



Innovation and Water Management for Sustainable Development in Agriculture



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Inter-American Institute for Cooperation on Agriculture

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Mexico

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At the Meeting of Ministers of Agriculture of the Americas, held in Argentina in September 2013, integrated water resources management (IWRM) for agriculture was the main topic of discussion, under the slogan “Water to feed the land.” In the Ministerial Declaration, the ministers expressed their commitment to supporting IWRM in areas such as public policy renewal, institutional capacity-building and the promotion of investments in strategic aspects.

The Declaration was the culmination of a process that lasted several months and began when the government of Argentina offered to host this important meeting and proposed to the rest of the countries that the issue of water for agriculture be the central theme of the deliberations and commitments.

With support from the Inter-American Institute for Cooperation on Agriculture (IICA), a study was carried out in all of the Member States prior to the Ministerial Meeting, which allowed for identifying the status of water resource management and of water management in agriculture in particular. The document resulting from that study offered four recommendations: a) to boost the institutional strengthening of the Ministries of Agriculture; b) to promote comprehensive water management in order to achieve agricultural sustainability and face the challenges of climate change; c) to strengthen innovation in order to improve the productivity of water resources in agriculture; and d) to strengthen human resources training in the new paradigms for agriculture.

Argentinian authorities shared the document proposal with the other Member States in order to gather their observations and suggestions and, in turn, ensure that the document accurately depicted the reality of this issue in the Americas. The document was presented for analysis at the Meeting of the Executive Committee of IICA, held in Mexico City in June 2013. The comments and proposals made by participants

at the meeting were incorporated into the text, and an agreement was made to draft the Ministerial Declaration Argentina 2013 based on the recommendations of the technical document.

The draft of the Declaration was distributed among the countries prior to the meeting and was negotiated by ministerial delegates appointed specifically for this purpose, in order to produce a fitting text for IICA's 34 member countries.

The Declaration recognizes that IWRM is critical to achieving a sustainable, competitive, and inclusive agricultural sector, and that innovation will help the agricultural sector to address economic and environmental challenges, providing it with the tools to transform it into a catalyst for economic and social development.

In the Declaration, the ministers also urged IICA and other international organizations to spearhead, coordinate and support a technical cooperation program that promotes IWRM in agriculture and that necessarily includes the strengthening of capacities within the ministries of agriculture and other institutions in the sector.

This document, which acknowledges the observations made by the ministers and the contributions of the technical document on which the Declaration is based, seeks to highlight the ways in which IICA has been helping to drive productivity and sustainable profitability in agriculture as well as the development of rural areas in the member countries, through strategic actions with respect to innovation and water management.

IICA has provided contributions in two ways. Firstly, it has supported various experiences with technological innovation and the management of irrigated agriculture taking place in the different countries, which are set out in this document. Secondly, it has collaborated with several national and regional initiatives through the use of various cooperation instruments it possesses, also described herein.

Furthermore, the final section presents a proposal for a hemispheric cooperation agenda for IWRM in agriculture, which would allow the Institute to comply with the mandate of the ministers of agriculture of the Americas.

Dr. Víctor M. Villalobos Arámbula
Director General

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This institutional contribution has been made possible through the collaboration of IICA representatives from several member countries and of technicians in charge of cooperation projects that addressed various aspects related to water management. The contributions were abridged using a pre-defined format that, albeit brief, still makes it possible to appreciate the contributions that have been made. The document was also enhanced by the contributions made by others outside of IICA, who reported on their experiences with innovations in the field of water management in agriculture.

Based on all of the contributions received, the document was prepared by Dr. Carlos Pomareda, with the collaboration of Diego Montenegro, IICA's Director of Management and Regional Integration.

We would like to express our sincere gratitude to everyone who collaborated with this initiative of the Institute. We hope that it will be of interest to and useful for both national and local authorities, as well as for stakeholders involved in addressing the challenges related to achieving innovation and improving water management in agriculture.



Acronyms

ACA	Rice Growers Association (Uruguay)
LAC	Latin America and the Caribbean
ANA	National Water Authority (Peru)
ASADA	Association for the Administration of Community Water Supply and Sewerage Systems (Costa Rica)
ASOFAIL	Association of Smallholder Lenca Farming Families (Honduras)
ASOPROL	Healthy Organic Food Producers of Lepaterique (Honduras)
IDB	Inter-American Development Bank
IBRD	International Bank for Reconstruction and Development (World Bank)
CAC	Central American Agricultural Council
CATIE	Tropical Agriculture Research and Higher Education Center
CENTER	National Irrigation Technology Center (Spain)
Centro GEO	Centro de Investigación en Geografía y Geomática Ing. Jorge L. Tamayo A.C. (México)
ECLAC	Economic Commission for Latin America and the Caribbean
CHN	Corporación Hortícola Nacional (Costa Rica)
CIAT	International Center for Tropical Agriculture
COFUPRO	Confederación de Fundaciones PRODUCE (México)
COLPOS	Colegio de Postgraduados (México)
CONAGUA	Comisión Nacional del Agua (México)
CORFO	Corporación de Fomento de la Producción (Chile)
CORPOICA	Corporación Colombiana de Investigación Agropecuaria
SDC	Swiss Agency for Development and Cooperation
DRAT	Distrito de Riego Arenal Tempisque (Costa Rica)
ETN	Equipo técnico nacional en riego (países de Centroamérica)
FAO	United Nations Food and Agriculture Organization
FEDEARROZ	Federación Nacional de Arroceros (Colombia)
GEF	Global Environment Fund
GAD	Decentralized autonomous governments (Ecuador)
GIAAF	Proyecto de Gestión Integral del Agua en Agricultura Familiar
CMWR	Comprehensive management of water resources
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (Germany)

GWP	Global Water Partnership
ICA	Instituto de Cuencas Andinas
IDRHI	Instituto Dominicano de Recursos Hídricos
IICA	Inter-American Institute for Cooperation on Agriculture
IMTA	Instituto Mexicano de Tecnología del Agua
INDAP	Instituto de Desarrollo Agropecuario (Chile)
INIA	Instituto de Investigaciones Agropecuarias (Chile), Instituto Nacional de Investigación Agropecuaria (Uruguay)
INIFAP	Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (México)
INTA	Instituto Nacional de Innovación y Transferencia de Tecnología Agropecuaria (Costa Rica); National Agricultural Technology Institute (Argentina); Instituto Nicaragüense de Tecnología Agropecuaria
IPROGA	Instituto de Promoción del Agua (Perú)
ITCR	Costa Rica Institute of Technology
ITDG	Intermediate Technology Development Group (Peru)
IABA	Inter-American Board of Agriculture
MAG	Ministry of Agriculture and Livestock (several countries)
MAGA	Ministry of Agriculture and Livestock (Guatemala)
MAGFOR	Ministerio Agropecuario Forestal (Nicaragua)
MAGRAMA	Ministerio de Agricultura, Alimentación y Medio Ambiente (España)
MAGyP	Ministerio de Agricultura, Ganadería y Pesca de la Nación (Argentina)
MERCOSUR	Southern Common Market
MINAGRI	Ministerio de Agricultura y Riego (Perú)
NGO	Non-governmental organization
WACDEP	Water, Climate and Development Program (GWP Central America)
PLHINO	Plan Hidráulico del Noroeste (México)
PNRD	Plan Nacional de Riego y Drenaje (Honduras)
UNEP	United Nations Environment Program
PROMUDEL	Programa Municipios para el Desarrollo Local (Guatemala)
PROSAP	Programa de Servicios Agropecuarios Provinciales (Argentina)
SAGARPA	General Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food (Mexico)
SEAM	Secretariat of the Environment (Paraguay)
SENARA	National Groundwater, Irrigation and Drainage Service (Costa Rica)
SNIP	National Public Investment System (Peru)
EU	European Union
UNA	National Agrarian University (Nicaragua)
UNESCO	United Nations Educational, Scientific and Cultural Organization
UPANIC	Unión Nacional de Productores Nicaragüenses

1. Background





The pillars that support the cooperation offered by the Inter-American Institute for Cooperation on Agriculture (IICA) are defined in the Institute's 2010-2020 Strategic Plan and in its medium-term plans for the 2010-2014 and 2014-2018 periods. These two pillars sum up the focus of the Institute's work: to contribute to sustainable and inclusive agriculture that supports the countries' development.

- **Sowing innovation to harvest prosperity:** The concept of innovation in agriculture was defined by IICA's current administration, when it began its term in 2010, as the cornerstone that would guide the Institute's work in the Americas. In light of scientific and technological developments, ongoing changes in management methods, and globalization, it was considered imperative that farmers in Latin America and the Caribbean (LAC) boost innovation in order to make agriculture more competitive in a sustainable manner.
- **Water to feed the land:** For many years now under the current Administration, IICA has recognized the importance of water in agriculture, although technical cooperation work tended to focus on a limited number of countries. In 2013, IICA commissioned a study on behalf of all its Member States, which allowed for identifying needs with regard to the management of water resources and of water in agriculture in particular. As a result, the document "Water to Feed the Land" was produced; furthermore, at the meeting of the Inter-American Board of Agriculture (IABA) held in Buenos Aires, Argentina, in September 2013, IICA received the mandate of incorporating the topic as a cornerstone for its other areas of interest.

In 2014, two changes took place that bolstered the Institute's strategy. On the one hand, the *flagship projects* were created as a way of articulating twelve topics or components that reflect the main interests of the countries. On the other hand, in September the internal document *Plan de Acción para el Fomento de la Agricultura Bajo Riego en América Latina y el Caribe* (Plan of Action to Promote Irrigated Agriculture in Latin America and the Caribbean) was produced. This document indicates how the issue of water resources, and water usage in particular, is relevant to all twelve components of the flagship projects.

The document *Water to feed the land*, the *flagship projects* and the aforementioned plan of action all highlight the requests of the countries in areas such as innovation in water management; the skills required in the ministries of agriculture and special units; the local, integrated management of water resources; policies and strategic public investment; and the training of human resources.

2. Conceptual Framework





The purpose of this chapter is to summarize the conceptual foundations that have given rise to the increasing importance of the topic of integrated water management (IWRM) in agriculture in national strategies and required policies. It is an introduction to a public policy framework for water in agriculture that goes well beyond simply addressing aspects related to technology or the responsibilities of institutions within the agricultural sector. Both aspects are of vital importance since *water is the quintessential shared resource*, and how this resource is used in agriculture is deeply linked to all human activity.

The aspects addressed in this chapter serve as a frame of reference for the accounts included in the following two sections, which document the experiences of the countries and IICA's contributions.

2.1 IWRM and water management in agriculture

Water resources include water and the means through which it flows and is stored: glaciers, hillsides, ponds and lakes, springs, rivers and streams, aquifers and man-made structures such as dams, wells, canals and drains.

Water resources management refers to the set of practices that people and private enterprises undertake on properties that they own or rent, and those carried out by public entities, including user organizations and state entities, for the proper management and operation of water resources. Naturally, water management includes all actions that allow for rational use of water, saving water, and preserving its quality.

Managing water resources is, therefore, a two-tiered responsibility: one that is collective, in that it refers to water that runs through public spaces, and the other private, covering water management on private properties or estates. The first type of responsibility focuses on the protection of hill-sides and slopes on public land, agreements on water distribution among various users, and institutional mechanisms for joint action, such as watershed councils and user boards. The second type of responsibility, on a farm level in agriculture, livestock, agribusiness, and other activities, focuses on the proper use of water in order to save as much as possible and lower costs, avoid waste and prevent the pollution of water with agrochemicals or waste matter from agricultural activities, mining, and industries. At this level, the responsibility is even greater, since adequate water management on private properties is what allows water as a common good to preserve its quality and producers to obtain greater benefits and mitigate the damages associated with the instability of climate change.

The synergy between the two dimensions is therefore evident, and it becomes clear that, in order to achieve this synergy, an institutional framework over and above the entities associated with the use of water in agriculture is required. The next chapter presents various innovations for water management in agriculture, and, in some cases, references are made to the institutional aspects that played a role in the cases analyzed.

2.2 Diversity of situations

Although the importance of good water management is relevant to agriculture in general, a wide variety of situations must be taken into account, mainly due to the nature of ecosystems, water availability, the existence of damming and piping infrastructure, conditions on farms, the economic capacity of farmers, and their attitude toward safeguarding water and its alternative uses on farms.

Ecosystems are immensely varied and demonstrate extreme situations. On the one hand, some ecosystems include high precipitation and run-offs, while on the other hand, there are ecosystems in which, due to low or seasonal rainfall, are dependent on irrigation as the only means of production, thus requiring the extraction of water from aquifers. In both cases, problems can arise as a result of floods, especially when drainage systems are deficient.

The availability of damming and piping infrastructure for public water determines the viability of using water for irrigation. If this infrastructure does not exist, there are only two alternatives: harvesting water on farms, when there is sufficient rainfall, or extracting groundwater.

Farm conditions also vary significantly in terms of size, slopes, soil conditions, etc., which are determining factors for technological options regarding possible irrigation systems.

The level of knowledge producers have of water management, as well as their financial status, also determines which technology may be used for irrigation, drainage, and proper water management on their properties.

Finally, the alternative uses of water on farms are manifold, as are their requirements throughout the crop cycle and in terms of water availability and quality. In addition to the demands of alternative farming and stock-breeding, water for human use also has specific requirements, most importantly, access to clean water.

Bearing in mind this diversity, the present document sets out cases that illustrate why a knowledge of technological and management alternatives is so important, and their best possible use in different circumstances.

2.3 Best use of irrigation and drainage to mitigate climate variability

This aspect is becoming increasingly important due to climate trends, climate instability, the increasing demand for water, and the decreasing water supply.

With respect to climatic trends, some noteworthy aspects include, on the one hand, higher temperatures leading to increased snow melt and evapotranspiration, and, on the other hand, low temperatures and the risk of frosts. In these cases, adapting agriculture through various means, including the development of different varieties and technology, must be undertaken gradually but without delay, and based on the conditions and characteristics of each geographical area.

Climate instability, on the other hand, is reflected in various ways, including longer dry seasons, more frequent high-intensity winds, unexpected and abundant rainfall, etc., resulting in reduced or inexistent flowering, lower yields, greater incidence of pests and diseases, higher costs and, in some cases, the inability to harvest. These situations require solutions: most notably, irrigation and proper drainage.

Changes in the demand for water and its reduced availability place agriculture in a position of increased competition in relation to other economic activities and the requirements for human consumption. This implies a double challenge: to use water more efficiently and to preserve its quality.

Throughout the document, but particularly in chapter 3, which outlines the interesting innovation taking place in the countries, and chapter 4, which describes IICA's experiences in providing support for the countries, irrigation and proper drainage are shown to be highly significant for adapting agriculture to climate change and mitigating the impact of climate instability. It should be pointed out that climate instability alters both the water requirements of plants and water availability.

2.4 Irrigation in family agriculture

The greatest benefit of using irrigation is in increasing the productivity of all the factors involved in production, particularly the land and workforce. This topic is particularly relevant to small-scale family agriculture, which usually depends only on seasonal rainfall once a year, resulting in significant underutilization of the remaining resources.

