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Resources and Markets Branch

Achieving Sustainable Development Goals on Socially Inclusive and Sustainable Water through Fiscal and Pricing Reforms in Uruguay

Working Paper

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List of acronyms

BCU	Central Bank of Uruguay
WB	World Bank
ECLAC	Economic Commission for Latin America and the Caribbean
COMAP	Implementation Comission
DGI	General Tax Directorate
DINAGUA	National Water Directorate
DNE	National Energy Directorate
ECH	Continuous Household Survey
FAO	Food and Agriculture Organization
GEF	Global Environment Facility
IMESI	Internal Specific Tax
INAC	National Meat Institute
INE	National Institute of Statistics
IRAE	Income Tax on Economic Activities
VAT	Value Added Tax
MGAP	Ministry of Livestock, Agriculture and Fisheries
MIEM	Ministry of Industry, Energy and Mining
MVOTMA	Ministry of Housing, Territorial Planning and the Environment
OECD	Organization for Economic Co-operation and Development
MDG	Millennium Development Goals
SDG	Sustainable Development Goals
UN	United Nations
OPYPA	Office of Programming and Agricultural Policy
OSE	Sanitary Works of the State
GDP	Gross Domestic Product
PNA	National Water Policy
UNEP	United Nations Environment Programme
PPR	Responsible Production Project
PRENADER	Natural Resources Management and Irrigation Development Program
PUMS	Land Use and Management Plan
RPI	Investment Promotion Regime
SADI	Industrial drains
TNC	The Nature Conservancy
UNASEP	Private Sector Support Unit
UTE	National Administration of Power Plants and Power Transmissions

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1. Introduction

The main objective of this chapter is to present the national context regarding the problems related to the provision of water for the achievement of the Sustainable Development Goals (SDGs). Specifically, it will be deepened with regard to SDG 6: *Ensure availability and sustainable management of water and sanitation for all.* Apart from this being the main SDG related to water supply, ensuring its sustainable management is closely linked to SDG 12: *Ensure sustainable consumption and production patterns*, and SDG 13: *Take urgent action to combat climate change and its impacts.*

To achieve this objective, an exhaustive review of technical reports, both national and international, was carried out to systematize information related to the background of the SDGs, the role of fiscal instruments and pricing policies in the water sector, and the socioeconomic characterization of the agricultural sector in Uruguay.

The study will focus mainly on water quantity issues. Beyond the fact that the quality of water in Uruguay also represents a challenge, the focus of attention will be directed to agricultural irrigation and to the main competitor regarding the use of water, the generation of hydroelectricity.

1.1 Background on SDGs

The sustainable development goals (SDGs) came into force in 2016, after the 2030 Agenda for Sustainable Development was approved by the General Assembly of the United Nations in 2015. The SDGs take the advances achieved in the implementation of the Millennium Development Goals (MDGs), agreed by governments in 2001, as background information. With a holistic perspective and ensuring that nobody is left behind, the new objectives are universally applicable for all countries, while the MDGs were only addressed to developing countries. Furthermore, this holistic perspective allows us to recognize that the reduction of poverty in all its forms, the most important challenge facing the world, involves different strategies that contribute to economic growth, the fulfilment of social needs such as education and employment, and the fight against climate change and the care of the environment.

The 2030 Agenda for Sustainable Development includes 17 objectives and 169 associated targets, which cover the three dimensions of sustainable development: economic growth, social inclusion and environmental protection. Although the SDGs are not legally binding, governments are expected to adopt them as their own and establish national frameworks to achieve them (UN, 2016). They are intended to be used to frame their agendas and policies for the next 15 years. In this context, Uruguay presented its first voluntary report on the progress in the implementation of the 2030 Agenda, in the High-level Political Forum on Sustainable Development, held in New York in July 2017.

The first voluntary report submitted by Uruguay, reported on the situation of the different public policies, programmes, regulations and experiences in their implementation, which contribute to the fulfilment of the following SDGs: 1 "No poverty"; 2 "Zero Hunger"; 3 "Good health and well-being"; 5 "Gender equality"; 9 "Industry, innovation and infrastructure"; 14 "Life below water" and 16 "Peace, justice and strong institutions." Although SDG 6 was not included in this first voluntary report, issues related to water quantity and quality have played an important role in public policies, as we will see in the following sections.

SDG 6 seeks to guarantee the availability of water, its sustainable management and universal sanitation. This objective goes beyond drinking water, sanitation and hygiene, seeking to address additionally issues of quality and sustainability of water resources, which are fundamental for the survival of people and the planet. The 2030 Agenda recognizes the importance of water resources for sustainable development and the vital role that access to safe water, sanitation and hygiene play in other areas such as health, education and reduction of poverty (UN, 2016). The SDG establishes eight targets to be reached by 2030, ranging from achieving universal and equitable access to drinking water and sanitation, to the recovery and protection of associated ecosystems (Table 1).[1]

Table 1: Description of SDG 6, its targets and respective indicators

SDG 6. Ensure availability and sustainable management of water and sanitation for all		
Target	**Description**	**Indicator**
6. 1	By 2030, achieve universal and equitable access to safe drinking and affordable drinking water for all	6.1.1. Proportion of population using safely managed drinking water services
6.2	By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations	6.2.1. Proportion of population using safely managed sanitation services, including a hand-washing facility with soap and water
6.3	By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally	6.3.1. Proportion of wastewater safely treated
		6.3.2. Proportion of bodies of water with good ambient water quality
6.4	By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity	6.4.1 Change in water-use efficiency over time
		6.4.2. Level of water stress: freshwater withdrawal as a proportion of available freshwater resources
6.5	By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate	6.5.1. Degree of integrated water resources management implementation (0-100)
		6.5.2. Proportion of transboundary basin area with an operational arrangement for water cooperation
6.6	By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes	6.6.1. Change in the extent of water-related ecosystems over time

[1] To expand the reading and access more data, figures and targets regarding SDG 6 and other goals, please consult the following link.

6.a	By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies	6.a.1. Amount of water- and sanitation-related official development assistance that is part of a government-coordinated spending plan
6.b	Support and strengthen the participation of local communities in improving water and sanitation management	6.b.1. Proportion of local administrative units with established and operational policies and procedures for participation of local communities in water and sanitation management

Source: UN (2017)

According to United Nations data in 2015, 6.6 billion people (91% of the world's population) used improved sources of drinking water (UN, 2016). This proportion has increased by approximately 10% in relation to the situation in 2000. However, in 2015 it is estimated that 663 million people continue to use unimproved sources or surface waters.

In terms of access to sanitation, between 2000 and 2015 the proportion of the world population that accessed improved sanitation increased from 59% to 68%. However, 2.4 billion people have been left behind, among which 946 million people continue to practise open defecation (UN, 2016).

