, also has a value and an economic return. Sound water and soil management is therefore very important in terms of production based on rainfall. The effect is not only improved land productivity, but also soil conservation, erosion prevention, water conservation, and the facilitated replenishment of water tables and conservation of plant cover and its biodiversity.

- Sound water and soil management for sustainable production under rainfed conditions includes conservation practices such as permanent ground cover (including retaining stubble), zero tillage, minimum tillage, which has a great influence on improving water and soil conservation, efficient water-use and improved seepage. These practices are being adopted by numerous farmers in Argentina and in southern Brazil, and to a lesser extent in other countries in the region.

- In areas with a low rainfall, rainwater capture, also known as harvesting, is based on simple techniques which concentrate the water falling in a given area on only a small part of the area in order to increase the volume of water the plants there receive. These techniques range from focusing on each plant individually, spacing them out more widely in places where the annual rainfall is lower, to other systems in which part of the land is set aside as a reservoir to be used for one single irrigation operation for a whole plantation in the dry season. Even though these techniques have been successfully tested in field trials in several countries, and despite their powerful effect on productivity and the economic spin-offs, even though they are mainly based on intensive labour, they are not yet sufficiently widespread and applied in the semi-arid zones in the region, mainly because they are unknown.

Box 4 – PROMOTION OF FISH CULTURE

- Inland fisheries play a major part in food production in the rural areas and in urban centres located near major river systems, as well as in places where reservoirs have been built for irrigation or electricity generation purposes.

- Rural fish farming requires the building of fish ponds, fry production, the use of by-products and agricultural waste to feed the fish, the use of chicken droppings to fertilize the water, and regular sampling to monitor the development of the fish and draw up harvesting timetables. Once the importance of small fisheries is recognized, strategies will have to be designed to encourage freshwater fish farming in the rural communities.

- To promote the sustainable growth of inland fisheries and aquaculture, an appropriate legal framework must be established and the institutions and fishery management mechanisms must be strengthened. Both sectors must be included in macro-economic policy planning, in drawing up rural development programmes and laying down guidelines for the management and protection of renewal resources; fisheries and aquaculture must be incorporated into watershed management, protection and usage plans; greater decision-making authority for fisheries management and plans for aquaculture development must be devolved to local government agencies and fishing communities; specific rights must be assigned to fisher organizations; marketing and post-harvest loss-reduction from fishery and fish farming products must be developed; the necessary infrastructure must be built for landing, packaging and distributing fish; and the orderly development of rural aquaculture for domestic consumption must be encouraged, and incentives provided to supply fish for local consumption and urban markets.