In many cases, the use of irrigation makes it possible to sow and reap all year round. There is ample evidence that proper and responsible water management on small-scale farms, through the use of a variety of technological options for collecting and storing water, generates greater income and reduces the negative impacts of climate instability. In the case of smaller-scale agriculture, modernized irrigation increases—in relative terms, compared to larger farms—the productivity of the land and workforce. Irrigation technology is not only limited to modern drip irrigation, but also includes ancestral technological practices that have been in use for a long time, and which also protect the soil, such as lagoons and terraces in the Andean Region.

The availability of technology for water usage on small-scale farms is extensive. A very good overview of the options available for small-scale agriculture can be found in the work of FAO and the Global Water Partnership (2013). The document emphasizes, firstly, that other aspects besides technology must be considered, including the capacities of the producers and their families. Reference is made to managing natural springs, harvesting water, different irrigation systems, etc. ITDG (2013) also offers a good description of the options available and provides training material and technical assistance. Very useful material is available in several national research and technical assistance institutions in Latin America, such as the Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA), the National Institute for Research on Forestry, Farming and Fisheries (INIFAP), both in Mexico, and the Institute for Agricultural Development (INDAP) in Chile.

Alongside irrigation, there are two additional aspects in which innovation has been critical for good water usage: a) for collecting and storing water to prevent run-offs from going to waste; and b) land drainage, which prevents excess water from accumulating and damaging crops and soils.

Naturally, achieving greater productivity through the use of water involves making investments with the expectation that the income obtained will be higher and sufficient to cover the repayment of these investments and the operating costs. Hence, researching and promoting the use of low-cost technology for good water usage in family agriculture are key aspects that should be addressed by State policies.

The level of investment depends on technological considerations for each crop or activity in which water will be used, as well as on water availability. Based on the foregoing, private investments for better use of limited water should focus on aspects that make a greater impact on productivity and profitability. This investment may be in different areas and of varying dimensions, including farmland management (for example, land leveling, drainage, etc.), infrastructure, equipment and materials. The range of technological options available is dependent on the viability of the category in question and the degree of maturity of the period in which returns are obtained. The highest investments are particularly justifiable in the case of fruit trees and vegetables.

In the process of analyzing the different technological options, it is important to clarify which technology is best suited to each ecosystem, crop, scale of operation and economic conditions of the producers. Additionally, when considering the use of mechanized irrigation for perishable products such as vegetables, which often entails considerable investments, it is important to assess market risks and risk aversion among producers with the greatest limitations. In other words, although irrigation helps to diminish production risks, it does not eliminate other risks.

2.5 Water footprint

Water footprint is a concept that enables the measurement of how much water is used to produce certain goods or a specific service. It is also used to measure per capita water usage, in the case of urban populations. In the context of agriculture and livestock, water footprints should be measured throughout the different stages of the production chain until the end product is attained. Water footprint certification, as in the case of carbon footprint, is becoming an increasingly important element for differentiating products within different markets.

Green and blue water footprints distinguish the origin of water. The first is the quantity of water used by vegetation, which comes from rain and does not turn into runoff; in other words, it is rainwater that it is stored in the upper strata of the soil and is taken advantage of by the roots of plants. The blue water footprint is water collected by superficial sources or extracted from underground sources, which is used in irrigation to supplement rainwater deficits or a complete lack of rainfall.

Most of the bibliography available on water footprints in agriculture only reports the total values of water footprint and, as observed in Table 1, there is a very broad range of data for the different products obtained from several crops and animals. This information does not distinguish between technologies, ecosystems, and chain segments and, as a result, caution must be exercised in analyzing this data.

When the water footprint is measured in liters of water/kilocalories and liters of water/grams of protein, the figures vary based on each product's contribution to those components. Fruits apparently require a lot of water per protein unit, but that is due to the fact that the protein content of fruits per weight unit is low.

Table 1. Water footprint for different crops

Product	Liters of water/ kilogram of product	Liters of water/ K-calories	Liters of water/ gram of protein
Sugar	197	0.69	0
Vegetables	322	1.34	26
Fruits	962	2.09	180
Milk	1020	1.82	31
Eggs	3265	2.29	29
Chicken	4325	3.00	34
Beef	15 415	10.19	112

Source: IICA 2013b.

Although the data in Table 1 is meant to be used as a reference, it is important to acknowledge some limitations. For example, the high estimates for meat are due to the use of information on the production and fattening systems in Europe, Canada, and the United States. The estimates also include the required consumption for the production of grains used to feed livestock, which is not a common practice in Latin America.

In other studies, analyses are undertaken at the country level, and in this case, the aforementioned figures must be used cautiously. For example, citing that Yemen, Botswana, Somalia and Ethiopia have the lowest water footprints, as if this were a merit, shows ignorance of the severe lack of water in those countries. This is no water consumption problem, but rather an availability problem. Furthermore, the method used shows that tropical countries and countries in which evapotranspiration is high tend to have larger agricultural water footprints, even though this is not a reflection of poor water usage in agriculture.

Given that the issue is gaining importance on the global agenda, research carried out should be more detailed and better reflect the reality of LAC countries in order to support arguments on which to base national and international policy measures for reducing water footprints. Colombia has made progress in this regard (Quintero *et al.* 2013), by using categories to differentiate the various production systems.

2.6 Individual and collective responsibility

Water management and usage, regardless of farm size, are the responsibility of farmers. These responsibilities include managing infrastructure for irrigation, building infrastructure for collecting and storing rainwater, the proper use of different technologies, managing water surplus, and complying with standards on the use of aquifers. Personal and corporate responsibility should be a matter of principle in water management. These observations on personal and corporate responsibility are of the utmost importance, and should be fostered by the State. Unfortunately, in many cases, the State fails in its attempt to foster capacity-building to help producers take on this responsibility: in its eagerness to encourage the use of irrigation in small-scale farming, it gives away equipment that is used poorly and does not last because it is not handled properly. Evidently, the best option is to provide producers with more training and support to handle successful, environmentally-responsible projects in which water is a decisive factor.

Collective responsibility is of extreme and growing importance to the good management of water resources and of water in particular. This collective responsibility refers to that which organized producers take on in order to ensure the availability of water from different sources (basins, channels, aquifers), follow common standards for managing water and preserving/improving its quality, and build and maintain the infrastructure for protecting basins and irrigating and draining water for collective use.

Tree planting, the protection of soil coverage on public land and farmlands, the proper design of road systems, and the proper use of agrochemicals and other environmentally-harmful substances, are determining factors for water conservation, and can be considered a collective responsibility.

The improvement and conservation of the quality of soils and forests on slopes where water runs through, have been some of the greatest concerns in water management for subsequent human use in agriculture and other activities. However, despite the insistence of local and global organizations, the results of watershed management are inadequate. This is an immense undertaking, since water conservation and its availability in sufficient quantity and quality is dependent on its adequate management.

As is shown by the examples in the following chapter, there are multiple ways in which joint action adds value to water management in agriculture.

2.7 Multiplier effects on rural economies

Although not many references are made in the literature to the contribution of irrigation, especially mechanized irrigation, to generating multiplier effects on rural economies, there is sufficient evidence to show that the production of fruits and vegetables using mechanized irrigation increases the demand for labor, which creates greater job opportunities. Furthermore, in areas of influence, businesses offering supplies, equipment, services for equipment maintenance, etc., employ young people; these types of businesses usually offer young people higher incomes than farmland work. Thus, the use of irrigation creates multiplier effects and adds value to rural economies, which is one of the best ways to contribute to local development.

Other indirect benefits for rural economies, achieved by means of joint action and the commitment of people and companies to their territories, are the protection of slopes and tree planting, which result in green areas, less landslides, and runoffs that are better controlled. This, on the one hand, creates opportunities for tourism and, on the other hand, reduces the expenses incurred by local governments in repairing damages.

2.8 Availability of equipment and services

Innovation in agriculture to incorporate and make good use of water requires strong ties between producers and their immediate environment, and in particular, with suppliers of technology. Technology comes in the form of knowledge but also of materials, seeds, equipment and services. Without it, innovation in irrigated agriculture is not very feasible.

In recent years, significant progress has been made in developing more energy-efficient equipment, more manageable and efficient conductive hoses, lighter and more durable coverage for reservoirs, pipes to replace open channels that are covered or uncovered in order to eliminate

infiltration and evaporation, nozzle systems in more durable hoses, etc. And with respect to drainage, markets offer a broad variety of pipes of varying diameters, groove types and filters for pipes made of different materials that adapt to a variety of soil types.

In addition to the wide range of equipment available, a service sector has been developed for irrigation maintenance and management systems, which are accessible to producers in towns close to their properties. These services include those directly related to the production of each crop (more intensive) and those which are specific to irrigation management. The latter include the maintenance of pumps and other equipment, water laboratories, etc.

It is clear, then, that innovation in agriculture and in water management in particular, requires the active participation of the private sector that offers the services described herein.

2.9 Training of human resources

Innovation is achieved when the human resources involved in different tasks take them on with diligence, responsibility, and based on their understanding and capacity. This includes people in different positions such as professionals teaching at universities and high schools, technicians who conduct research and provide technical assistance, professionals selling equipment and services, entrepreneurs and farmers of every scale, and farm employees who must handle a variety of equipment and tools. The training requirements for capacity-building vary for each of the stakeholders described above; but in all cases, these qualified resources are necessary for the development of irrigated agriculture. As a result, it is the State's fundamental responsibility to contribute to the development of those capacities; doing so will prove to be one of the public investments with the greatest and most lasting impact.

2.10 Infrastructure for collecting and transporting water

From a conceptual and strategic point of view, it is useful to refer to the changes in perspectives on infrastructure for collecting, storing and transporting water.

Large water dams for generating electricity and water for irrigation have, since the 1950s, represented one of the greatest contributions to development in Latin America. They made it possible to irrigate several million hectares, broaden the networks of electric services, and, in some countries, generate electric power that partially mitigated the use of oil for this purpose. In several cases, the large dams also helped to ensure that water was treated and distributed by drinking water systems. In other, though fewer, cases, they also made recreation possible and increased the value of properties in the surrounding areas.

These large works were questioned for various reasons, for example due to the fact that: i) the beneficiaries were the largest producers and those who were already landowners; ii) the logic that prevailed was to take water from the damming areas to flat areas, leaving many communities and agricultural areas without access to the water that was collected; iii) the works were funded exclusively by public spending and large foreign debts; iv) they were built on areas inhabited by poor communities that were evicted and received very little compensation for their land and belongings; and v) the works were not accompanied by pricing policies that would allow for recovering public investment in proportion to the way in which the water benefits were distributed, with some exceptions.

In recent years there has been a significant change in regard to infrastructure for dams and long-distance canals. In view of the limitations of the aforementioned model, there is now growing interest in small infrastructure projects for dams and for supplying water to neighboring areas. Additionally, tubing systems for facilitating the flow of water without having to depend on gravity have contributed to improving the efficiency of water conveyance.

These two changes, as will be illustrated further on, not only present new ways of democratizing water use, but also encourage reflection on the necessary forms of public investment and on the participation of the local communities that are direct beneficiaries.

2.11 Institutional framework for water resources management

In recent years, changes in laws on water resources have included sensitive topics such as rights of use, sanctions against pollution, user fees,

etc., which have been accompanied by the creation of national water authorities and local entities in charge of IWRM, both of which hold greater responsibilities than sectoral entities.

Without minimizing the importance of sectoral public entities and organizations of agricultural producers in the management of water resources and water in that sector in particular, it is important to highlight the fact that they are subordinate to the higher bodies mentioned above, which possess comprehensive responsibilities. This subordination is required due to the fact that laws explicitly state that water is the most shared of all resources.

The creation of these entities, which are considered absolutely necessary, has met with resistance from those who have managed water as a personal resource and have used it with no consideration for waste or the deterioration of its quality. These habits are common among many people and companies in all areas of society and production sectors, including cities, agriculture, mining, industry, etc. The challenge of complying with updated rules is a huge responsibility that also concerns people working in agriculture.

2.12 Renewal of financial mechanisms

The State's responsibilities with regard to promoting the proper management of water resources and of water in particular are very diverse and constantly expanding. These responsibilities include setting standards and ensuring compliance with them, establishing the means for conflict resolution, educating users, building infrastructure, researching and providing information, among many others. These responsibilities are justified in light of the great need for society, including farmers, to have access to sufficient and quality water in a timely fashion in order to serve its different needs, and to use it properly.

The resources needed to fund the aforementioned actions must be obtained through innovative means supported by society. This entails moving beyond user fees and traditional assignments in the regular budgets of central and local governments. Continued dependency on these two sources only would require both to increase significantly in order to generate the required amount of resources.

Based on the above, defining and implementing measures for adequately obtaining the resources the State requires for good water management, is an urgent task. Experiences in Europe and some of the countries of Latin America provide certain aspects to consider and also allow for assessing mechanisms for allocating resources between different alternatives and managing them properly.

2.13 Conclusions

This chapter has briefly presented the diversity of situations related to the management of water resources and of water in agriculture in particular.

It is clear that innovation is widely justifiable, and that it is needed not only at the farm level, but also in terms of the collection and conveyance of water for its distribution among various users who require it in different quantities.

It is also evident that the role of the State in infrastructure projects must be reconsidered in order to democratize the benefits of water and, especially, so that they may reach rural communities where rainfalls and runoffs originate.

Giving more attention to obtaining a higher return on investment is a priority, in order to boost the capacity of human resources at all levels, since the change that is needed depends on them to a great extent.

The importance of fostering collective responsibility through the watershed user organizations is clear.

Complying with standards that are greater in scope than sectoral or partial standards is essential, in order to contribute to valuing water as a shared resource.

Equally important is the need for innovation in funding mechanisms for acquiring more resources, and in instruments for effective management so as to enable the State to fully carry out its growing responsibilities in this area.

Although all of these aspects are important, not all of them can be illustrated in each of the case studies in the following chapters. Each case illustrates one or more of these aspects, demonstrating their relevance in the important mission of managing water adequately for the development of agriculture.

3. Experiences in Innovation for Water Management in Agriculture





Experiences in Innovation for Water Management in Agriculture

3.1 Selected Cases

The aim of this chapter is to illustrate the progress made in the technological innovation, management and institutional aspects of water management in agriculture, and to highlight the fact that LAC has great potential for making good use of these capabilities. IICA highly values these experiences and thus underscores them in order to expand this knowledge both within and beyond the countries that have provided the lessons reported herein.

Prior to addressing the innovation experiences and specific cases, a brief reference to some general considerations was deemed worthwhile. The use of different technology depends on the area of production, agro-ecological conditions and scale (usually related to producers' capacities). In this regard, as discussed in previous sections, the alternatives for the best possible use of water in small-scale farming - the dominant scale in this hemisphere - are highlighted.

This chapter addresses the following aspects of innovation: i) innovation for more efficient use of water on farms via pressurized irrigation systems; ii) innovation for reducing energy consumption for water usage on farms; iii) progress made in water harvesting at the farm and community levels; iv) micro dams: a new investment trend for achieving greater democratization of the benefits of water collection; v) piping systems for canals to eliminate water losses. In all these cases continuous innovation is highlighted as a leading factor for more efficient use and better care of water quality.

Based on a geographical journey from North to South, a group of examples is presented and analyzed, illustrating the diversity of situations in which innovation in the proper use of water in agriculture has allowed for increased productivity and profitability, as well as improvements in soil quality and environmental conditions on farms of different sizes, working in very diverse areas, and among producers with varied levels of capitalization.