Although Latin America and the Caribbean are not the regions most affected by water stress, it affects more than 2 billion people around the world, and it is expected that this number will continue to increase (UN, 2016). Additionally, with different degrees of development, all the regions of the world are carrying out plans to achieve an integrated management of water resources as a fundamental aspect to achieve sustainable water management. This is particularly important in the face of future scenarios in which episodes of water scarcity are expected to be more severe as a result of the increase in extreme climate events associated with climate change.[2]

Uruguay has a high degree of compliance with respect to the targets related to access to drinking water (6.1), sanitation services (6.2), and the role of the State in providing official assistance for the provision of these (6.a) (Table 2).

Table 2: Summary of targets and indicators for Uruguay SDG 6

Target	Indicator	Type of Indicator	Location	Units	2013	2014	2015
6.1	6.1.1	Additional indicator	Rural	%	91,62	92,74	93,86
			Urban	%	99,89	100	100
			Total	%	99,47	99,64	99,71
6.2	6.2.1	Additional indicator	Rural	%	91,49	92,05	92,6
			Urban	%	96,31	96,47	96,62
			Total	%	96,07	96,25	96,44

[2] The level of water stress is understood as the percentage of extraction of fresh water in relation to the stock of available freshwater resources. In 2012, water stress in Latin America was 2%, well below the threshold of 25% that marks the first stages of physical water stress.

6.a	6.a.1	SDG Indicator	Total	USD (millions in nominal terms)	0,68	0,15	n.a

Source: UN (2017)

As expected, the degree of compliance is greater in urban areas than in rural areas, mainly as a result of the decrease in the scale costs associated with services related to infrastructure networks.

1.2 Evaluation of the role of fiscal instruments and pricing policies for water management

The main challenge facing the countries of Latin America and the Caribbean, in terms of compliance with the SDGs, is the need to mobilize internal resources to finance their goals. The task of elaborating proposals to achieve a better integration and greater coherence between the environmental policy and the set of public policies is key, with special emphasis on the fiscal aspects and the national budget with the environmental policy goals. The need to meet the goals that implies the improvement of environmental quality at the lowest possible economic cost, is imposed. In general, there is a context of fiscal constraints in the region that limits the possibilities of obtaining greater budgetary allocations, and therefore other options to self-finance progress in environmental management must be explored. Additionally, environmental regulatory institutions face the growing challenge of designing management instruments that are effective and economically efficient to achieve the goals that countries have set at national and local levels (Acquatella and Bárcena, 2005).

In turn, water consumption has certain characteristics that make it not a private good. In general, water consumption, depending on the use and the source being considered, is a public good or a common good. For example, if many agricultural producers extract water from a reservoir, where some cannot prevent others from extracting the amount they want from water, that good can be considered a resource of common use.[3] The characteristic of the property is directly associated with the exploitation rights of the resource. The incomplete assignment of the exploitation rights of the resource means that the resource is often used inefficiently. This situation should be corrected in order to increase the welfare of society as a result of the exploitation of the resource. This can be achieved, for example, through the design and implementation of public policies.

In general, environmental policy instruments are usually classified into two categories: 'market-based' and 'regulation and monitoring'. However, this classification is very limited because it is not enough to reduce the vast universe of existing instruments in two categories (Sterner and Coria 2012). Markets require the interaction of prices and quantities, while regulations are often backed by economic sanctions. Moreover, economic theory sometimes suggests, under certain assumptions, that the instruments that regulate quantities, such as standards, emissions targets, or permits, may be optimal.

Economy studies the decision-making processes of individuals. In that sense, any instrument that affects the decision-making processes can be considered an economic instrument of

[3] A private good is one that is excludable (who acquires it can prevent others from consuming it) and a rival (if an individual consumes more of that good others have less quantity of the available good). Two types of goods relevant to our discussion are public goods (non-rival, and non-excludable), and common-use goods (rivals but not excludable).

policy. That is, the supply of policy instruments is much broader than simple dichotomous categorization.

There are several taxonomies to classify the instruments according to the mechanism through which they seek to change the behaviour of individuals. Sterner and Coria (2012) propose a classification of policy instruments into four categories (Table 3). The first category is called 'using existing markets'. This includes the reduction of perverse subsidies, taxes and fees on emissions, inputs, or production, user fees and taxes, performance-related bonuses, deposit and refund systems, and the creation of specific subsidies. This category also includes reimbursements for emission payments and subsidized credits. In this category the price of water consumption, in any of its uses, could be considered.

The second category is called 'creating markets' and consists in the design of mechanisms that define property rights. As mentioned before, the lack of well-defined property rights is one of the market failures that make it difficult for private decisions to achieve a sustainable management of resources. The allocation of property rights does not mean the privatization of the environment, but often sustainable management is achieved through communal or public management. Well-defined property rights and low transaction costs allow the parties involved to reach an efficient solution to possible environmental damages that one party causes to the other (Coase, 1960). However, the solution may be different depending on which part has the rights assigned, with implications for both social welfare and justice (CORE 2010). However, sometimes this is the most efficient solution from a cost-effective point of view. An example of this type of instrument in relation to water consumption are water extraction rights, and their commercialization.

The category of 'environmental regulations' includes standards, prohibitions, permits or quotas (non-negotiable), and regulations that refer to the time and location where the activities are carried out (zoning). Licenses and legal liability rules also belong to this category, linking it to the disciplines related to law and policy compliance.

Table 3: Classification of instruments in the policy matrix

Using existing markets	Creating markets	Environmental regulations	Involving citizens
Reduction of subsidies	Property rights and decentralization	Standards	Public participation
Environmental taxes and fees	Permits and tradable rights	Prohibitions	Information disclosure
Fees and taxes for users	International compensation systems	Permits and quotas	
Deposit-refund systems		Zoning	
Specific subsidies		Legal responsibility	

Source: (Sterner and Coria, 2012)

Finally, the category 'involving citizens' includes mechanisms such as the dissemination of information, labelling, and the participation of citizens in the management of resources and the environment. In general, these mechanisms imply a voluntary participation of citizens.

Other mechanisms not included in this categorization but that are equally relevant are: direct provision of environmental services (such as the collection of solid waste), international agreements (very relevant to push greenhouse gas mitigation policies), audits and environmental certifications (mainly at the level of companies, which can be used in conjunction with labelling policies, provision of information), and macroeconomic policies in general (any fiscal, monetary, and commercial policy that has implications for the economy, and therefore, for the environment).

Thus all the previous categories seek to change the behaviour of the agents, but through different foundations. While the first two are based on monetary incentives, regulations are based on prohibitions and control. The regulation is supported by fines, while mechanisms through monetary incentives are backed by regulatory instruments. The mechanisms related to participation and information also seek to change behaviour, but through non-monetary incentives. However, these instruments are often used in conjunction with those of the other categories. In turn, while the first three groups are mechanisms that achieve a certain environmental goal ensuring compliance with it, the latter relies heavily on voluntary participation.

In general, there is not a single solution, or a single instrument that achieves the desired objective. Often it is the combination of instruments that provide the incentives, sanctions and information necessary to achieve environmental quality objectives. In turn, the biggest difference between the categories is that while enforcement is feasible when using instruments based on/creating markets and regulation, citizen participation programmes are voluntary.