In each case under consideration this chapter illustrates the importance of synergy between different entities, which has allowed innovation to be successful. The value of the contribution of producer organizations is highlighted, as is that of companies providing equipment and services and those that market products, as well as the entities responsible for research and technical assistance, in addition to wholesale buyers, including supermarkets and exporters. It is therefore evident that innovation in irrigated agriculture requires much more than knowledge of water management for crop growing.

3.2 Corn Production using Fertigation in Mexico

The state of Sinaloa in Mexico has been renowned for many years as one of the states in which irrigated agriculture has had greater success. The Northwest Hydraulic Plan (PLHINO), developed over fifty years ago, allowed for the interconnection of several dams and sufficient water for farming one million hectares in eleven valleys in Sonora, Sinaloa and Nayarit. Since the sixties, Sinaloa has excelled in the production of irrigated vegetables (especially tomatoes, bell peppers and cucumbers, among others), much of which is harvested between November and May and exported to the United States market during those months. For some twenty years now, the irrigation technology has spread to other areas such as corn, and is currently a model of precision agriculture.

Corn is the most important crop in Mexico in terms of food, as well as from an industrial, political and social point of view. The annual average planted area is 8.4 million hectares, of which 85.5% is temporary (7.20 million hectares), while 1.20 million hectares of farmed land is irrigated (14.5% of the total). At the national level, the state of Sinaloa is the main producer of white corn, most of which is irrigated, with approximately 500,000 hectares yielding over 5 million tons per annum.

Sinaloa's agriculture has undergone a greater recurrence and severity of extreme weather events, putting its sustainability to the test. Such is the case of droughts, prompting restrictions to the normal supply of water for irrigation, decreasing arable land and restricting use per unit area. Gravity irrigation technology in corn crops means only 45% of the water applied on the land is taken advantage of; that is, for every 100 liters of water entering the plot of land, only 45 liters remain in the root zone; the rest is lost in drainage and deep percolation, dragging along mobile fertilizers and soil, which causes stress on the crops.

On the one hand, water shortages and, on the other hand, the poor efficiency of gravity irrigation have led to pressurized irrigation being used in a greater area of cornfields, and to several studies on the use of drip irrigation in corn as a way of saving water. In order to learn of the benefits of drip irrigation (*cintilla*) in corn in terms of efficiency, profitability and sustainability, supported by the IRRIMODEL system, a study was carried out on the grounds of the INIFAP's Experimental *Valle del Fuerte Field*.



Source: Depositphotos Inc. 2015.

Assistance irrigation was undertaken via the IRRIMODEL-2.0 program to determine appropriate timing, the net laminate irrigation requirement and run time. Irrigation was applied in 18 doses at decreasing intervals (22 to 5 days) and increasing amounts of net water depth from 0.22 to 2.80 cm of water for a total of 154 days; with a total volume of 5070m³. Application efficiency was 91% compared to conventional irrigation, which fluctuates around 45%. For comparative purposes, the following table shows costs and other indicators related to drip and gravity irrigation systems for corn. Equipment for individual or group use can be installed from an irrigation well.

Table 2. Costs, yields and water productivity for corn with two irrigation technologies in Sinaloa, Mexico (in Mexican pesos).

Cost Component	Drip Irrigation	Gravity Irrigation
Land preparation	2263	2833
Planting	10 255	10 346
Fertilization	5790	5114
Tillage	1275	1548
Irrigation	6184	1504
Phytosanitary control	950	350
Harvesting	2586	2235
Total cost	29 309	23 930
Yield (kg of corn/ha)	15 600	11 500
Water productivity (kg of corn/m ³)	2.60	1.74
Production cost per kilo (US\$ /kilo)	1.81	2.08
Irrigation efficiency (%)	91.00	45.00

Source: Sifuentes et al. 2013.

The information provided in this section shows that drip irrigation is an excellent alternative for the production of corn, a product in which many of the LAC countries are deficient. Drip irrigation has the advantage of lower production costs per kilo of corn, greater productivity per hectare and, more importantly, higher water productivity. The latter, coupled with more efficient irrigation, is extremely pertinent to areas

with water shortages. The aforementioned case also demonstrates the importance of research on specific aspects related to the proper supply of water, depending on the demand during the crop cycle.

3.3 Family Farming and Irrigated Vegetables in Honduras

Honduras is one of the poorest countries in LAC, and its economy relies heavily on agriculture. Its arable farming land is dominated by the production of corn and beans, with approximately 300,000 producers; coffee, which employs around 110,000 farmers; and banana and palm oil production, which is controlled by a handful of international corporations.

Honduras has traditionally been an importer of fresh vegetables, especially from Guatemala. In 2001 these imports represented USD 8.7 million. As a result of increased domestic production, in 2013 fresh vegetable imports only represented USD 500,000, and exports to El Salvador, which were previously very limited (and partly triangulated from Guatemala), now total USD 4.8 million.

The major change in the production of vegetables in Honduras has been achieved by way of alliances between small producer organizations, international cooperation (SDC-Swisscontact and MCA), the supermarket chain Walmart and the Zamorano Pan-American Agricultural School. Not all of these entities have participated in all the local initiatives.

One of the success stories is that of the Association of Smallholder Lenca Farming Families (ASOFAIL), comprised of 120 partners and farming 25 hectares of vegetables using mechanized irrigation. The table tomato is one of the most widely produced vegetables, from which seedling nurseries are developed to grow plants for up to 25 days; these are later transplanted on a staggered basis, taking 75 days on average to harvest. The total harvesting period extends to 120 days.

The technology used consists of sowing in planting beds, drip irrigation (with tape buried at 5 cm) and plastic protection. The latter reduces evaporation, in addition to allowing the plants to develop an adequate root system faster, thus promoting their growth and helping to control weeds. However, warnings have been made to the effect that poor

irrigation management is counterproductive because when it is too localized it inhibits root development. The limitations reported are linked to the handling of filters and water quality control, excessive water applications, inadequate use of fertilizers in irrigation and the mismanagement of waste plastics.

Production technology and crop management allow families working in this field to produce more than double the volume using furrow irrigation technology, and to generate more than five times the revenue from their corn and bean production, which is mainly for their own consumption. It also allows for the employment of family members and neighbors who choose to participate in this farming rather than migrate.

Honduras has also developed the macro-tunnel system. These are used to plant vegetables with small leaf growth. The experience of the Healthy Organic Food Producers of Lepaterique (ASOPROL) company in producing celery and parsley is a welcome example of vegetable production by very small-scale producers. The advantage of the tunnel system is that it allows for year-round production and offers protection, especially from the rain. It is recommended that the tunnels –measuring up to 16 meters long and 5 meters wide –be placed ten meters apart with adequate positioning for optimal internal wind circulation.

The investment is around US\$5 per square meter of tunnel and US\$3 per square meter of the irrigation system with an estimated duration of five to six years. This system is not recommended for areas with temperatures exceeding 24° C.

The system allows for up to 40% more output per unit area, and healthier products which fetch better prices. It has also been noted that the higher yield per unit area allows for greater labor efficiency. In addition, it permits easier programming of planting and harvesting for different products.

The cases mentioned are not exclusive to Honduras, since there have been similar experiences in other countries in Central America. The point is that it is a low-cost investment and affordable technology for small-scale farmers to produce high-yield crops and generate employment for the producers' families and neighboring communities.



Source: Depositphotos Inc. 2015.

These two cases also illustrate the fact that the synergy between the various entities supporting the farmers provides the opportunity for each of them to contribute in accordance with their mandate, experience and expectations. In these two cases, no reference to the participation of public entities has been found. The role of the State is thus to propagate these experiences and provide timely support in its areas of competence, for example, sanitary measures, funding and demanding transparency in contracts with trading companies.

3.4 Growing Sugarcane for Ethanol in the Peruvian Desert

According to the latest Agriculture Census in Peru (2012), this country has 2,292,772 agricultural units. Of this total area, 64% is located in the mountains, a region that includes the Andean valleys and Puna

highlands. The rest is on the coast, a region stretching from the Pacific Ocean to the foothills of the Western highlands, where the mountain begins.

On the coast of Peru, where it does not rain, water usage by means of irrigation in agriculture is an ancient practice, since this activity would not be possible without it. It is estimated that, on the coast, there are approximately 600,000 irrigated hectares in the valleys and another 200,000 hectares with irrigation from dams, which, in recent years, has given rise to modern agriculture in medium to large-scale farms in the coastal deserts with pressurized irrigation and fertigation, and water from irrigation. In contrast, the rest of the irrigated farming –most of the agricultural activity on the coast and all of that in the mountains –is still in smallholdings.

Promoting irrigated agriculture has constituted an important part of this sector's policy. Prialé (2013) estimates that, between 2009 and 2012, annual investment directly related to irrigation ranged from USD 500 to USD 700 million. The policy of promoting irrigation over the past five years has focused on decentralizing investments in small-scale infrastructure, now implemented mainly by regional and local governments, taking advantage, in several of these cases, of the mining law and land concessions in desert areas on the coast. In the latter case, agriculture is in the hands of companies who grow sugarcane on a large scale, dominate the ethanol industry and provide opportunities for medium-sized businesses and, in some cases, smallholder farmers. Others grow asparagus, *piquillo* peppers and grapes, also in the desert.

Law 994, enacted in March 2008, promotes private investment in irrigation projects for expanding the agricultural frontier. It stipulates that unproductive state-owned land is to be handed over to individuals for irrigation works. On the other hand, the legal framework established that, at the national level: By 1 January 2009, it would be mandatory to sell biodiesel-diesel 2% blends (B2 Diesel); by 2010 it would be mandatory to sell gasoline with fuel alcohol 7.8% blends (Gasohol) nationwide and, by 1 January, 2011, it would be mandatory to sell biodiesel with diesel 5% blends (B5 Diesel) nationwide.

This legislation regarding private investment in land and biofuels boosted the production of sugarcane for ethanol in the Peruvian desert. In

the Piura region on the northern coast of Peru there are currently three business groups dedicated to sugarcane plantations and the ethanol industry: the Miraflores Group Corporation with 12,000 hectares and a target of 20,000 hectares of the 26,000 total at the *La Golondrina* estate; *Caña Brava* of the Romero Group sows 6,670 hectares, aiming for a total of 8,000 hectares; and the *Proyecto Maple Etanol* has 12,000 hectares. In all three cases the respective plants have been built to produce ethanol.

The areas where the sugarcane is planted are on both banks of the Chira River. Most of the areas sown with sugarcane for ethanol use drip irrigation, and the investment in these plantations, including the irrigation system, is around USD 6,000 per hectare. The underground irrigation systems used in sugarcane cultivation consume 60% less water per hectare, compared to gravity irrigation. Average productivity is 140 t/ha, largely due to the conditions of temperatures between 19 and 30 degrees Celsius; the differences in temperature between day and night (up to 12 degrees); low rainfall (120-140 mm per year) and strong sunlight in the region of Piura.



Source: Depositphotos Inc. 2015.

The participation of small-scale farmers in these consortia is, for the time being, very limited. For example, in the case of *Caña Brava*, the crops planted by small-scale producers represent around 3% of the total. The business model implemented by *Caña Brava* is geared toward meeting commercial needs, generating profitability and including smallholder producers from neighboring communities as sugarcane suppliers. This model's corporate responsibility efforts are common among large sugar mills in Guatemala and Costa Rica, for stocking up on the primary product.

In this case, the company buys up the entire production of sugarcane obtained within the crop area corresponding to the first five harvests, on average 140 t/ha; the contract is entered into for a period of five years, and may be extended by agreement of the parties; the purchase price is variable depending on the international market price of ethanol; it is agreed upon 15 days before the harvest, and is paid weekly. The company provides free technical advice and technical information for crop management and the smallholder farmers must meet the technical specifications or instructions issued by the company. The company sells sugarcane seeds and biological control insects at cost prices and small farmers pay the cost at the end of the first harvest.

According to the production costs, estimated yield, purchase price and financial costs estimated by Agro Banco, in coordination with *Caña Brava*, the direct revenue generated by the production of cane per hectare is the following: USD 375 in the first year; USD 1,143 in the second; USD 1,886 in the third; USD 1,765 in the fourth; and USD 1,544 in the fifth year; with a total estimated income, in five years, of USD 6,713. It is recommended that the crop be cut and replanted at the end of the fifth harvest. This income, compared to that reported from renting the land, can range from USD 441 to USD 588, when rented for the whole year. The revenue per hectare totals USD 2,206 in five years.

This case highlights a particular aspect in relation to the influence of non-sectoral legislation –such as that mentioned above concerning fuel and land concessions –in encouraging innovation and investment in large-scale irrigated agriculture. It also illustrates the challenge of large-scale innovations in sharing the model with small and medium-scale farmers. Once again, this case highlights the importance of the State's responsibility in promoting environmentally sustainable and socially responsible innovation.

3.5 Innovations in Fruit Crop Irrigation in Chile

Of the total area under cultivation in Chile, 1.10 million hectares are irrigated and, in recent years, this area has increased in terms of the use of intensive management systems, to the point that 28% of the irrigated land currently uses pressurized systems. The most frequent use of (pressurized) irrigation technology occurs in fruit crops, of which Chile farms 300,000 hectares.

Innovation in irrigation for the production of fruit crops in Chile has increased dramatically, and has been strongly supported by studies carried out by the Institute of Agricultural Research (INIA) in collaboration with producer organizations and companies selling equipment and nutrients for use with the irrigation water. Some of the characteristics of these circumstances are highlighted below.

Irrigation technology in fruit crops in Chile has reached high levels of precision due to the limited availability of water, hence the need to address the plants' sensitivity to water stress, according to the crop cycle and other factors. Water stress naturally varies according to the species, variety and ecosystem, and during the crop cycle. Among the factors that have required more monitoring care are: evaporation and potential evapotranspiration; the soil's infiltration capacity—both influenced by the distance between plants; and the quality and timeliness of the pruning of trees, among others. Root development, which results from the soil's moisture content and texture, is a decisive factor for the growth and productivity of the plants. The table below shows the most sensitive periods of water stress in several fruit crops.

Table 3. Chile: Critical periods for water supply in fruit crops.

Fruit Crop	Critical Period
Citrus fruits	Flowering to fruit setting, period of rapid fruit growth
Apple and pear trees	Fruit setting to period immediately before harvest
Peaches and apricots	Rapid fruit growth
Grapevine	Sprouting and flowering
Kiwi	Fruit setting before ripening

Source: Government of Chile 2007.



Source: Depositphotos Inc. 2015.

As a result of the moisture limitations at critical periods there is insufficient root development; poor blooming; cell development in the fruit in its initial phase is not achieved; the fruits do not develop and there are many more smaller fruits.

Ways to reduce evaporation from the soil are just as important as knowing the most critical periods for providing adequate soil moisture. These include coverage with slow degradation plant residues and plastics. Added to this is the knowledge needed to reduce the total amount of water in a plantation, which can be achieved by selecting early season varieties and scheduled pruning.

On the other hand, increasing attention is being given to foreknowledge of the potential availability and quality of water. With respect to

the latter, it is fundamental to be aware of the limits regarding salinity and the presence of minerals and suspended solid waste that cause the impairment or blockage of irrigation equipment. These should not exceed 100mg/liter of water. And no less important now is the requirement of compliance with regulations regarding biowaste, including coliforms.

The irrigation technology used in fruit crops in Chile is not a random result; rather, several factors have prompted producers to apply innovation that has resulted in the valuable results mentioned at the beginning of this section. The alliance between the INIA, the Economic Development Agency (CORFO) and producer organizations has been crucial for developing appropriate varieties of fruit crops and information for irrigation management. The cooperative efforts of the National Irrigation Commission, the Chilean Institute of Agricultural Development (INDAP) and the Ministry of Agriculture have allowed for a greater availability of water and outreach services. The motivation of profitability was a decisive factor for all producers to invest in the respective irrigation plants and installation of equipment. No less important has been the country's export strategy, with a great deal of services provided to all companies in the production chain, especially regarding irrigation management technology, bee pollination, controlled atmosphere storage, and many more, paving the way toward the most demanding markets worldwide.

3.6 Reducing the Water Footprint: Rice in Colombia and Uruguay

As discussed in section 2, growing international pressure to reduce the water footprint is expected, in particular, the aforementioned blue water footprint, related to the efficiency of the use of water collected in reservoirs, which meets the needs of the entire population. Agriculture is the sector with the highest water footprint; however, in agriculture there are significant differences in water consumption depending on the different crops. Two experiences related to reducing the water footprint of rice, one in Colombia and the other in Uruguay, provide valuable contributions to the analysis of this issue.

Irrigated rice has the highest water requirement per hectare. The crop registers an average evapotranspiration throughout its cycle of 670 to

700 mm (6700-7000 m³/ha). It is irrigated by permanent flooding and, although the plant is adapted to growing under anaerobic conditions, it could be produced without the need to keep the crop flooded throughout the development of the cycle. The probability of obtaining maximum yields is favored by the water saturation conditions of the soil. The availability of water in the ground prevents plants from having to use up energy to absorb water. If, at 7000 m³/ha of the evapotranspiration of rice, a coefficient of 65% to 70% irrigation efficiency is applied (achievable values with appropriate management and control) some 10,000 to 10,800 m³ of water per hectare would be needed on the farm. To this must be added the inefficiency of the water pipelines from the dam to the farm and of the dam itself.

Colombia plants 260,000 hectares of rice, of which approximately 65% is irrigated. In some cases, irrigated crops receive additional water from rain, in up to 40% of the total water used. In any event, given rice's high water consumption, the government encourages research and experimentation initiatives to improve the water footprint of rice. At the national level, the green footprint of rice represents 3,213 Mm³ and its blue footprint represents 1,130 Mm³. The blue footprint of rice represents 41% of all crops, given that it is grown in the flooding system, using water from dams.

Irrigation practices introduced in Colombia are enabling significant achievements in reducing water consumption and increasing productivity in rice farming. These practices include land leveling, the use of siphons and floodgates, varieties with shorter cycles and a higher yield per hectare, and a better response to fertilization with proper nutrients. In the cases where the aforementioned innovation practices are applied, water consumption has been reduced from 1,078m³/ha/week to 800 m³/ha/week; and the yield has increased from 5.4 to 7.4 t/ha.

In Uruguay, rice is grown in just one harvest per year, in annual rotation with other crops and only under irrigation. This aspect, combined with the renovation of varieties, has been crucial for maintaining productivity, caring for soil fertility and reducing the incidence of diseases. The area planted annually is, on average, 150,000 hectares and has a yield of over one million tons. Half of this area is currently irrigated from dams and the other half from rivers and lakes. In the case of dam irrigation, 82% of the area uses only unevenness energy and the rest

uses levers with diesel engines. Irrigation from lakes and rivers is carried out in 38% with electric lifts and 62% with diesel.

In order to increase the efficiency of irrigation in rice farming in Uruguay, replacing the secondary pipes or internal channels for hoses and floodgates, the system known as pipe-window is being implemented. The use of the pipe-window is intended, firstly, to precisely determine the inflow of irrigation and the amount of water used in each sector of the farm, as well as run times. This can be used to accurately estimate the irrigation lamina applied. The implementation of the pipe-window inside the rice fields lowers the dependence on staff who are skilled or experienced in irrigation, since it is easy to instruct a worker, indicating which gates must be opened and how to implement rotation irrigation in each plot to meet the water needs of the crop. Furthermore, farm workers can cover a larger area of irrigation using this technology. The water pipes usually built on land have sections and slopes that, together with the inflow, are prone to erosion. Another important contribution is the improved efficiency and performance of the ground equipment used in the farming, eliminating the need to go through the plots' normal secondary canals (each 150-200 meters long and 35-40 cm high).

It is important to note that Uruguay is one of the world's top rice exporters. It exports 90% of its production. This success has been achieved through the high productivity and quality of the rice on its farms, its milling quality and its international business strategy.

It should be pointed out that in both Colombia and Uruguay, the producers' organizational skills have been instrumental in their progress. In Colombia, the National Federation of Rice Producers (FEDEARROZ) offers farmers a wide range of services, including a robust program of research and technology transfer in partnership with the Colombian Agricultural Research Corporation (CORPOICA) and the International Center for Tropical Agriculture (CIAT), and the National Rice Fund allows various forms of credit to be provided, in addition to centers for the sale of equipment and information services. In Uruguay rice producers are represented by the Rice Farmers' Association (ACA, founded in 1947) and the industry is represented by the Rice Mill Guild. In 1968, the Executive Branch declared rice farming and processing of national interest and, in 1973, the Rice Sector Commission was set up, comprised of the ACA, the Rice Mill Guild, the Planning and

Budget Office (which presides it), ministries and the Banco República. The institutional design of this chain not only enables conflict resolution but also interpersonal contacts, building trust and exchanging information, which, in turn, generate a positive image that helps explain the dynamics observed.

The two cases referred to, that of Colombia and Uruguay, show high returns from innovation in water management, backed by producer organizations in partnership with government entities.



Source: Depositphotos Inc. 2015.

3.7 Piping of Irrigation Canals in Chile and Peru

The canals for channeling water from areas of greater availability and from dams, to deficit areas, have a long history in agriculture in Latin America. The stone-lined canals built in pre-Inca times still bear witness to that fact. Several countries have, for years, relied on canals to convey water from rivers to irrigation areas, with familiar seepage losses due to weeds growing in the canals and the conditions of the soil the canals are built on. Then came the big dams and concrete canals, which achieved a capacity in their initial sections of 50,000 liters per second and, although in this case infiltration was partially reduced, the problem of evaporation has continued. Some of these canals are reaching a critical period in which their deterioration and subsequent maintenance costs have become very apparent.

In recent years, the piping of irrigation canals has resulted in high return innovations. In addition to eliminating evaporation, the piping can, in some cases, allow pressurized water to reach the farms and land in areas of the same original slope and thus eliminate pumping requirements for pressurized irrigation. For example, in the case of Chile, the casing of the Vecinal Grande La Chimba canal was carried out in six kilometers, with diameter piping that was gradually reduced and has 104 valves for a plot delivery of 4 and 6 inches. This new piping system will also be used in the Huatulome River and Cogotí River in Chile and will lower the cost of applying pressurized irrigation to USD 500 per hectare, among approximately 3,500 small producers.

In the case of Peru, piping networks have also been installed for conveying water from the main canals with the aim of using it in the abovementioned case of sugarcane and grapevines, also in the desert. It is believed that if this technology had not been used, the abovementioned crops would not have been profitable. By way of a general comment, the fiber pipes used in northern Peru are produced in Ecuador, revealing significant South-South cooperation.

One of the benefits of canal piping is the elimination of water theft, an issue that tends to become compounded insofar as water becomes increasingly scarce. In addition, piping eliminates the growth of seaweed and algae in the waterways. Both of these can decrease the piping's efficiency by up to 50%. And last, but not least, piping can substantially

reduce the system's maintenance costs. The durability of the piping systems varies according to the tubing material used and the degree of external protection of the pipeline, and analyses of the ecosystem must be carried out to this end.

The abovementioned technology deserves considerable attention because it poses a major challenge for governments regarding public spending in the coming years, when most of the canals built in the past will be reaching the point where their conveyance efficiency and deterioration will call for decisions concerning their replacement. Just as pressurized irrigation is a growing need at the farm level, canal piping is required in watersheds and valleys.

3.8 Small dams: redirecting public investment in Nicaragua and Peru

Almost all Latin American countries have dams for water destined specifically for human consumption and agriculture, despite the fact that the water supply from dam and canal systems for use in agriculture still represents a low percentage of the total water used, due to the high dependence on rain alone. Several of these dams also have the capacity for generating energy. The study carried out by IICA entitled *Water: Food for the Land*, states that there are 68 dams in Latin America with water curtains over 130 meters high that dam around 2721 cubic kilometers of water. The largest are in Mexico, Brazil and Peru, but it is estimated that from the Rio Grande –on the border between Mexico and the United States –to Cape Horn, some two thousand 20-cubic-kilometer dams have been built.

One of the most noticeable changes in water damming in Latin America relates to the construction of smaller works for community use in hillside areas. In addition to these small dams, thousands are built each year to harvest water, which does not include water harvesting on the roofs of houses and intra-farm runoff.

The change from large dams to micro dams is one of the highlights of water resource management and, as mentioned in the section on conceptual framework, is focused in particular on democratizing the

benefits of water catchment. The change comes, in part, as a result of the acknowledgement that the large dams did not directly benefit the communities located in the areas where rainfall and primary runoff occur.

In order to illustrate the benefits of the new approach, references can be made to the cases of the program backed by the Swiss Agency for Development and Cooperation (SDC) and the Tropical Agricultural Research and Higher Education Center (CATIE) for water uptake in Nicaragua, as well as the state-funded MiRiego Project in Peru.

In Nicaragua's case, the region most affected by the conditions of seasonal water shortages is known as the "Dry Corridor", which covers almost 50% of the country (91 municipalities) and over 60% of the population. The majority of the population in this region is comprised of small subsistence farmers.

The Government of Nicaragua is determined to help overcome this situation. Decisions have been made based on studies indicating that harvesting rainwater runoff in large reservoirs presents certain limitations: i) large reservoirs are more demanding in regard to design, construction and supervision; ii) due to their high cost, small farmers with little land would not be able to repay these investments, even though the investments would initially be made by the state; and iii) their profitability and social benefits have not been proven. The study recognizes that technology for water uptake in small reservoirs is an important measure of adaptation; that the private sector has the capacity to offer services locally and that more and more farmers are requesting support in finding solutions to the problem of droughts.

The Government has therefore decided to implement a project that will proceed to: i) validate and promote the harvesting of rainwater runoff as an effective measure for adapting to climate change; ii) promote reservoirs of various sizes and for different uses tailored to the needs of the target group; iii) study the feasibility of other options for water harvesting; and iv) subsidize investments for building these reservoirs. It also proposes that the contribution of the beneficiaries be in kind in the construction of the works, assuming responsibility for their maintenance and introducing changes in their production systems to make them more sustainable and resilient.

The target group is made up of families of smallholder producers with no access to water for production purposes, who farm less than 3.5 hectares and have less than 20 head of cattle. The project plans to build around 1,200 family and community-based reservoirs. The water catchment facilities will have varying dimensions, ranging from 500 m³ to 20,000 m³. Over 90% of them will be for family use, while the rest will be geared toward the community. The project will provide close support for community initiatives regarding legal and organizational aspects to ensure its sustainability. It is expected to directly benefit 9,000 people, including women, to whom the project will give priority of access to water for domestic use and the irrigation of backyard crops, small animals, etc. The project will be implemented over four years for a total of 10.82 million, of which the majority is a donation made by the SDC. This project is run by CATIE.

In Peru, according to the latest Agricultural Census of 2012, there are 2,292,772 agricultural units. Of that total, 64% is in the Sierra (mountains) and, of the irrigated area, 38.4% is located in the Sierra. The dry land agricultural units across the country make up 1,242,970 of the abovementioned total figure, representing 56% of the 2,213,506 units with land nationwide. The majority of the rainfed agricultural area is located in the mountains (50.7%) and the jungle (44.5%).

In 2013, the Ministry of Agriculture (formerly MINAG, now MINAGRI) set up the MiRiego Program, which co-funds projects for the provision of services and small-scale infrastructure in the mountains for agricultural purposes that have an impact on reducing poverty and extreme poverty. The projects must be located at an altitude higher than 1,500 meters above sea level, and they must be declared viable by the National Public Investment System and possess a valid technical dossier.

In 2013 seven public investment projects were approved in the regions of Ancash, Amazonas, Ayacucho, Cajamarca, Cusco and La Libertad. The number of beneficiary areas totals 3,638 hectares, and 13,198 families have benefited thus far.

The selection criteria are the following: i) the number of beneficiary families; ii) the number of new or improved hectares to be incorporated into the irrigation area; iii) the levels of poverty and extreme poverty in the



Source: Depositphotos Inc. 2015.

district where the irrigation area of the project is located; and iv) the commitment of local authorities, community organizations and residents to the project's sustainability. The complementarity of projects in a watershed is also encouraged so that they may have a greater impact. The works financed by the MiRiego Fund are community and family-based, and must be developed specifically in communal lands and in accordance with the regulations of the National Public Investment System (SNIP).

The two cases mentioned, those of Nicaragua and Peru, show progress in what can be considered significant redirecting of public spending to address areas with greater poverty, climate vulnerability and food insecurity. The need to evaluate these experiences and, in particular, the participation of the local community, is evident, both with respect to the works and management of these, as well as their co-funding mechanisms.

3.9 Valuable partnership with the sector supplying equipment and services

The numerous companies that provide a wide variety of equipment for pumping water from where it is stored to the fields have undoubtedly constituted important allies for irrigation technology.

Innovation in irrigation has required the following contributions from private companies supplying equipment and services:

- Piping made of different materials and with varying diameters for water pipelines; some now used to replace concrete canals.
- Pipes and soft hoses for irrigation with different diameters, different sized/distanced nozzles, including those that are self-propelled.
- Electric pumps and fuel engines, including immersion, external and motor pumps.
- Water filtration equipment and a variety of filters, depending on the conditions of the waters.
- Computerized irrigation systems for irrigation and fertigation control in accordance with the growing seasons of the plants and moisture requirements detected in the root system.
- Integrated equipment for greenhouses; and many more.

In addition to the different equipment, many companies have developed a range of services including the diagnosis of water and nutrient requirements for various crops; the designing of irrigation systems and budgeting; procedures for obtaining bank financing; fertigation plans; and equipment maintenance, among others.

Suppliers of irrigation systems, equipment, materials and services have played a key role in the irrigation innovation process in all Latin American countries. The supply companies are present in all the countries, but on a larger scale and range in countries such as Mexico, Brazil, Peru, Argentina and Chile. Some of them have undergone expansion in several states, departments or provinces in those and other countries. For example, in Mexico, Netafim is one of the companies specializing in irrigation systems in larger greenhouses worldwide. It has 130 engineers in offices in several countries, including Chile (RiegoSistemas) and recently opened a new plant in Peru. Together

with this business expansion, different brands have also begun to manufacture equipment, although much is still imported from the United States, Israel and Europe.

The contribution of this segment of the private sector to the modernization of irrigated agriculture has been widely recognized and, in several cases, irrigation equipment has been granted exemption from import taxes. The Dominican Republic was a pioneer in this field, establishing a tax of only 5% on imported irrigation equipment (and other goods) for agricultural use, in Law 532 signed by President Balaguer in December 1969. Costa Rica granted exemption from all import duties on irrigation equipment (and other goods for agriculture) in 2000, through Legislative Decree 28648 MAG-MEIC-H. In Uruguay, in 1990, irrigation equipment imports intended exclusively for agricultural production were declared exempt from the payment of the global tariff rate, including the minimum surcharge of 10% established by Decree 125/977 of March 1977, as of the date that Decree 488/990 came into effect. However, these exemptions, which were considerable, are under review (El Pais, Montevideo, 3 May, 2014).