In the international sphere, instruments related to the market-based categories have been incorporated and markets have been created for environmental management, in order to complement the traditional direct regulation schemes (Acquatella and Bárcena, 2005). This trend is mainly explained by the fact that these instruments offer a series of advantages with respect to instruments based on regulation. On the one hand, they represent greater flexibility for who is the object of policy, since individuals have the freedom to freely adjust their behaviour based on what is most profitable, allowing agents to minimize the cost of meeting environmental objectives, and so reduce the total expenditure necessary to achieve the established environmental quality goals (Lanzilotta, 2015). In turn, it allows the allocation of resources among individuals in a way that is more efficiently utilized. Additionally, the environmental manager needs less information regarding both the preferences of individuals and their level of use of the resource.

Market-based or creating markets instruments can also be a source of additional financing for States to fund environmental management and investments. The countries of the Organization for Economic Cooperation and Development (OECD) have made significant progress in this area, and there are several successful experiences of using economic instruments to raise funds for financing projects, programmes and environmental management services (Lanzilotta, 2015). However, in developing countries the effective application of economic instruments in environmental management has so far been relatively scarce.[4] The experience of the industrialized countries shows that, in the application of taxes, charges and environmental tariffs, the predominant objective has been the collection and not the creation of incentives to improve environmental quality (ECLAC/UNEP, 1997). Also in

[4] For some years, the OECD has compiled information on environmental taxes in a special database, in cooperation with the European Commission, the European Environment Agency and the International Energy Agency. The database can be consulted at the following link http://www.oecd.org/env/tax-database.

developing countries, the main purpose of these environmental management instruments has been the collection of funds.

1.3 Economic instruments applied in water management

The economic instruments for water management comprise a whole range of options, from taxes on extraction to the establishment of conditions for the functioning of water markets, that is, commercial transfers of the liquid or of the rights to its use. The provision of drinking water and sanitation is one of the services with the greatest impact on the health of the population. The objective of environmental policies, in relation to the use of water, should be to reduce its pollution, encourage efficient management, and improve access and its quality. Given its social importance, it is necessary to encourage good use of the resource, which is possible to achieve through the application of properly designed economic instruments (Lanzilotta, 2015).

Next, we will review the main instruments used for water management in Latin America, based on the conceptual framework developed by Sterner and Coria (2012) presented in the previous section. The most frequently used 'market-based' instruments regarding water use are taxes and fees. These are mainly applied to the use or extraction of water as a mechanism to control the amount used or to cover the operating costs of the services. In Brazil, for example, incentives have been introduced to improve performance by applying specific taxes to those activities that exceed the regulations on environmental quality standards. In this context, a charge for water resources was established through Law No. 9985, in which it is envisaged that organizations or companies, public or private, responsible for water supply, generation and distribution of electricity, or that make use of protected water resources, make a contribution in the form of payment (Lanzilotta, 2015).

On the other hand, within this same category, the rates corresponding to water consumption stand out, which are often designed and used for different purposes (Ortega, 2006). Efficient design is a crucial issue for water companies and local communities. The first objective of a price design for water services is to generate income that covers costs. However, any type of tariff must also fulfil two other functions: a price level that allocates costs fairly among users, while providing incentives for efficient use and water conservation.

In the case of Uruguay, the tariff has a fixed charge component, which depends on the tariff category (residential, commercial, industrial, etc.) and the diameter of the connection, and another variable charge (per cubic metre) that increases according to the consumption bracket. In turn, the variable charge per cubic metre for residential users is increased in blocks according to the volume of consumption. This seeks to discourage high consumption by adjusting the price depending on the volume demanded. Thus, the design of the tariff for consumption of drinking water penalizes the highest consumption according to a criterion of cautious use of the resource. However, this criterion does not apply to commercial and industrial users where the rate does not reflect costs. In these cases, the tariff establishes a limit from which the variable charge is lower, which does not seem to be economically justified since said cost is not determined by the scale of the consumption item. Experience has shown that, with efficient management and an adequate tariff structure, urban systems can even operate profitably in middle and high income countries (Lanzilotta, 2015). On the other hand, we find the case of Colombia, where the rates were adjusted to cover the costs of conservation of the watersheds supply based on the environmental organization "The Nature Conservancy" (TNC, 2017). Another example is the water company in Santiago, Chile, where there is a growing block rate system, complemented by an explicit consumption subsidy. This subsidy is aimed at the poorest 20% of the population and is higher in the tariff zones where water rates are higher and the average income of the lower income population is less (Sterner and Coria, 2011).

Subsidies or tax benefits to investments in irrigation systems or the adoption of technologies that affect the conservation of the resource, should also be considered in this category. This is the case of certain laws that, through tax exemptions to the sale of certain goods, seek to promote investments in technologies or machinery that generate savings in water consumption for irrigation. As an example, we find the Investment Promotion Law in Uruguay, which we will discuss later.

Another fiscal instrument within the present category is the so-called royalty for water use. In this line, an experience tending to improve the efficiency in the use of the resource is found in Costa Rica, where there is an environmentally adjusted water tax. This royalty must be paid by every physical or legal person, public or private, quarterly and in advance, generating public revenue and promoting the efficient use of water resources. According to data from UNEP (2010), before the application of the royalty, the average reference value of water in 2010 was USD 0.012 per thousand cubic metres per year. With the new structure, it averaged USD 4.76 per thousand cubic metres in surface water and USD 5.43 per thousand cubic metres in groundwater. In turn, the amount per flow assigned and by differentiated uses is established. In addition, in the case of groundwater, the complexity of its management and the value in its quality and safety are recognized, which is reflected in a higher charge.

In the case of environmental regulation instruments, there are not many examples of their application in relation to water consumption. In general, in Latin America, the most recent adoption of this kind of instruments in water management is associated mainly with the problems of pollutant discharges to water bodies (Acquatella and Bárcena, 2005). The water extraction permit systems fall into this category. In Uruguay, a system of allocation of permits for the consumption of non-potable water is applied, which is not charged while controlling its extraction by the need to request permits for such purposes in the National Water Directorate (DINAGUA-MVOTMA for its acronym in Spanish).

The systems of allocation of quotas or extraction permits can be complemented allowing the commercialization of the same among individuals. Once the extraction rights have been assigned by the competent authority, they can be marketed or traded, subject to a series of pre-established rules. Under different schemes, commercialization can occur within a facility or a company, between different facilities, companies or even between different countries. The systems of tradable permits are used to encourage the efficient use of natural resources, for example, in the extraction of water (ECLAC, 2015). In this way, the resource is poured into the use that provides a greater benefit to society, distributing the resources according to their initial allocation. An example of this is the case of Chile where water rights are privatized and there is a water market where these rights can be traded (Bauer, 2003).

Finally, within the instruments that promote citizen participation we find in Uruguay the case of irrigation boards as a clear example of public participation in issues related to water management. These spaces contribute to the improvement of the administration of water for irrigation, especially in times when there is less availability of the resource, setting irrigation schedules and coordinating actions among the irrigators themselves. Additionally, the Ecofluvial Network in Argentina supports research aimed at the conservation of large-scale water basins and the promotion of the integral management of these basins (TNC, 2017). This is a type of instrument based on technical assistance, trying to modify the behaviour of individuals by providing them with more information.

Water basin and aquifer commissions also work in Uruguay to give sustainability to the local management of natural resources and manage potential conflicts over their use, enabled for their creation based on the National Water Policy Law No. 18 610 of October 2nd 2009. The Watershed Commissions are integrated ensuring a broad representation of local actors with an active presence in the territory. Their role is to advise the Regional Water Resources Councils.[5]

Table 4: Fiscal instruments for the control of water use in Latin America

Category	Instrument	Application
Market-based	Taxes	Specific tax for the use of protected water resources (Brazil)
	Rates	Rates in increasing blocks to water consumption (Uruguay) Tariffs designed to cover costs of conservation of basins and water supply (Colombia)
	Combined (rate and subsidy)	Increasing block rate + explicit consumption subsidy (Chile)
	Environmental royalty	Royalty on the use of water (Costa Rica)
	Fiscal benefits	Adoption of technologies that affect the conservation of the resource (Uruguay)
	Water Funds	Public and private investment funds in the conservation of water resources (Chile, Colombia, Ecuador, Peru)
Creating markets	Rights of use of transferable water	Water use rights market (Chile)
Environmental regulations	Non-tradable permits	Permit to extract water (Uruguay). They are personal, but can be transferred with the corresponding authorization.
Promoting public participation	Public participation spaces	Irrigation boards (Uruguay) Basin Commissions (Uruguay) Ecofluvial Network (Argentina)

Source: Own elaboration.

[5] The Regional Councils of Water Resources have the following competencies: a) to formulate the Regional Plan of Water Resources, b) To accompany the execution of the Water Resources Plans adopting the necessary decisions for the fulfilment of their goals, c) to link the Executive Power with the other stakeholders involved in the formulation and execution of plans and other instruments of the National Water Policy, d) promote and coordinate the formation of Watershed and Aquifer Commissions, providing support through its Technical Secretariat, and e) advise and support the management of the Water Authority, f) formulate guidelines for the Local Water Resources Plans, g) promote the strengthening and effective exercise of the Right of Citizen Participation recognized in Chapter VI of the National Water Policy Law, h) propose general criteria for the granting of rights of use of water resources and for collection for their use, i) articulate actions with actors involved in drinking water supply, floods and drainage, fishing, river transport, hydroelectric use, land use, environment, hydrology, meteorology, among others, j) when required, advise on projects to take advantage of water resources, seeking their sustainability and efficiency, k) understand issues raised by the Watershed and/or Aquifer Commissions proposing dispute resolution mechanisms, linked to the use of water resources.

Another interesting instrument, which in general has been implemented through mechanisms that encourage citizen participation in a non-mandatory manner, are the Water Funds. These are independent organizations that receive permanent public and private contributions to invest in forest and riparian vegetation restoration activities, in sustainable production practices, among others, in order to improve the quality and availability of water. Examples of these operations can be found in Chile, Colombia, Ecuador and Peru (TNC, 2017).

At a general level, the different economic instruments can support the fulfilment of SDGs 6, 12 and 13, through the application of fiscal policies and reforms that imply, for example, charges on the extraction of water, or the granting of extraction rights of the resource. This makes sense only once the basic needs of the population, with regard to basic human rights have been met.

When we think about pricing policies for water consumption, a great challenge is to be able to assign a price to water when it is not possible to measure its consumption. While this may apply for any type of use, it is particularly relevant in regard to water for agricultural irrigation. However, there are some options that can be considered (Sterner and Coria 2012). The first is to apply a partial or a voluntary measurement. This requires that some users in particular must install metres, which can be identified from users who are particularly intensive (or wasteful) in the use of the resource, or other characteristics such as location. The second option implies that, maybe offering some users the option of installing metres, can be successful if the alternative is to apply a high fixed charge. The third option is to design policy instruments that aim to encourage the acquisition of certain types of capital investments related to water use. Finally, the authorities can regulate the choice of crops and agricultural practices, which are easier to observe.

1.4 National context of policy and challenges in the water sector

The quantity and quality of water are two closely related and interdependent concepts. The limitations of availability of water resources are added to the deterioration of the quality of water and that of aquatic ecosystems, generating conflicts between users and concern in society in general. As expressed in the National Water Policy (PNA for its acronym in Spanish), the integrated management of water resources requires the articulation of water quantity and quality and includes social, economic and environmental aspects, as a way to ensure its long-term sustainable use (PNA, 2016).

In Uruguay, the percentage of the population with access to drinking water is among the highest in Latin America and the Caribbean. 99.4% of the population has an improved source of water both inside and outside the home, 96% of the population has access to drinking water through supply networks and this figure rises to 98% for the population that lives in populated centres (INE, 2011). The lack of drinking water inside the house is considered as an unsatisfied basic need.[6] Just over 2.6% of the population does not have access to potable water through networks within the home and around 1.3% has water inside the house that comes from protected wells (category used by the INE), many of which, due to their characteristics and lack of potability control, cannot be considered as a drinking water supply. As stated in the PNA (2016), the country's challenge of universal access to drinking water lies in the extension of the service and in the generation of strategies for small rural housing centres and for the dispersed rural population.

[6] There is an improved source if the origin of the water is a general network of drinking water supply, or it is a protected rising well (INE).

Regarding water quantity management, the challenge is to adapt and expand the availability and use of tools for managing information on the amount of water available in cases of drought (real-time information, modelling) and promote the efficient use of drinking water by establishing regulations in this regard and deepening campaigns to disseminate good practices.

With regard to water quality, this can be directly affected by the development of various human activities. The sources of contamination can be of two types, specific or diffuse. The specific ones are those that come from a particular source, such as the drainage system of a city, industry, or a concentrated activity (dairy farms, feed lots, etc.), directly to the body of water. The main sources of this type in Uruguay are related to the discharge of wastewater or industrial water when these do not have previous treatments or are insufficient. The diffuse, correspond mainly to discharges by surface runoff of agrochemical compounds or natural nutrients derived from the use of the soil which cannot be associated to a single point of emission. Regarding this point, the challenge arises when it comes to continuing with the processes of protection and recovery of the superficial sources used for drinking water, to advancing in the management and protection of aquifers, and in the monitoring of the diffuse contributions of nutrients towards the bodies of surface water, as well as in the measures tending to their control, among others.