Unfortunately, in some cases, the red tape for processing these exemptions on imports involve high transaction costs that end up being reflected in the prices of equipment.

3.10 Water Governance Innovation: Experiences in Peru, Costa Rica and Guatemala

The urgent need for new mechanisms for the proper governance of water is undeniable. In referring to the declaration made by UNESCO in 2006 (UN-UNESCO, 2006), Ballestero (2010), points out that: “There is enough water for everyone; the problem we face today is mostly a problem of governance for sharing water in an equitable manner and ensuring the sustainability of natural ecosystems. To date we have not managed to achieve this balance”. The author also notes that democratic decision-making processes need to be included with regard to water as a public or common asset, in addition to consolidating the IWRM scheme and improving the processes and mechanisms of interaction between government and non-government stakeholders.

Ongoing conflicts and inequities persist as the main elements characterizing the management of water resources in rural areas in many countries. The lack of participation of the population, particularly of smallholder farmers and rural communities, in the management of river basins, exists even though there are rules and policies that supposedly promote a participatory outlook with respect to the issue of water. The lack of common ground between national legislation and local realities is a key factor to be taken into consideration.

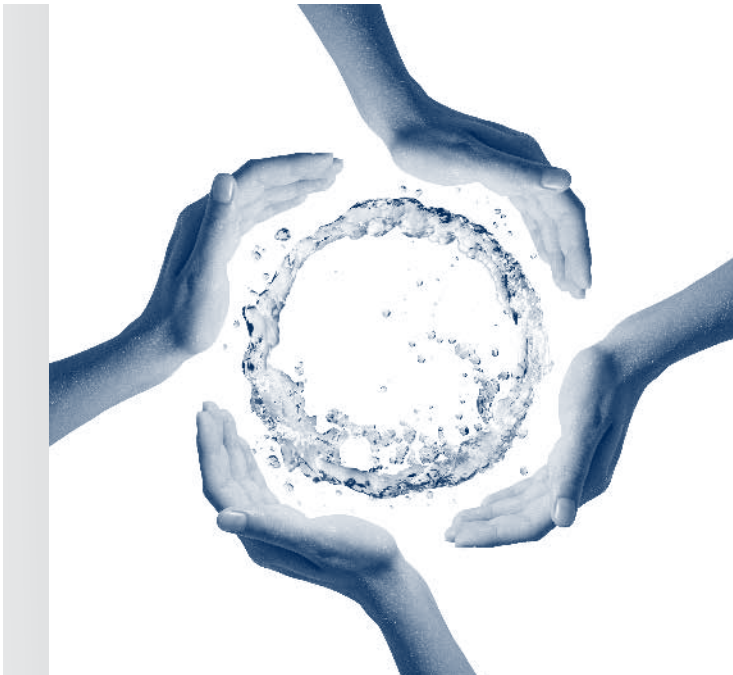
Without a doubt, a number of increasingly significant innovations are those related to community water management at the territorial level. These are becoming an essential tool for conflict prevention and resolution. Three of these institutional agreements are the water consumers' boards in Guatemala, the administrative associations of municipal aqueducts (ASADAS) in Costa Rica and the watershed councils in Peru. All of these cases have shown that, since water is a shared resource required by many stakeholders in society and has many uses, it is essential to build a shared vision and rules of the game that ensure availability, planning and conflict resolution.

In Costa Rica, Pomareda (2010) stresses the need to also distinguish two levels –the national and the local –responsible for various state entities at both levels. In this respect, the author points out that, regardless of the public entity where the policy-making role is established, the shared responsibilities of the various entities nationwide should be made clear. The situation is somewhat more manageable at the local level, since Costa Rica created ASADAS in 1966.

At present, there are 1,580 rural aqueducts, of which 70% are run by ASADAS. In 2010, Arellano-Hartig noted that this mechanism required an update for it to be perfected as a public-private body, which is becoming increasingly relevant given the increase and diversity of users and the need to protect watersheds. One of the limitations that needs to be overcome concerns the difficulty of reconciling the use of water for irrigation with other uses; and the other is the issue of water pollution. Difficulties regarding administrative management and the availability of funding are quite common, however, in no case are they reported as a critical issue. One of the topics of most interest for the immediate future is the protection (tree planting) of watersheds and user education for improving water quality and reducing the risks associated with uncontrolled runoff.

Guatemala is a country where conflicts over water quality have been commonplace and its society has repeatedly been urged to reach commitments in this regard. Valenzuela (2013) points out that it is possible to achieve changes, but these require a political pact and agreement on a new agenda of effective reforms at the area-based level. Improved services will result from redesigning economic and institutional mechanisms at the local level that promote a new set of best practices, as outlined for water governance. The experience of the Municipalities for Local Development Program (PROMUDEL), and the efforts and results obtained by 25 municipalities involved in the program, bear witness to the fact that it is possible to achieve this, despite the unfavorable environment.

The PROMUDEL began in 2007 and concluded in 2013, as a joint program of the governments of Germany and Sweden run by the German Technical Cooperation Agency (GIZ, formerly GTZ). Its goal has been to entuse municipalities to fulfill their main task: to improve water



Source: Depositphotos Inc. 2015.

systems, especially in the Mayan areas of extreme poverty. The strategy involved the implementation of four instruments that converge around the same main objective: i) improve local finances in the pursuit of basic services; ii) enable citizen participation in valuing water; iii) set up professional public utilities units; and iv) implement public policies approved by the City Council. One needs to bear in mind that Guatemala has a total of 338 municipalities in 22 departments, involving a very high level of interaction between all activities in society at the municipal level, including, naturally, agriculture.

In Peru, at the national level, the National Water Authority (ANA) is the highest ranking regulatory body. At the local level they have set up watershed councils (CCs), demonstrating the importance of reconciling interests at both the national and the local level. The social vision of water management is incorporated into policy No. 33 of the National Agreement - "State Policy on Water Resources" - and also in the Water Resources Act (Law 29338), in force since 2009; however, water conflicts have not ceased (Ore 2013).

One of the important points in the Water Resources Act is that it provides that Watershed Councils (WCs) be set up for good water management practice. In general terms, the WC is a forum for dialogue involving both the State, in the form of local ANA representation, and the Regional Government; economic interest groups (miners, farmers, industrialists) and civil society, with the different bargaining power of all parties. Pomareda (2013) notes that the process has been underway since 2009 and in some regions is more active, for example in Piura and Lambayeque. In the remaining regions it is still taking shape and they are in the learning stage of how the WCs should work. In any event, it is a mechanism based on a new institutional framework which the aforementioned stakeholders are not familiar with.

This section reveals that the demands for better water governance at the national and local levels are giving rise to innovations in community management, which farmers cannot ignore. Moreover, their participation is essential, bearing in mind they are the main consumers and would be the most affected by water shortages and the consequences of pollution caused by third parties.

3.11 Conclusions

The range of experiences described demonstrates that many innovation practices are being implemented in several countries in the region in different fields and that there is great potential for taking advantage of them. This innovation can be seen in aspects related to technology used at the farm level; in new public spending to democratize water usage through local infrastructure; in investments for improving the efficiency of water conveyance; in community water management and discussion forums.

Producer organizations, research centers, government agencies, private companies and non-governmental organizations (NGOs) have played an important role in this innovation, demonstrating the value of cooperation in each case.

These findings are important for two reasons: the first is that the aspects requiring innovation are very diverse; and the second is that the capacities for contributing to them exist in different entities.

IICA values these innovations, as well as the role of institutional synergy, and gives careful consideration to both aspects in order to propose, in the final chapter of this document, a program of technical cooperation at the hemispheric level, based on these national experiences, thus complying with the recommendation made by the IABA in 2013.

4. IICA Support for Countries in Water Management for Agriculture





IICA Support for Countries in Water Management for Agriculture

4.1 Technical cooperation instruments

In compliance with the mandate received at the IABA in 2013, IICA is presenting in this chapter a synthesis of major efforts to support Member States in matters directly related to water management in agriculture, using a variety of technical cooperation instruments.

IICA's range of useful cooperation instruments is a valuable asset, as this enables it to meet the demands of countries in a timely manner. This section refers to cases in which IICA has supported innovation and good water management in agriculture in various ways over the past three years, using the following cooperation instruments:

- Generation of strategies and policies for water management.
- Development of legislation for IWRM
- Project conceptualization and preparation
- Project management
- Training in local organization management
- Training in technical areas of water management
- Creation and management of knowledge networks

The technical cooperation instruments have been implemented in the various areas relating to water management on farms in order to improve the productivity and profitability of crops, and in those areas relating to regional water resources management. In both cases,

careful consideration has been given to measures for cushioning the effects of climate change.

These cooperation instruments are implemented in the different initiatives being developed by IICA and are summarized in the Table below. More than one instrument is being used in several ongoing projects, thereby achieving greater synergy and effective cooperation.

Table 4. Cooperation Instruments used by IICA for generation of public goods with regard to water resources management in agriculture.

Country	Strategy and Policies	Training	Information Knowledge Network	Technical Assistance	Project Development	Development of Legislation	Management of Resources
Mexico		X			X		X
Central America	X	X	X	X		X	
Nicaragua		X	X				
Costa Rica		X	X			X	
Ecuador	X				X	X	
Peru		X	X				
Bolivia				X			
Brazil			X		X		X
Paraguay		X	X	X	X		
Argentina		X	X		X		X
Dominican Republic	X	X	X				

Table 4. Cooperation Instruments used by IICA for generation of public goods with regard to water resources management in agriculture.

The Institute has played the role of cooperation manager. To that end in its Medium Term Plan for the 2014-2018 period, it established four instruments: Flagship Projects, the Technical Cooperation Fund, Rapid Response Actions, and externally funded projects. In addition, an important element of the Institute's action is horizontal cooperation, which allows it to leverage existing capacity in Member States.

This chapter has been organized by case at the country level, with areas of intervention/cooperation instruments highlighted, with reference to what has been done and what has been achieved. Furthermore, in some instances, reference is made to the use of more than one cooperation instrument to achieve greater synergy.

In order to obtain baseline information to develop this section of the document, IICA's country representatives were asked to supply in each case, information that would briefly highlight the activities carried out, resources used, and results obtained. These contributions from IICA have occurred in some cases within the framework of national and regional projects. As can be seen, the actions vary widely, as do the number of resources contributed by IICA, and those mobilized from other sources. Contributions from the IICA Offices in the countries were very comprehensive and the most significant aspects are summarized in this chapter.

As in the previous chapter, the cases are presented from the northern to the southern countries of the Americas, with each case having equal relevance, thus making it possible to point out different areas and cooperation instruments.

4.2 Outline of development plans for irrigated agriculture in Mexico and Costa Rica

This section summarizes two IICA experiences in support of initiatives for the development of irrigated agriculture locally, one in Mexico and the other in Costa Rica.

In response to a request from the Government of the State of Nayarit, Mexico, the IICA Office in this country in 2014 developed the plan for cultivating 1000 Hectares of land, as a pilot project, within the 043 irrigation district in that state.

The main problems of agriculture in the state of Nayarit are: low productivity (reduced use of productive potential of crops); low efficiency and conservation of natural resources; few vocational and modernized extension services; deficiencies in innovation and technology transfer systems; lack of dynamism in investment in the agricultural sector;

inefficient use of existing irrigation infrastructure; no analysis of the effects of climate change; and limited organization of producers, which impacts their access to funding arrangements and credit. This situation has resulted in levels of poverty and malnutrition in a significant proportion of the rural sector.

For this reason, the Government of Nayarit along with the Federal Government agreed to boost production with high productive potential, taking advantage of the conditions of the 043 irrigation district, which will reduce grain imports, increase exports of fruits and vegetables, and positively impact the income of Nayarit producers. In order to achieve this, it has been suggested that dried lands be incorporated into the irrigation system in the coastal plains of the state of Nayarit by expanding the 043 irrigation district, with the construction of the centennial channel and its respective distribution network. The Government of Nayarit sought IICA's assistance in formulating alternatives for addressing this challenge through a pilot project that would develop a business plan covering 1000 hectares of land within the 043 irrigation district.

The purpose of the cooperation agreement with IICA was to evaluate the productive potential and profitability of the pilot program for the development of crops with similar agroecological conditions and proximity to the new area that will be irrigated with the centennial channel, in order to demonstrate to both the current users and future beneficiaries of the irrigation district, the productive potential and profitability of the application of technologies and alternative crops that available irrigation enables. The support was provided between May and August 2014, a period in which IICA provided technical cooperation through the preparation of the draft business plan .

Technical cooperation was provided through a rapid response action, involving an IICA mission (Headquarters, Mexico) to do a familiarization tour of the project area, as well as interviews with key actors, and a suggestion for two proposals, in order to finalize preparation of the draft business plan. IICA contributed additional resources to complement the country's resources in response to a request from the government of Nayarit. The areas of technical cooperation that were specifically proposed were knowledge management and use; development of institutional capacities; strengthening of corporate governance, public-private consensus building and articulation, as well as policies for IWRM

and integrated national strategies to secure funding for actions that seek to make better use of irrigation.

The products obtained are presented in a document with the draft business plan (which includes a market study, a production plan and list of proposed crops), an organization and human resources plan, an economic plan, and an implementation and expansion plan. The proposed business model, entails modern, efficient and sustainable irrigated agriculture, which will maximize productive capacity and productivity. To this end, an optimal investment portfolio of crops was designed, through a linear programming algorithm that took into account: 1) the potential crops for the region that have efficient production technology; 2) the market potential of the crops both in Nayarit, and at the national level with potential for export; and 3) the individual profitability of each crop recommended.

The optimal investment portfolio estimated for the 1000 hectares takes into account the cyclical planting of yellow corn, sorrel, red tomatoes and peppers, as well as the planting (where applicable in accordance with the technology package) and annual maintenance of the following perennial crops: limes, papaya, pineapple, guava, jackfruit and prairie grass. Annual income from these crops on 1000 hectares was estimated at USD 153 million in a worst-case scenario, at USD 180 million for the “most likely” scenario and at USD 198 million for the optimistic scenario.

After submission of the draft business plan last August, IICA-Mexico was notified, via feedback from the Secretary of Rural Development of the State of Nayarit, that the proposal was well received by the Governor of that entity, pending a meeting with officials from the Ministry of Finance of the Federal Government, in order to identify the allocation of resources for implementing this business plan.

Since mid 2014 and in 2015, the IICA Office in **Costa Rica** has supported the National Groundwater, Irrigation and Drainage Service, (SENARA) in the preparation of the Productive Development Plan for the Expansion of the Southern Channel of the Irrigation District of Arsenal Tempisque (DRAT).

The area being referred to is located in the Province of Guanacaste, the driest part of the country. This area is part of the only irrigation district

in Costa Rica that has a diversion dam with water from the Lake Arenal reservoir; 255 km of channels (southern and western channels); 252 km of roads and 90 km of drains, providing irrigation to some 27 000 hectares (especially sugar cane and rice and small areas of pasture grass, water melon and cantaloupe) and providing water service for about 700 hectares of fish farming, an action that has stimulated the economy of the cantons of Cañas and Bagaces.