In terms of sanitation, the final disposal of wastewater of domestic origin in water courses directly impacts its quality. According to data from the ECH of 2015, 38% of households in Uruguay do not have a connection to the general sanitation network. This is increased to 45% of households if only the interior of the country is considered. Of the households without connection to the sanitation network, only 3% discharges directly to water courses or discharges the wastewater directly on the surface, while the remaining 97% has a septic tank or cesspit.[7] However, despite the existence of septic tanks, these can also represent a problem due to non-compliance with the waterproofing or handling requirements with regard to the frequency of emptying.[8] Another problem of additional contamination is the disposal of liquids collected by barometric trucks, generally with few controls.

In this sense, the fundamental challenge lies in expanding the coverage of sewerage networks, increasing connections in areas covered by networks, advancing the incorporation of technologies for the treatment and disposal of waste liquids, as well as updating the regulations on effluents for domestic wastewater and those of non-domestic origin (PNA, 2016).

Additionally, untreated industrial effluents also pose a risk to water quality. These specific sources of contamination must be treated prior to the final discharge to mitigate waste contamination. Although the DINAMA (MVOTMA) manages and controls the authorizations of industrial drains (SADI), those entrepreneurships that discharge their effluents into watercourses or infiltrated lands, represent a risk to water quality.

On the other hand, the diffuse sources in Uruguay are mainly associated with agricultural activities, as a combination of the use of agrochemicals and the productive practices implemented. Livestock activity has also been identified as a source of pressure, by letting cattle enter to drink along water courses, eroding the soil and affecting the quality of water

[7] Estimated data from the 2015 Continuous Household Survey of the National Institute of Statistics (ECH, INE).

[8] According to the National Water Plan (PNA 2016), the high operating cost for users, and the inability to meet the demand for the service, if it were correctly implemented, suggests that this is not fulfilled.

by contributions of organic matter and nutrients, and that can also be a source of microbiological contamination (PNA, 2016).

Agricultural activities also have an impact on the amount of water, which could come from the overexploitation of surface and/or underground sources given the inefficient use of water for irrigation. This can originate both in the excessive use of water and in the design and inadequate management of hydraulic works.

Law No. 16858 of 1997 states that irrigation for agriculture is of general interest. The requirements for the granting of concessions are: i) that there is available water in quantity and quality, in accordance with the regulations issued by the Executive Power, ii) that the applicant has a land and water use plan approved by the Ministry of Livestock, Agriculture and Fisheries (MGAP for its acronym in Spanish), in accordance with the provisions of the regulations of this law, and iii) the applicant is the accredited holder of a property right, usufruct or enjoyment of the land where the hydraulic works are settled or are affected by them. On the other hand, the Irrigation Law Project is proposed as a measure of adaptation and reduction of vulnerability to climate change, the basis for sustainable intensification. It is based on the use of rainwater that is lost by runoff, and promotes multi property irrigation projects allowing the inclusion of small producers.

There is also a regulatory framework that seeks to promote responsible and sustainable use of soils and surface waters. In this case, Laws 15239/1981 and 18564/2009 are included. Likewise, Decree 405/2008 aims to develop a productive use of the soil resource, with an emphasis on erosion.[9] It extends the obligation to elaborate and comply with a Land Use and Management Plan (PUMS for its acronym in Spanish) to other activities beyond those that apply irrigation systems. This begins to be applied in 2010 through a pilot stage in farms with cereal and oilseed agricultural systems. In 2013, the mandatory presentation phase began, establishing a certain graduality in terms of area and production systems. At present, the PUMS must be presented, in addition to the producers that use irrigation systems, by agricultural holdings or the holder of any title that sows more than 50 ha. of rain fed agriculture. In this context, the Sustainable Dairy Plans have a similar component to the plans for agriculture (presentation of crop sequences considering tolerable erosion) and an additional component of management of chemical and organic fertilization, as a measure to control the export of phosphorus from the productive systems to the water courses.

Regarding the availability of water resources in Uruguay, these are distinguished in surface and underground. The surface areas are grouped into different basins: Uruguay River (113 637 km^2), Merín Lagoon (33 000 km^2) and Río de la Plata and its sea front (34 110 km^2). Within the basin of the Uruguay river, the trans-border basin of the Río Negro (approximately 64 000 km^2) is included and, as part of the basin of the Río de la Plata, the main one is the Santa Lucía river basin (approximately 13 400 km^2), all entirely included in national territory (PNA, 2016). The MVOTMA has established an Action Plan for the protection of water in the Santa Lucia basin. The plan is aimed at protecting water quality by limiting the contribution of nutrients from diffuse sources of contamination[10].

In terms of underground water resources, the most important aquifers in the country are: Guaraní, Raigón, Salto, Arapey, the Cristalino Basin, the Cretaceous and Permian sediments

[9] This decree results from a process of revaluation, recognition and application of a set of regulations from previous years: Law 13,663 / 1968, Law 15,239 / 1981, Decree 126/1992 and Decree 333/2004.
[10] Ministerial resolutions: 966/2013, 1025/2013. Presidential Decrees: 282/013, 429/013)

and the Merín Lagoon Basin. To think about the management of water resources necessarily implies thinking about the management of watersheds and aquifers as basic units.

Depending on the specific flows of the volumetric regions and the degree of affectation of the superficial resource of the water courses, the PNA (2016) classifies with different degrees of availability such as:

- ✓ High availability: area where reference limiting values are not applied. They include the areas under the influence of the Merín Lagoon, the River Uruguay and the initial stretch of the Río de la Plata.
- ✓ Medium availability: areas where high competitiveness due to the use of the resource is not yet established.
- ✓ Low availability: areas where there is high competitiveness due to the use of the resource, it is even common to deny applications for rights of use.
- ✓ Low availability, bounded by UTE: Río Negro Basin, above hydroelectric dams. Cumulative maximum annual flow 16 850 l/s
- ✓ Low availability and conditioned by OSE: area where significant volume and flow is required by populations for use. Specifically, the Santa Lucía River Basin, above Aguas Corrientes.
- ✓ Saline intrusion: coastal areas of the Río de la Plata, Atlantic Ocean and lagoons with connection to the ocean.

With regard to the use of water, these are distinguished in two, surface and underground. Regarding surface water, it is by means of collection works from the water source and/or by means of storage works. The collection works are called intakes and are hydraulic works designed to extract water by pumping directly from a body of water. The storage works are dams, embankments, reservoirs and excavated tanks. Finally, the small-scale cattle troughs are excavated next to a water course, within the same channel, or the topography of the land is used to excavate and the extracted material is used as lateral retentions.

The use of groundwater is carried out through the construction of wells through one or more aquifer systems or through spring water collection works. [11]

Water for the agricultural sector

The predominant use of surface water in the country corresponds to agriculture under irrigation systems. The cultivation of rice is the main consumer of water, with 80% of the consumptive use of water resources (MVOTMA, 2017). Given the rainfall regime in Uruguay, irrigation is mainly used as a supplement to rainfall. The storage of water for irrigation is dominated by individual strategies and is carried out mainly by surface (irrigation by gravity) given its lower cost. Irrigation has developed in Uruguay to boost the expansion of rice, sugarcane, fruit and vegetable crops. As a result, most of the irrigation infrastructure (mainly reservoirs, intakes and wells) is located in the north and east (rice area) and in the south of the country (fruit and horticultural area).