IICA support was developed with resources provided by the flagship project “Resilience and Comprehensive Risk Management in Agriculture” in component 4: Efficient water use and sustainable soil management for agriculture adaptable to climate change.

The circumstances that led to this collaboration is the certification of 8,800 hectares in the subdistricts of Lajas and Abangares for irrigation, with the expansion of the South Channel DRAT/IDAT-Phase II, as there was need for better use of this infrastructure as well as for boosting the productive development of the beneficiary area.

The objective to be achieved is the draft proposal for development of the Lajas and Abangares districts, with emphasis on agricultural production based on efficient and innovative irrigation systems. IICA’s role will be the development and systematization of a participatory methodology to generate a plan for productive development of the area through water resources.

This had the backing of the authorities of the national agriculture sector, through an agreement with the National Sectoral Agricultural Council (CAN), for the participation of institutions in the agricultural and rural public sectors of the Chorotega Region, during the development, implementation and monitoring processes of the production development plan. A baseline instrument was created and applied in the survey of current conditions of small farmers who are beneficiaries of the expansion of the DRAT South Channel and an analysis was carried out from their perspective of the presence of water, as well as their views on future participation in possible development processes.

IICA’s contribution made it possible to create areas of cooperation and coordination between small and large scale producers and public-private stakeholders in the area, through participatory approaches and

dialogue; and also through the development and systematization of two processes of consultation with producers and public-private actors in the area, in order to identify the main constraints and opportunities for generating agro-productive development through efficient management of water.

For the remainder of the year, work will continue with defining ongoing consultation processes with farmers and citizens in the area for identification of the main strategic lines of action that must include the agricultural sector-production development plan. In order to do this, we have identified action on three fronts: i) activities with small and medium scale producers, ii) seeking partnerships and cooperation between small and medium scale producers and the private sector, and iii) activities of large scale producers and the private sector.

The result will be the creation of a project proposal for the development of the Lajas and Abangares districts, with emphasis on agricultural production based on efficient and innovative irrigation systems and the systematization of a methodology for generating agriproduction development plans through efficient water management, which may potentially benefit other countries.

This example of IICA's support in Guanacaste, Costa Rica, with resources from the regular budget, and in Nayarit, Mexico, through a rapid response action, are small-scale initiatives a type of pre-investment which make it possible to appreciate that the Institute possesses the tools to enable it to respond quickly and effectively to the needs of the countries, in order to support strategic public investment for the development of agriculture.

4.3. Cooperation in capacity building in Mexico, Central America and the Caribbean

The year 2011 saw the beginning of Mexico's cooperation with the countries of Central America and the Dominican Republic with a regional focus with respect to irrigation, with resource inputs from the Institute and the Government of Mexico, through SAGARPA. Additionally, several Mexican entities have offered bilateral support to several countries in the region in various aspects of irrigated agriculture.

In 2011, IICA carried out an analysis of the requirements for supporting the countries of Central America and the Dominican Republic in irrigated agriculture and identified opportunities for support from the Mexican authorities (SAGARPA, CONAGUA, IMTA, INIFAP, COLPOS Chapingo, COFUPRO). The initiative received broad support from technical agencies and ministers from the Central American Agricultural Council (CAC), of which Mexico is now a member. In 2012 the support was consolidated with resources provided by SAGARPA under an agreement signed between SAGARPA, COFUPRO, and IICA.

In 2012 and 2013 three activities for regional training and sharing of experiences were held, involving professionals from the aforementioned Mexican entities and 67 technical personnel from public agencies, academics and administrators of producer organizations of the eight countries of Central America and the Dominican Republic. The establishment of national, inter-institutional, and representative technical teams (NTTs), in each of the eight countries was also achieved. The NTTs were composed of a representative of the Ministry of Agriculture in the area of Policy and Planning, a technician from the national body with responsibility for water management in agriculture, a representative from the irrigation organizations, and a representative from the university which provides vocational training in the field of agronomy and water management. A professional from IICA served as technical secretary of the NTT.

The creation of a regional network for the exchange of experiences among the participants was a very valuable contribution .

The most significant support was the development of a draft Strategy and Policy Document for irrigated agriculture in each of the countries. These documents were prepared by the NTT and submitted to the national authorities for consideration.

For their part, the ministers of Agriculture, under the CAC, approved the document “Central American Program for Integrated Management of Water Resources for Agricultural Irrigation and Drainage”. The document consists of a profile of the program, terms of reference and pre-investment resources for program formulation and sourcing of external funding.

The recent climatic crisis associated with El Niño has exposed all the countries of Latin America, particularly those with agricultural areas in the Central Pacific region, to severe limitations in the development of agriculture and livestock. This situation requires immediate action, but such action should take into account the effectiveness of increasing agricultural sustainability while reducing vulnerability over the short and medium term. That is to say, the situation should be used to support public and private investments with quick returns, not only relief programs and transient results, but rather, laying the groundwork for the expansion of irrigated agriculture. Recognizing the reality of Central America, and building on the experience of cooperation with Mexico within the framework of its 2014-2018 Medium Term Plan, IICA presented for consideration to the Government of Mexico and with the support of CAC, the request for technical and financial support to undertake several activities.

Additionally, IICA has recently launched a cooperation program with the Jorge L. Tamayo Center for Research in Geography and Geomatics (CentroGEO) in Mexico for the establishment of a geo-referencing multi-information system for territories in the Dry Zone of Mesoamerica. This system will facilitate the documentation and analysis of a number of variables, supported with historical data, of the circumstances of these territories, and make it possible to adopt measures for planning the use of resources and for forecasting climatic conditions and their possible implications for agriculture at the micro-territorial level.

IICA has also facilitated the cooperation of Mexico with these Member Countries to support capacity building in the Caribbean, and in 2014, this enabled the training of 295 people in areas such as protected agriculture, water conservation and family agriculture management. Professionals from five Mexican institutions participated. This program is expected to continue in 2015 and one of the priority topics is water and soil conservation.

4.4 Creating strategies in the Dominican Republic, Honduras and Guatemala

Defining and implementing a strategy for the proper management of water and its use in agriculture in particular, requires discussion

relating to a medium-term vision that brings together many actors and establishes commitments. IICA has supported these processes in several countries and three cases are referred to below:

In the Dominican Republic in 2013, with support from IICA, and within the framework of cooperation with the Mexican authorities, the Dominican Institute of Water Resources (IDRHI) prepared a draft strategy for water management in agriculture. This first document should be validated and actions specified for implementation. Subsequently, in January 2014, the National Irrigation Sector Development Strategy Workshop organized by the IDRHI and IICA was held, with participation from a wide cross-section of national institutions and international agencies.

Experiences relating to irrigation development programs in Mexico and Chile were analyzed and the Draft National Strategy and Irrigation Policy Document were also discussed at this workshop. Then, in working groups, proposals were generated concerning: i) institutional modernization, training and research, extension, irrigation technology; ii) public-private partnerships for water management; iii) prioritization of public investment; and iv) mechanisms for financing investment for water management. The event concluded with proposals for actions to be developed as part of the process of implementing the strategy.

During the workshop, priority areas for action were analyzed to improve the policy framework for better water management in agriculture. Given the overall goal, the following areas for public investment were prioritized: Public works for better water management in an environment of climatic instability, especially dams of different sizes, and measures for protection from excessive runoff and flooding; strengthening the capacity of watershed organizations in which all relevant stakeholders are represented, and creating mechanisms to facilitate joint action. This includes organizations of users of water for agricultural purposes; training of human resources at the technical and professional level in proper water management with multiple uses in agriculture; the creation of competitive alliances to facilitate partnerships that generate knowledge and immediate application of technologies in irrigated agriculture, including those related to land drainage; and financial instruments to enable innovations and medium-term investments associated with the adoption of conservation practices and the rational use of water in agriculture.

Although these investments may be considerable, emphasis was placed on the importance of setting priorities and developing a plan for medium term public investment, whereby the policy instruments in which resources are allocated are adequately defined. On the other hand, it must be remembered that some of the most useful investments are not always physical facilities, but may be investments that contribute to better water management, which have no tangible indicators, but which need to be developed in order to convince those who allocate State resources.

In Honduras, the development of a National Irrigation and Drainage Plan (NIDP) is a high-priority task for the government . The NIDP is considered to be a key instrument for developing the different rural areas, intensifying agriculture, promoting job creation, improving and increasing food security and reducing vulnerability through preventive and corrective measures arising from effective strategies for adaptation to and mitigation of the recurring effect of climate variability on Honduras in terms of droughts and flooding.

As a first step in the development of the NPID of Honduras, IICA collaborated with the Departments of Agriculture and Energy, Natural Resources, Environment and Mining in organizing the May 26-27, 2015 seminar-workshop “Water for Agriculture”, which was attended by 150 participants, including representatives from the public and private sector, members of irrigators associations from irrigation districts, independent farmers, funding institutions, members of academia and innovators, distributors of irrigation equipment and materials, NGOs, private sector representatives, and international agencies linked to the topic of water, climate change as well as agricultural and livestock production. During this event, opportunities, limitations and the strategy for developing the NPID for Agriculture in Honduras were analyzed. The roadmap describing the actions to be undertaken in the country in the coming years with respect to integrated water management was identified.

During the seminar/workshop, sessions were conducted by experienced presenters from the hemisphere, particularly from countries in Latin America with more advanced planning in irrigation and drainage such as Ecuador, Costa Rica and Mexico. The seminar-workshop was organized in three parts: Water and Agriculture: politico-economic

context and its challenges; Integrated Water Management for Agriculture, facilitated by panels where experiences and lessons learned in integrated water management were demonstrated via case studies; and a third part where working groups in parallel sessions presented strategic proposals to improve the water situation for irrigation and drainage in Honduras, including: the Current situation of irrigation and drainage in Honduras (potential problems and limitations); priority policies and strategic guidelines for the development of a National Plan for Irrigation and Drainage in Honduras; generation of priority public goods (infrastructure etc.); development priorities and irrigated production systems.

Given the importance of the issue, the IICA Office in Honduras has included it in its IICA Country Strategy, under one of its flagship projects “Competitiveness and Sustainability of Agricultural Chains for Food Security and Economic Development”, in order to assist Honduras to improve its ability to manage policies and strengthen institutions through innovative plans and strategies, via a plan for regional integrated water management, that includes the collection and efficient use of water. This is consistent with the guidelines of IICA’s 2014-2018 Medium Term Plan.

The session concluded with a commitment to strengthen the capacity of participating institutions; to continue the participatory process of developing a project profile aimed at the creation of the NPID; to create the NPID based on the outcomes of the event, given that the participatory process had been initiated for this purpose. It was recommended that the results of the seminar/workshop be instrumental in guiding the strategic direction and management of resources and that the NPID be constituted with a strong portfolio of projects for integrated water management with a human face.

In 2013, IICA assisted **Guatemala** in creating a proposal relating to ‘water for agriculture’, in keeping with its support of national strategies in this area. As a follow-up to the aforementioned contribution, and in response to a request from the Ministry of Agriculture, Livestock and Food (MAGA), IICA attended the workshop “Financial Mechanisms for Promoting the Correct Use of Water in Agriculture”. The workshop addressed issues related to requests for financial resources to implement policies for water management, for application in various

activities by different entities and potential sources of funds. The discussion drew on the experience of many countries, especially in Europe, but several in Latin America.

The starting point was the recognition that good water management is a top political priority as it is one of the essential means of economic and social development and improvement of environmental conditions. Consequently, investment and expenditure by the State must be targeted at the generation of public goods. There was also recognition of the multiple responsibilities facing the State in the generation of public goods. To this end, it was necessary to identify and specify the roles assumed by the various State agencies at the national and local levels, including municipalities, and that the most important responsibility of the State is to ensure that measures for the allocation of resources are undertaken with a short, medium and long term vision for establishing the basis for sustainable water management.

These public investments require resources and to this end, the State is at liberty to consider many options, given the specific priority of meeting the demands of society and ensuring the supply of water in terms of adequate quantity, timeliness and quality. With regard to the resources for such funding, the State may identify these in the interest of having an adequate amount for ensuring the self sustainability of the system, or at least having a goal in terms of the time in which such sustainability will be achieved. Possible sources of funding include new taxes on non conventional items (cell phone calls), taxes on fuel consumption, user fees for water, fines for sanctions, the budget provided by the State, contributions from municipalities, charging a fee for water treatment, and user rights of aquifers, external debt funds, grants from the Global Environment Facility (GEF) or from friendly governments or NGOs, Special trust funds, etc.. The issue is of high importance because without resources, there is little the State can do to support the strategy and policies for water management.

4.5 IICA support in national legislation and regional action in Ecuador

IICA support in Ecuador for the management of water resources has been provided in two ways. The first is support for the enactment of a

law for the management of water resources and the other is support for three Decentralized Autonomous Governments (Los Rios, Bolivar and Cotopaxi).

In mid-2013, the National Assembly and its Standing Special Committee for Food Sovereignty and Development of the Agricultural and Fisheries Sector were, based on the Constitution, involved in drafting legislation concerning water resources, use and collection. It was considered appropriate in this situation to engage IICA's specialized advisory services during the preparatory stages of the approval of the proposed law on water resources. In this regard, and with IICA support, elaboration of the draft legislations has been proposed, particularly in areas relating to the national strategic interest.

The results have been the creation of an opportunity for dialogue and technical assistance to the Commission on Food Sovereignty from international and national experts who provide feedback on the water bill in the areas of priority interest.

This support made it possible to organize specialized technical events and seminars to exchange information and offer advice to the Special Committee of the Assembly on the main concerns regarding the institutional framework for water in new contexts and the proposed Water Fund, from the perspective of the institutional stakeholders involved. Direct technical cooperation and horizontal cooperation with international experts from Peru, Brazil, Costa Rica and Ecuador were provided.

Meanwhile, the Decentralized Autonomous Governments (DAG) in Ecuador have, under their exclusive powers, identified the planning of irrigation and drainage as a priority. Within the process of decentralization, this priority requires the identification of instruments or specific actions to advance the development of a provincial irrigation and drainage plan that supports regional development by improving the agricultural production base, with irrigation being a mainstay in production from a holistic perspective, given its contribution as a change agent in the production matrix. This initiative requires the capacity building of provincial technical teams for planning of the aforementioned undertaking that forms part of the provincial productive economic system. Thus, it is expected that it will contribute to improving

the quality of life of farmers in the region. This support has been provided by IICA since September 2012 and is expected to continue until March 2016. The aim is to strengthen the capacities of local governments with teams of national experts who will identify, adapt and implement a planning tool to guide institutional efforts for the short, medium and long term. This process requires dialogue and joint work between productive actors (irrigation boards), provincial authorities, and production and social organizations for undertaking specific actions in the economic-productive dimension which falls within the framework of the different programmatic instruments in effect in the country, especially for the DAGs.

The following has been achieved with the technical assistance and cooperation of national experts: harmonization of plans, provincial agendas and strategies related to irrigation and drainage; study of the existing inventory to determine the scope of the upgrading; strategic alliances with key stakeholders to complete the inventories; training of teams to undertake the design of the study and execution of the inventory; assistance in the analysis and study of secondary information and databases; development of comprehensive assessment of irrigation and drainage at the provincial level, and determination of critical points and baseline.