The cultivation of rice is conditioned by the aptitude of the soil. According to data from the Rice Survey (harvest 2016/17) the area of greatest development of the crop is the east of the country, corresponding to 72% of the total area. The planted area is in a range of between 160 000 and 165 000 ha, being sensitive to the profitability of the crop and the availability of water resources.

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[11] The construction of the wells is governed by Decree No. 86/04 of "Technical Standard for the Construction of Perforated Wells for Subterranean Water Collection" and must be executed by companies authorized by the water authority (Perforating Companies License).

The area irrigated by irrigation type for the 2016/2017 harvest varies according to the region. In the central area, 78% of the surface is irrigated by gravity (mainly due to the presence of dams), whereas in the eastern area, 68.6% of the surface is supplied through irrigation systems by direct outlets (pumping). The presence of infrastructure in this area (direct outlets) could be used for a strategy of filling dams in winter through the intakes.

The number of farms, according to the aforementioned survey, was estimated at 426. The east area accounted for 66% of farms, the north and west coast 21% and the centre 13%. The lease, as is well known, is the main form of land tenure in the farms reaching 79% of the total area. In addition, most of the lease contracts are made under the modality of payment in fixed quantity of product (rice husk base). For example, in the 2016/17 harvest, the price paid for the use of land and water nationwide was 31.1 bags of rice per hectare. The cost of water reached 19.9 bags, while the cost of land represented 12.5 bags per hectare. The eastern area is the region where most is paid.

In the event that the profitability of the crop is high, the availability of water to make new direct outlets would depend on each particular area. In the east area, there is currently no possibility of installing new direct outlets, the central area is restricted by the production of electrical energy and in the north coast it would depend on where the crop is to be expanded. In the case of the use of dams, in the three areas there would always be possibilities considering the restrictions in the central area due to the use for hydroelectricity.

Without considering rice and sugarcane, in recent years there has been a growth in the irrigated area of corn and soybean crops. The technology of Pivot-Micro aspersion that is currently being incorporated for this type of irrigation, uses the resource more efficiently and requires little labour, so the cost per hectare is relatively low. It must be borne in mind that the Investment Law has played a very important role in the incorporation of this technology in the sector, which was accompanied in turn by a high profitability of the crops, stimulating the development of agricultural irrigation, an issue which will be deepened later in this work. In conclusion, an increase in water demands for agricultural irrigation, basically for the area located on the west coast could be expected. A plan that considers the expansion of irrigation in summer crops in this area, and that wants to take advantage of the development that they have had so far, will require the provision of reservoir infrastructure, distribution and water conduction.

The MGAP is carrying out an Agriculture Development project under irrigation systems in Uruguay, in which the *Development Strategy for Irrigated Agriculture in Uruguay* has been drafted. The analysis presented in this document is based on an initial situation, with an irrigated area of 181 000 ha of rice and 55 000 ha of other crops (excluding horticulture and sugarcane), and three growth scenarios of the area under irrigation are elaborated (trending, medium and high) until the year 2045, without discriminating the spatial distribution.

According to the projections made by the MGAP, the increase in demand for agricultural irrigation of traditionally rain fed crops is foreseen. It is expected that the irrigation of crops such as corn and soybean will be implemented in those areas where the production of these crops is currently concentrated and where there are possibilities of having enough water.
As already noted, both current uses and water availability vary from one region to another and the irrigation permits already granted in the whole country add up to a volume of 3 600 hm^3.

The MGAP has also initiated studies to analyse the use for irrigation purposes in the basins of the rivers Arapey, San Salvador and Yí, in all cases considering the need to resort to reservoirs to ensure the flows required for that use.

Finally, the project to modify the Irrigation Law is currently under parliamentary treatment. With this, the promotion of a regulatory framework that supports the development of major reservoir projects among a group of neighbours and/or these with investors and/or operators specialized in irrigation management, is sought.

Water for the generation of hydroelectricity and other uses

Uruguay's state electric power company, National Administration of Power Plants and Transmissions (UTE for its acronym in Spanish), owns three hydroelectric plants on the Rio Negro and a binational hydroelectric plant, the Salto Grande dam on the Río Uruguay.

The main competition for the resource occurs in the Río Negro basin. The upper basin of the Río Negro, with approximately 40,000 km^2, is located in the northeast of Uruguay, covering part of the departments of Tacuarembó, Rivera, Durazno and Cerro Largo. The Gabriel Terra hydroelectric dam is located in its closure, downstream from where the hydroelectric dams of Baygorria and Constitución are located. This system, formed by the 3 hydroelectric dams of the Río Negro, represented 15% of the total installed power of the country and 25% of the total electric power generated in it in 2015 (DNE, 2016). Likewise, there is an increasing demand of water for irrigation in the basin, especially for rice, which resulted in a large number of individual reservoirs (with a wide range of dammed volumes from 0.02 to 17 hm^3). Decree No. 160/1980 limits the extraction of water from reservoirs (which condition not only the construction of reservoirs to reserve water, but also the capture by direct intake) of the Rio Negro and the tributaries that feed them to ensure the use for power generation. The current extraction limits assigned by UTE (Resolution No. 10-1154 of 08/27/2010) are 1 000 hm^3 for reservoirs and 16,850 l/s for direct intake. As of March 2013, the estimated use is 796.4 hm^3 for dammed volumes and 14 860 l/s for direct intakes, including permits granted or pending. Therefore, there would be a remaining volume of 203.6 hm^3 for dammed volume and 1990 l/s for outtakes (PNA, 2016).

On the other hand, the basin has an important percentage of forest priority soils (40%) in which, since the enactment of the Forestry Law of 1987, the forested area has increased exponentially year after year, reaching currently an area of approximately 400 000 hectares. The increase in the demand for water as a consequence of new scenarios of agricultural and forestry production within the basin, the increase in the demand for electric power that has been registered in the country in recent years and the strong inter-annual variability of rainfall, that characterizes the climate of Uruguay, highlight the need to have instruments that allow managing the use of the resource efficiently.

1.5 Socioeconomic characterization of the agricultural sector

The productive structure of Uruguay is closely linked to the development of activities based on natural resources. The Uruguayan agricultural sector is characterized by great dynamism, conditioned by several factors, including international prices, the productivity of some crops and livestock and the high quality and image of Uruguayan meat worldwide. In general terms and from a historical perspective, there is a positive correlation between growth of the economy and growth of the agricultural sector.

The agricultural Gross Domestic Product (GDP) represents a little more than 6% of the national

GDP in 2016, considering agricultural production as a whole (agriculture, livestock, hunting and forestry). Despite its low share in the national GDP, the primary sector is very relevant in terms of the entry of foreign currency into the country through exports. Approximately 28% of national exports are products of primary origin (BCU, 2016). Among these, cereals and oilseeds (wheat, corn and soybeans mainly) and meat (cattle and sheep to a lesser extent)[12] stand out. Given this, it is not surprising that Uruguay has benefited in recent years from the high price of food raw materials.

However, the participation of the primary sector in employment is lower. Only 8% of the total number of employed people in the country are in the agricultural sector and of this, only 3% is employed in farming (ECH, 2015). As for the indicators associated to the labour market in the agricultural sector, they maintain the existing deterioration at the national level since 2015, where the unemployment rate exceeded 8% in the country's total during the third quarter of 2016. The unemployment rate in rural areas also increased and stood at 7% in the same period (Recent performance of the Uruguayan economy and of some variables relevant to the agricultural sector, OPYPA 2016).

Although these primary activities (non-mining) have a reduced incidence in terms of product measured at constant prices, in a study carried out by the Ministry of Livestock, Agriculture and Fisheries (Terra et al., 2009), it is found that the multiplier effect of the sector (6.2) is higher than the multiplier effect of industry (5.5) and that of services (6.1). This confirms that the development of the first has important spillover effects on the economy as a whole (Lanzilotta, 2015).

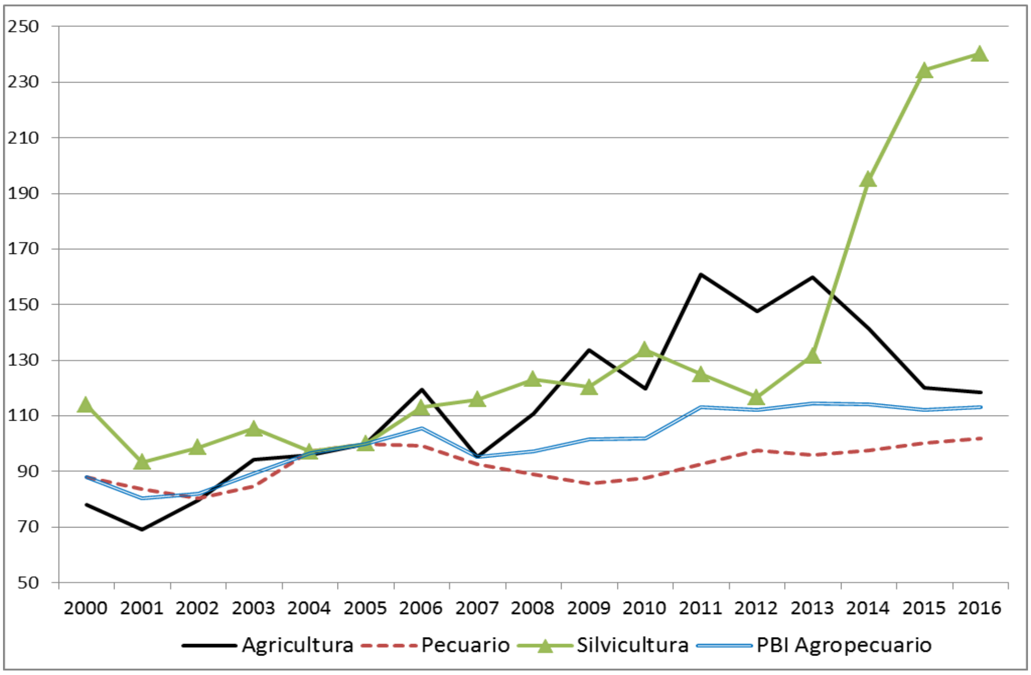
From the Input Product Matrix to 2005 it is concluded that agro industries have strong backward linkages, generating a dispersed stimulus in several sectors of the economy. For its part, the agricultural sectors of livestock production, milk, fruit, rice and cereals have strong forward linkages. However, the sector that has the strongest forward linkages is trade, followed by refinery and other services. In general, the different items of agricultural production demand few imported inputs, except cereals and oilseeds. In contrast, some agro industries are demanders of imported inputs and are additionally export-oriented sectors, such as knitwear, textiles, refrigerators, dairy companies, rice mills and pulp mills (Terra et al., 2009).

Even though the agricultural sector has a smaller direct impact on GDP and employment, it is a sector that presents linkages with other sectors and employment and product multipliers, which are important. Therefore, when defining sectoral, commercial or macroeconomic policy priorities, the government should take into account the impacts on this sector. In particular, the employment multiplier for low or unskilled labour is the highest in the economy (Terra et al., 2009).

Regarding the dynamics of the agricultural sector, Figure 1 on the evolution index of the agricultural and livestock GDP shows the evolution of the sector in Uruguay between 2000 and 2016. There is a period in which the agricultural and livestock GDP data shows a relative growth where an average annual rate of 1.6% was recorded.

[12] According to information from Uruguay XXI: www.uruguayxxi.gub.uy

Figure 1: Agricultural and Livestock GDP evolution index



Constant prices (base year 2005)
Source: National Accounts Information of the Central Bank (BCU for its acronym in Spanish)

Beyond this dynamic at an aggregate level, within the sector the performance has been very heterogeneous. For example, the forestry and agricultural sectors stand out as the engines of agricultural growth in contrast with the lower dynamics of the livestock sector. In short, the first two sectors become the most responsible ones for an important productive transformation of the economy.

According to BCU data, the GDP of the primary phase of forestry, timber extraction and related services has shown a growing trajectory, exhibiting an average annual growth rate of 7.8% in the last decade. In the same period, the participation of the primary sector of the forestry chain in the global GDP has remained relatively constant, at around 0.5%.

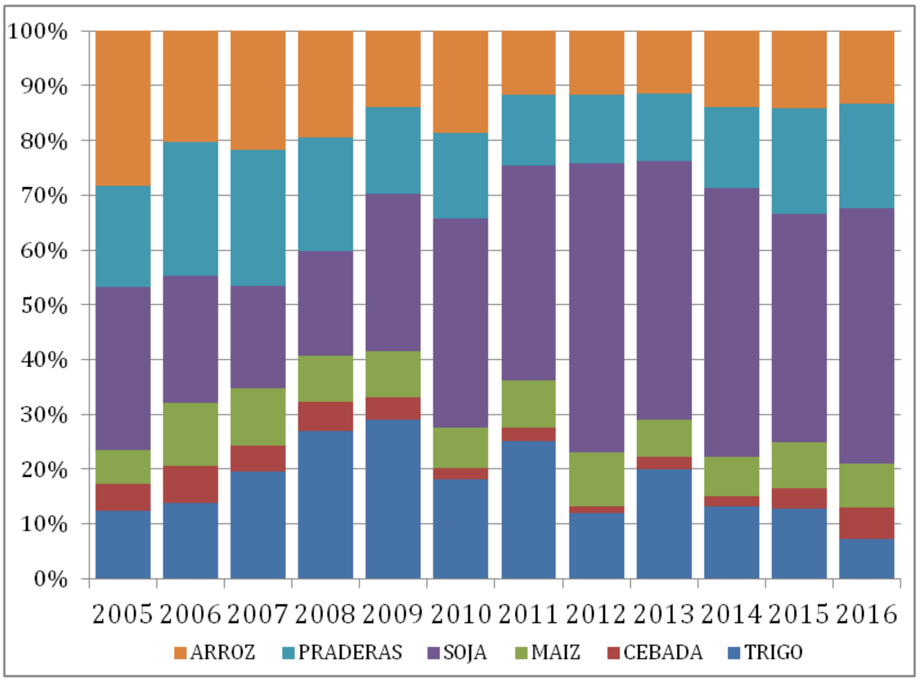
For its part, the added value in the industrial phase has also shown a strongly growing trajectory, fundamentally from the beginning of the activities of UPM's pulp mill at the end of 2007. Between 2006 and 2012 Uruguay's pulp production increased almost 40 times. At the same time, the installation of Montes del Plata in mid-2014 almost doubled the country's pulp production.