This support offered by the Institute highlights the importance of actions at the national level (Water Law and Fund) and the local level (planning and capacity building). Action at both levels is highly complementary and shows the Institute's clear perception of not only needing to have a guiding strategy and policies, but also the local capacity for implementing the national mandate based on the reality of the territories.

4.6 Knowledge management of IWRM in Peru, Costa Rica and Nicaragua

In September 2014, IICA launched the Integrated Water Management in Family Agriculture (IWMFA) Project with emphasis on knowledge management and institutional and personal capacity building. The project considers as a central issue the limited institutional capacity for addressing the problem of water management in family agriculture from an integrated perspective.

On the one hand, among the direct causes identified is the limited access to available knowledge on good practices and appropriate technological innovations suitable for this type of agriculture, whether through the dissemination of public goods based on successful experiences in the rural areas and reference countries, or the weak articulation of actors and mechanisms for the identification, collection, analysis and dissemination of that knowledge.

On the other hand, there are capacity needs in producers' associations, irrigators' organizations, watershed management committees and consequently, public and private support institutions have called for promotion of and guidance in the processes of improving water management in rural areas. The latter is due to weaknesses in previous training efforts related to insufficient coordination, relevance, accessibility, and sustainability.

These issues in turn, weaken the policy, strategy and investment framework that solutions for small-scale agriculture represent. They also affect the level of adoption of innovations and best practices for the protection, handling and integrated management of water, which in short, impedes the ability to overcome the high vulnerability of family farming to economic, social and environmental risks.

Source: Depositphotos Inc. 2015.



The overall objective of the project is to contribute to the development of a more competitive, sustainable and inclusive agriculture, by strengthening the institutional capacity to promote and guide the processes of improving water management in family agriculture, from an integrated perspective. One aspect of the project that should be emphasized is the wide engagement of several national entities.

Table 5. Participating entities in the GIAAF in Peru, Costa Rica and Nicaragua.

Country	Entity	Other participants
Peru	<ul style="list-style-type: none"> • National Water Authority (NWA) • Helvetas Swiss Intercoperation • International Center for Tropical Agriculture(ICAT) 	<ul style="list-style-type: none"> • Practical Action • Promotion Institute for Water Management (IPROGA) • Institute of Andean Watersheds (ICA) • Water, Climate and Development Program(PACyD—GWP)
Costa Rica	<ul style="list-style-type: none"> • National Service for Groundwater Irrigation, and Drainage (SENARA) • National Horticultural Corporation (CHN) 	<ul style="list-style-type: none"> • Technological Institute of Costa Rica (ITCR) • National Institute of Innovation and Transfer of Agricultural Technology (INTA)
Nicaragua	<ul style="list-style-type: none"> • Nicaraguan Institute of Agricultural Technology (INTA) • ActionAid (AeA-Nicaragua) 	<ul style="list-style-type: none"> • National University of Engineering • National Agrarian University (UNA) • Union of Agricultural Producers of Nicaragua (UPANIC)
Spain	<ul style="list-style-type: none"> • Ministry of Agriculture, Food and Environment (MAGRAMA) 	<ul style="list-style-type: none"> • National Center for Irrigation Technology (CENTER) • ActionAid (AeA)

Source: IICA, GIAAF Project, Lima Peru.

The project is funded by IICA’s Competitive Fund for Technical Cooperation, and with these contributions, the synergy of national entities with different capacities is being achieved, along with horizontal cooperation. It is anticipated that the knowledge network created by the project will be extended to more countries.

4.7 Technical cooperation for water collection in Paraguay

IICA's support in Paraguay is provided through the Project "Physical Demonstrative Interventions for Prevention, Mitigation and Rehabilitation in Areas at Risk from Desertification and Drought in the MERCOSUR Countries.

A large portion the Paraguayan Chaco lacks the quantity and quality of water necessary for household and agricultural production use. One of the most significant problems is that the amount of water evaporated is higher than the amount of rainfall, which causes water deficiency. This is added to the fact that the water that can be drawn from a rudimentary well in the areas of intervention contains levels of salinity that are higher than that of sea water. In order to have water available, one of the most common alternatives is to resort to harvesting rainwater as a source of supply; the project applies the most efficient techniques for collecting rainwater. This method was initially applied by the Israelis, but has been adapted to the particular conditions of the Paraguayan Chaco. The priority areas for the government were the localities of Teniente Irala Fernández and Campo Aceval in the Department of Presidente Hayes in the Paraguayan Chaco Region.

The objective and expected result is to have water available to 500 families for household and agricultural use in the dry season, which can last up to 240 days during the drought in the Chaco. As a result of the project, there are now two efficient systems for harvesting rainwater that together collect around 80 million liters of water, thus benefiting 500 families.

Each system has a collection area of approximately 10 acres where ridges have been constructed, depending on the topography of the land, but always with a 0.5% slope. It is expected that rain falls in the area, and that the collection area functions like a great roof that collects the water, since the soil is very clay-like and is very easily saturated. The water collected is gravity fed into a breakwater that is in the lower part of the project, with a storage capacity of 10 million liters. From this breakwater, the water runs into the main reservoir that has a storage capacity of 30 million liters for each water collection system. The stored water passes through a filtration system prior to entering the distribution system, which is managed by the Municipal Government of the District of Irala Fernández. The operating mechanism is similar in the 2 rainwater harvesting systems.



Source: IICA Office in Paraguay

The entities that requested support, and are participating, are the Secretariat of the Environment (SEAM) at the MERCOSUR level and the Municipal Government of Teniente Primero Irala Fernández, at the national level. Cooperation is being provided during the period of March 2013 to September 2015. IICA's intervention, in this case, within the framework of the regional project (MERCOSUR) is aimed at increasing the capacity for local organization with respect to irrigation in family agriculture and for training persons with the knowledge to manage water resources.

The project is being undertaken under a framework agreement for contribution by the European Union (European Union) and an international organization, in this case, ECONORMA 018/2012/interventions Fight against Desertification and Drought (CRI:20 2012/308-020). The amount to be executed for the two rainwater catchment systems for consumption and irrigation in Paraguay is USD 200,000, of which USD 159,970 is provided by the European Union and USD 40,000 by IICA, as counterpart funding.

This experience for IICA in support of local actions has made it possible for the Institute to once again assess the reality of its actions on the

ground, which means combining planning with actual work carried out and technical assistance. This is also important since it demonstrates that the Institute can carry out actions that are complementary to the resources obtained through international cooperation.

4.8 Cooperation to increase public investment in irrigation in Argentina

Support was provided by IICA through a project for delivery of technical cooperation services relating to the formulation, administration and monitoring of studies, programs and/or projects with external financing. The project responds to the country's need for public investment. These needs gave rise to the emergence of the Program for Provincial Agricultural Services (PROSAP) which is the public investment instrument of the Paraguayan Ministry of Agriculture, Livestock and Fisheries (MAGyP).

Since 1999, and through successive technical cooperation agreements, the IICA Office in Argentina has supported the PROSAP in management for the formulation of projects for public investment in rural infrastructure and productive development financed with external resources (Inter-American Development Bank and IBRD). The vision, outlined in the Agricultural and Agroindustrial Strategic Plan, formulated in 2010, states that Argentina *“will be the leader in the production of agricultural and agroindustrial goods and services, of quality and with value added, particularly in terms of origin, while ensuring that the nation is provided with food and meets international demand in terms of quantity and quality, within a framework of territorial equity, social inclusion and environmental sustainability, both economic and social, thereby promoting the development of the Nation and its regions”*.

In order to achieve these goals, agricultural and rural development in Argentina requires continuous and substantial public investment in rural infrastructure, as well as in the generation of conditions, resources and capabilities for productive development, and in marketing.

The importance of public investment in the specific case of irrigation is evidenced by the fact that 70% of the Argentine territory is arid or semiarid. Provinces that are quite distinct such as Catamarca, Chubut, Jujuy, La Pampa, La Rioja, Mendoza, Neuquen, Rio Negro, Salta, San Juan, Santa Cruz, Santiago del Estero, and Tierra del Fuego conduct their agricultural production in conditions of total or partial aridity and



Source: Depositphotos Inc. 2015.

in which the use of integrated irrigation systems is indispensable. In turn, on the “wet plains” themselves, complementary irrigation plays a key role in building up production and increasing competitiveness, applying the water required by the crops in a timely manner and in the required quantity, based on their specific needs.

Within this framework, the PROSAP has focused its actions on rehabilitating the public technology-based irrigation systems on the farms and, more recently, on extending irrigation to new areas, by sustainably using the water resources that the country has, by expanding the production limits, by facilitating retention of the rural population, by increasing competitiveness, and by contributing to an increase in exports (PROSAP 2014).

Successive technical cooperation agreements between PROSAP and IICA have been aimed at contributing to the development of regional economies, with special focus on the agroindustrial and agrifood sector and with particular attention paid to medium and small-scale producers, rural entrepreneurs and business people, through an increase in productivity, in sales volumes and in the competitiveness of local and international trade.

The expected results of these agreements are as follows: project profiles presented by the provinces linked to PROSAP reviewed and approved; public investment projects at the feasibility level in the areas of irrigation and drainage, rural electrification, rural roads, productive development, commercial development and other areas of intervention, formulated for the different provinces that are a part of the PROSAP, and submitted to the banks for financing and clearance; and studies, programs, or projects formulated at the feasibility level to be carried out within the framework of the PROSAP with external funding, in accordance with the requirements of the provinces or the national bodies and subsidiaries of the MAGyP.

Table 6. PROSAP projects supported by IICA and at various stages.

Projects	Number of projects	Surface area rehabilitated or to be rehabilitated (ha)	Administration of water resources and water for livestock production (ha)	New irrigation areas (ha)	Total surface area (ha)	Investment (USD)
Executed	18	119 892	422 900		542 792	201 927 310
Under way	14	286 002	145 337		431 339	226 953 296
Under evaluation	18	74 135	275 000	16 830	365 965	263 736 027
In preparation	20	125 980	2 774 000	129 670	3 029 650	623 545 000
Ideas and profiles	37	252 129	660 100	578 082	1 490 311	840 500 000
Total	107	858 138	4 277 337	724 582	5 860 057	2 156 661 633

Source: IICA Office in Argentina.

The projects developed relate to consolidation and rehabilitation of the public irrigation systems; to improvement of irrigation efficiency in accumulation, management, distribution, and use of water on the farms; to operational innovation within the water distribution structures; to support for the actions of the provinces and user organizations; to investment in collective public irrigation systems; to promotion of private investment on the farms; and to support for the creation, installation and development of the organizations of water users.

The main achievements of the projects already implemented have been: an increase in efficiency in the use of water; equitable water

supply; incorporation of new productive areas and improvement in supply in areas with limited water; increase in productivity in the areas of influence; increase in the fee collection capabilities; average increase of 70% to 90%; improvement in the efficiency of water distribution and piping; and productive transformation to crops with higher value.

IICA's functions have been to identify, formulate, administer and monitor the studies, programs and/or projects; locate the experiences available in Latin America that are related to the expected results and make them available to PROSAP. IICA must also provide PROSAP with all the financial and accounting information it deems pertinent, and which relates to the execution of the agreement. Furthermore, IICA participated decisively in the design of the second phase of the PROSAP. Based on this, the Institute has been involved in the design, preparation and administration of the projects. The funds contributed between 2013 and 2014 amount to USD 97.85 million, and as shown below, these have been loans from the Inter-American Development Bank, the IBRD and the public treasury.

Table 7. Resources administered by IICA within the framework of the agreement with PROSAP (pesos).

Agreement/ contribution	Execution				Budget 2015	To be budgeted	Total agreement
	2011 and before	2012	2013	2014			
IICA/PROSAP-IDB 2573 Project design [signed: Jul. 12/ maturity: Dec. 15]							
Bank contribution		5 543 594	10 668 287	18 774 217	3 150 000	1 947 996	40 084 094
Local contribution		887436	9 678 341	7 562 605	21 077 084	4 539 579	43 745 045
Total Contribution	0	6 431.030	20 346 628	26 336 822	24 227 084	6 487 575	83 829 139
IICA/PROSAP-IBRD 7597-AR Project design [signed: May 10/ maturity: Jun. 15]							
Bank contribution	8 104 069	12 135 014	2 201 527	3 319 062	2 000 000	1 042 938	28 802 610
Local contribution	605 493	5 832 573	7 031 665	5 513 876	544 000	808 850	20 336 457
Total Contribution	8 709 562	17 967 587	9 233 192	8 832 938	2 544 000	1 851 788	49 139 067
IICA/PROSAP - TOTAL							
Bank contribution	8 104 069	17 678 608	12 869 814	22 093 279	5 150 000	2 990 934	68 886 704
Local contribution	605 493	6720 009	16 710 006	13 076 481	21 621084	5 348 429	64 081 502
Total Contribution	8 709 562	24 398 617	29 579820	35 169 760	26 771 084	8 339 363	132 968 206

4.9 IICA Support to Brazil in IWRM

By virtue of being the largest country in Latin America, Brazil has areas of high contrasts with respect to water availability. The wettest regions, particularly the Amazon region that houses the Amazon River basin, contains the most extensive fluvial system in the world, covering a total surface area of 6.11 million km² from its origin in the Peruvian Andes to its mouth on the Atlantic Ocean (north of Brazil). This continental basin covers several countries in South America: Brazil (63%), Peru (17%), Bolivia (11%), Colombia (5.8%), Ecuador (2.2%), Venezuela (0.7%), and Guyana (0.2%). The average space occupied by the watershed of the Amazon River is in the order of 73.6% of Brazil's surface area. In contrast, in most of the northeast, the semiarid area and other parts of the country, water shortage is severe and is a serious limitation to the development of agriculture. In these areas, rural poverty is also severe and it is difficult to produce food when irrigation and rain are not available.

Given the need to carry out proper integrated management of water resources, and in order to increase the availability of water for use in agriculture and for human consumption, the Federal Government of Brazil and the State Governments have been making large investments for more than 20 years. These projects are multisectoral and are financed with State funds as well as loans from the Inter-American Development Bank, the World Bank (IBRD), and State banks.

In its Strategy, Brazil points out that, as important as the infrastructure for water collection and distribution, is the need to strengthen the organizations with shared responsibility in this field and to increase the human resources capacity at various levels. The latter ranges from human resources for research in national entities where those responsible for policies and project preparation are located, such as the public institutes, and those who have to manage water at the area-based level and on the farms, with assistance from the universities and private institutions.

IICA's collaboration in improving water resources management and administering the required public investment dates back to the seventies. Between 2008 and 2012, the projects that were administered with IICA's participation amounted to around USD 12.6 million. This

amount has increased over the last three years and, as the following table shows, it is anticipated that this figure will be the same or higher in 2015 and 2016.

Table 8. Brazil: resources for public investment generated in IWRM with support from IICA (reals).

Project	Total budget	2008	2009	2010	2011	2012	2013	2014	2015	2016
Project	82 786 000						16 016 760	27 369 255	21 636 801	17 763 183
Interaguas MI	5 131 245						8 400 000	10 968 300	12 495 000	14 227 500
Interaguas MCID	46 090 800					525 000	1 115 363	1 137 413	1 142 138	1 211 333
Interaguas MMA/ANA	7 000 000							1 645 000	2 677 500	2 677 500
Interaguas MMA/SRHU	23 038 400		1 585 600	6 486 183	1 451 293	2 270 207	2 69 853	700 847	7 847 381	
Regional Policies	12 000 000	857.375	1.390.878	1.115.311	1 043 297	507.356	1 617 708	5 468 072		
Irrigated Agriculture	1 364 357			69 708	270 804	129 003	318 780	576 062		
CERB-BA	14 816 760	31 545	408 857	654 348	1 131 521	4 640 375	282 802	1 689 211	3 979 549	1 998 546
IBNET-SRHU	5 564 405	912 015	1 008 106	1 981 405	256 554	210 000	518 219	678 104		
Desertification-MI	12 254 233	740.077	1.324.747	4 004 174	905 571	772.735	2 084 929	1 504 589		
Desertification-MMA (1)										

(1) Started in 2006 and between that year and 2007, 910 000 reals were disbursed.

Source: Office of IICA in Brazil.

Table 9. Brazil: resources for public investment in IWRM administered by IICA (USD)

Indicator	2008-12	2013	2014	2015	2016
Public investment with IICA administration	12 603 202	3 641 780	3 174 742	3 021 608	2 861 000

Source: IICA Office in Brazil.

Some of the projects supported by IICA that are under way were initiated in 2008 and at present, the portfolio is eleven current projects and one in preparation. Four of the projects with extensive scope started in 2013 and are those of INTERAGUAS (MY, MCID, MMA/ANA and MMA/SRHU). Due to their multi-sectoral nature, these projects are the responsibility of the Ministry of National Integration, Ministry of Environment by means of the National Water Agency of the Secretariat of Water Resources and Urban Environment and the Ministry of the Cities. In the case of the state of Bahia, support was provided to the Environmental Engineering and Water Resources Company. In all these cases, there are other entities which participate.

Within the framework of these projects and in order to achieve its objectives, IICA's support is given, among other aspects, to facilitate inter-sectoral and inter-institutional coordination; to support, plan, monitor and evaluate investments; to develop and disseminate methodologies for project management; to supervise contracting for executive core projects for infrastructure construction, maintenance and repair of works in critical regions; water management at the area-based level and on the farms; as well as innovation development and dissemination for better water management.

Source: Depositphotos Inc. 2015.



In five of the other projects, the issues of regional policies, management of irrigated agriculture and human resources training are underscored. These projects have been underway since 2008 and some of them will continue this year and next year.

The MERCOSUR countries, with support from IICA, participate in the ECONORMAS Project, which is underway with financial contribution from the European Union. The purpose of this regional project is to improve knowledge for combating the processes of desertification and drought, through physical interventions that make it possible to generate information on good practices, disseminate it, train personnel, and improve the quality of life of the beneficiary populations in critical regions in the MERCOSUR countries (Argentina, Brazil, Paraguay and Uruguay).

Based on IICA's experience with these projects in Brazil, three aspects stand out. First, the projects are multi-sectoral and require support for the task of inter-institutional coordination, with national entities and multilateral banks, a task that IICA has demonstrated that it can perform more than adequately. Second, they are projects with a significant public investment component, which has proven to be quite justified. It is important that other member countries adopt this model; in this regard, IICA can be of great assistance, given the vast experience it has acquired. And third, IICA has shown that it has the technical capability and the administrative-accounting mechanisms that allow it to administer investment resources. Thus, the experience of IICA in Brazil to support the integrated management of water is of high value and needs to be taken advantage of by the other member countries of the Institute.

4.10 Euroclima: interagency cooperation to disseminate knowledge and create capacities

The Declaration of Lima, agreed at the Fifth EU-LAC Summit (Peru, May 2008) established EUROCLIMA as a joint program between the European Union and Latin America, focused on climate change. It is within this context that on 18 December 2009, the European Commission approved the EUROCLIMA regional cooperation program. It was launched in San Jose, Costa Rica in April 2010, for its first phase lasting until the beginning of 2013.

The Declaration of Santiago, a result of the EU-ECLAC Summit (Chile, January 2013) reiterated the importance of actions to combat climate change. The EU-ECLAC Plan of Action 2013-2015 pointed to the need to continue sharing experiences and information among the countries and between the two regions, through the EUROCLIMA program. The Program has therefore been extended to 2016.

The EUROCLIMA program is carried out by five partners: the Economic Commission for Latin America and the Caribbean (ECLAC), the Inter-American Institute for Cooperation on Agriculture (IICA), the Common Research Center of the European Commission, the United Nations Environment Program (UNEP) and EuropeAid (General Directorate of International Cooperation and Development of the European Commission), supported by the Technical Assistance Unit.

The EUROCLIMA program operates jointly in 18 countries in Latin America, and in each country a focal point, who collaborates proactively, has been named. The focal points represent the position of their government on the program, ensuring that there are synergies and complementarities. Their objective is to facilitate integration of the strategies and measures for mitigation and adaptation in the face of climate change, as well as in the policies and public development plans in Latin America.

IICA, as a partner of the EUROCLIMA program, collaborates in the execution of component 3: Sustainable agriculture, food security, and climate change within the framework of the objectives of the Institute: *to ensure food security through the strengthening of the capacities of the agricultural sector in order to incorporate measures of adaptation for mitigation of climate change in productive systems.*

The following are among IICA's responsibilities: i) to identify and disseminate good practices for adaptation to climate change and mitigation of greenhouse gases in the agricultural sector, practices that have been validated based on climate change scenarios as well as biophysical and socioeconomic conditions, by the focal points of the member countries in the EUROCLIMA program, officers and technical staff in the agriculture sector and other sectors; ii) to strengthen the technical capabilities of the focal points in the member countries of the EUROCLIMA program, officers and technical personnel in the agricultural sector and other related sectors with respect to the knowledge and implementation of good

agricultural practices and appropriate technical innovations through virtual and regional forums/courses and sub-regional workshops; iii) to prepare and disseminate an interactive database on agriculture, food security and climate change; and iv) to share information with other institutions for the benefit of the focal points in the member countries of the EUROCLIMA program, officers and technical personnel of the agricultural sector and other sectors.

In order to achieve these objectives, IICA has been working actively in most of the member countries in the dissemination of knowledge and in personal and institutional capacity development, to bring about agriculture that is more resilient to climate change. These activities are developed within the framework of the flagship project “Resilience and Comprehensive Risk Management in Agriculture.” In the various training events, participants exchange knowledge on drought, desertification, integrated management of climate change risks and impact on the agricultural sector. Among the activities carried out were seminars in Mexico in September 2014, and the course offered in San José in November of that year, for technical personnel in national organizations in Central America.

4.11 Lessons learned

The summary presented below of IICA cooperation in the area of water for agriculture demonstrates the great flexibility of the Institute in meeting the technical cooperation needs of the countries and regions. In this regard, the following lessons can be highlighted.

IICA’s limited technical capability in the area of water management and water in agriculture has been corrected through the mobilization of professionals in the countries with significant knowledge of the subject, through horizontal cooperation. This valuable resource has great potential and a professional directory needs to be systematized and disseminated at the hemispheric level on the topic. This capacity in technical areas complements well the capacity of the Institute with respect to the use of cooperation instruments.

In sensitive aspects such as the development of new legislation and the definition of policies, IICA has acted with diligence, through international and national experts, by facilitating forums for sharing

experiences and through the signing of agreements of national and regional interest. Given the fact that, in several countries, legislative reform for water management is under way, this is an area in which IICA, in collaboration with other specialized agencies, could make an important contribution and avoid lengthy legislative processes.

IICA's actions are carried out at the national level, not only in providing support for the development of legislation, for knowledge management, defining policies, project preparation, and training; but also in supporting local entities, with respect to the use of water. This capacity of the Institute enables it to address the needs of the countries in different areas.

Through its instruments for implementation of the 2014-2018 Medium-term Plan, such as the Fund for Technical Cooperation and the Rapid Response Actions, IICA contributes resources as seed funding, and with these small contributions has achieved substantial counterpart funding from the national governments, the technical-financial cooperation bodies and the multilateral banks. This shows that the Institute is recognized as being able to carry out synergetic actions while seeking to use the funds effectively.

The fact that IICA has demonstrated its experience in the area of project preparation for strategic public investment in water management and, in particular, management of water in agriculture, the countries should seize this opportunity to channel more resources towards these goals.

5. Constructing a Hemispheric Agenda





Constructing a Hemispheric Agenda

The Declaration of Ministers of Agriculture Argentina 2013 laid the foundation for countries to collaborate among themselves in the integrated management of water resources, since it identified the need for a hemispheric agenda that would chart the direction to follow and which included commitments, that although not legally binding, would make it possible to achieve the political will to face that important challenge.

The ministers, meeting as the Inter-American Board of Agriculture (IABA), the highest governing body of IICA, requested that the Institute collaborate in the design and adoption of an Inter-American agenda for water in agriculture (Resolution 482).

In fulfilment of the above, and based on the Institute's experience, it was felt that this agenda should focus on the following topics:

5.1 Policies

Since water is a resource that benefits the entire society, it is important to recognize that policies are needed that encompass many areas, such as the capacity and responsibility of one's human resources, collection and distribution infrastructure, research and technology development for appropriate use, organization for collective management, protection of the watersheds to ensure quality and availability, management of

aquifers to prevent their depletion and contamination, incentives for innovation and access to financial resources, among others.

In the past there were different policies for the use of water by various sectors, but this is no longer the case and the sectors must be aligned with the national policies. This requires a cultural change, permanent dialogue, and the fulfillment of responsibilities and commitments. This implies that since agriculture is the greatest user of water, the impact of this sector is of the utmost importance. As a result, the sectoral policies that govern the use of water in agriculture are important, since they are linked to the management of crops and the feeding of animals, but they should also contribute to responsible, collective use of water.

Without minimizing the importance of the foregoing statement, sectoral policies linked to the use and care of water in agriculture must promote the effective and efficient management of that resource in order to improve the productivity and profitability of crops. This document has shown the diversity of technological options for the proper use of water in agriculture, which requires education, technical assistance, funding, and other specific measures that have proven to be beneficial in order to achieve more prosperous agribusinesses at all levels of agriculture. Of particular importance is the support for the use of modernized irrigation in family farming in all the ecosystems.

The agenda in this regard requires that the ministers of Agriculture strengthen their relations with other cabinet ministers and with the legislative assemblies or national congresses, so that both legislation and public investments related to water management consider seriously the conditions that exist in agriculture.

5.2 Institutional framework and governance

Since there are many entities with shared responsibilities for the management of water, mechanisms should be developed that promote the achievement of synergies and the effective use of water. The examples shown reveal the high value of harmonizing regulations among the national institutions on this topic at the national level and of strengthening capacities to implement the measures at the local level. Although in the first case the regulatory entity is the State, through the emerging national water authorities (NWA), at the local level (watershed, valley

or territory) the institutional framework is greater, since the participation of many institutional actors is required.

With respect to the national institutional framework, the major challenge is compliance with the mandate of the higher bodies. The NWA function as general oversight entities for water, so that it is essential that they know their mandates and are subjected to the standards established under the law. On the other hand, it is important that these higher authorities have the capacity to understand the specificities of the sector and the complexities that exist for the administration of water at the area-based level.

The examples provided above with regard to forms of local organization reveal that a significant step must be taken from what were committees of users in agriculture and administration of irrigation divisions, toward a more robust institutional framework which should have greater convening power, more responsibility to guide the appropriate use of water, more authority to enforce the regulations and more resources to operate effectively. The latter leads to the need for renewing the funding mechanisms for the management of water in agriculture and in other activities.

The agenda in this area implies that the ministers of Agriculture should reform the entities that are a part of the agricultural public sector to achieve cooperation on the topic of water in agriculture, as well as open the dialogue with respect to new types of relationships between the public entities and civil society organizations, especially at the area-based level, where harmony and consensus-building between the parties must be ensured.

5.3 Investment

In the 1960s and up until the eighties, there was important investment in multi-purpose dams and in canal systems for irrigation, and progress with water and sewerage systems for urban use was achieved. Although public investment has continued in this regard, this has not been the case in all countries with respect to increasing availability and supporting proper use of water in agriculture. Today, there is a pressing need for these investments, since the gap in public investment in this area is very obvious.

New investments for the integrated management of water, as pointed out earlier in this document, need to be made in many areas, including small and medium-sized reservoirs for the benefit of communities located on hillsides, the renewal of concrete channels for pipes, human resource capacity development, institutional modernization, systems for watershed protection through tree planting and other methods to improve plant coverage.

Each country should analyze its investment requirements for appropriate water management, schedule these investments, manage its financial resources with respect to the entities responsible for treasury and fiscal management and, when necessary, resort to foreign debt. This subject is of such high importance as far as national security is concerned that it can no longer be postponed.

The minister must emphatically place on the agenda of each country, and on the hemispheric agenda, the fact that water is today, and even more so in the coming years, the most valued natural resource, and that it is especially important to the viability of agriculture and food security. As a result, there should be a substantial increase in public investment that ensures the availability and quality of water for agriculture.

5.4 Human resources

The human resource capacities for adequate management of water should be created and strengthened according to the needs of the public and private sectors at several levels. This implies recognizing that there are limitations in the capacities of those who handle water on the farms, of engineers and technical personnel who offer technical assistance and training services, of those responsible for research, of managers of local consensus-building mechanisms and of those who handle the related public policies. For each case, alternative methods and different training contents are required.

There are many examples throughout the hemisphere of capacity building for these types of actors, carried out by nongovernmental organizations, state entities, special projects, and universities, among others.

The ministers should include on both the domestic and hemispheric agendas, the strengthening of all aspects of human resource training

related to the management of water resources, and especially of water in agriculture. The training programs in the primary and secondary schools, technical schools, and universities should be reviewed in order to promote a change of attitude and development of the required capabilities.

5.5 Support for IICA in expanding its work in water management

Proper water management in agriculture has been revived as an important linchpin in achieving innovation and increasing resilience to climate change. What has been outlined in this document provides a full account of what has been achieved in this regard by the producers, companies, national research entities and those who offer their support, together with the grain of sand that IICA has contributed to this enormous task.

The magnitude of this challenge was stated repeatedly in the document *Water: food for the land*, presented in 2013. However, time is upon us and we must hurry. The disasters caused by drought, on the one hand, and by floods, on the other, require that urgent measures be put in place to increase the resiliency of agriculture and adapt it to the new requirements.

The development of the hemispheric collaboration agenda is expected to pool the joint efforts of the national and local actors linked to the integrated management of water resources. Such efforts may be externally complemented through technical, bilateral, or multilateral cooperation, as well as the creation of international public goods. The way in which support from financial and cooperation international organizations has been used, has been successful on many occasions.

IICA's support to the countries in aspects related to water management in agriculture has been linked in several cases to agreements with technical and financial international cooperation agencies. Proof of this is the recent recognition that the Institute received in Brazil from the World Water Council, for five years of fruitful collaboration. IICA values highly these experiences in collaboration, recognizes that the opportunity for greater synergy in the area of water management in agriculture is broad and is aware that greater advantage can be gained

through complementing capacities. It therefore urges the countries to promote such cooperation between the international organizations.

The efforts that IICA has made have borne fruit, but in order to extend and deepen cooperation more resources should be allocated, so that the hemispheric agenda can be fulfilled. In this regard, IICA is recommending that the ministers of Agriculture access the range of services that the Institute offers, thus taking advantage of the experience acquired and its productive capacity in order to make more efficient use of the resources that the countries have in their public budgets, from international cooperation projects and from projects undertaken through external borrowing.

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