The forestry sector had a significant share in the total Foreign Direct Investment (FDI) in Uruguay. According to data from Uruguay XXI between 2004 and 2013, the FDI accumulated in forestry, wood production, wood products, paper and the construction of pulp mills exceeded USD 4 000 million. In short, the industrial phase has had an annual average growth of 34% in the last decade, which consolidates the wood forest complex as a new value chain in the Uruguayan productive structure.

As for agriculture, it moved from a subsidiary to a specialized activity with high levels of investment, which brought about strong transformations and trends in recent decades. Mainly it was with the soybean that agriculture experienced an exceptional development during the years 2000 and 2013. Between those years, agriculture registered an average annual growth of 6%. Rain fed agriculture and principally the soybean, occupied about 12 thousand hectares in the year 2000. Today it occupies an area of more than 1.2 million hectares.

As shown in Figure 2 on production of the main crops of the country, the soybean represents an increasing share of the total production of extensive crops, rice, pastures and other applied agricultural services. As of 2012, soybean production accounts for about 50% of total crop production.

Figure 2: Production of the main crops of the country

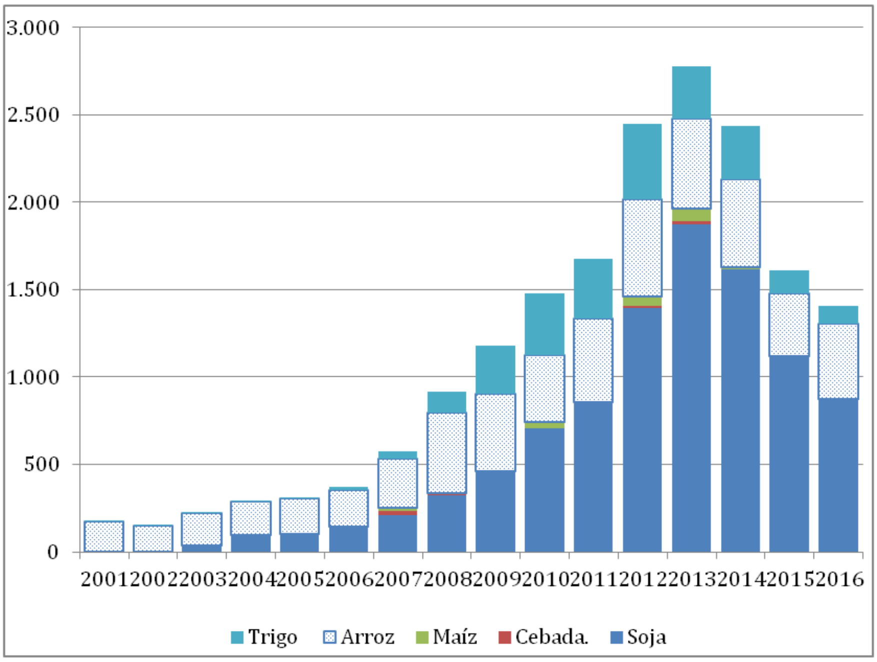


Source: National Accounts Information of the Central Bank (BCU)

The traditional producer gave way to networked companies who assumed the risk of sowing without having the land and at the same time contracted different agricultural services. Thus, the sowing pools were expanded through different societies whose main origin was the Argentine one, as one of the main driving factors of agriculture. In short, agricultural production grew because it expanded, but also because it intensified, made improvements in machinery, had better fertilizers and also better management.

Another key element of this radical and accelerated change is the growth of grain exports. Soy, which at the beginning of the 2000s practically did not exist, in a matter of very few years has become one of the main export products, together with meat and pulp. In 2001, exports reached USD 175 million, of which soybeans had a weight of 1%, while rice represented 98% of the total value exported. On the other hand, in 2013, total exports reached USD 1 420 million, where soybeans accounted for 61%, followed by rice with 30% of total exports.

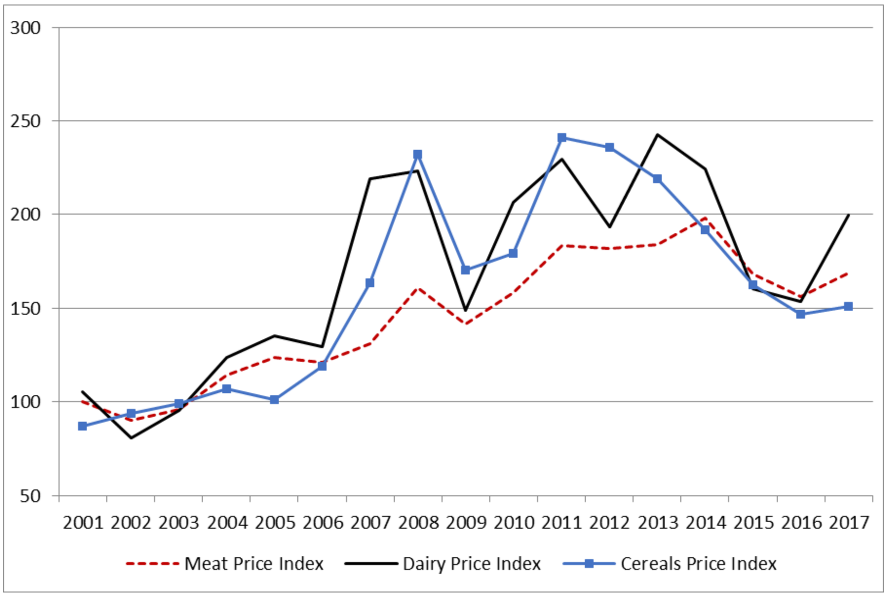
Figure 3: Exports of main crops (millions of dollars)



Does not include exports from free zones
Source: Customs

Throughout the period or a large part of it there was a very favourable international context, with sharp increases in commodity prices (see Figure 4).

Figure 4: Evolution of the food price index (meat, cereals and milk)



Source: Own elaboration based on FAO data[13]

The impact of the 2009 global financial crisis on the formation of international prices is also evident in the figure. The conditions of the low interest rates favoured a dollar which was

[13] The FAO food price index is a measure of the monthly variation of the international prices of a basket of food products. It consists of the average of the price indices of five groups of basic products, weighted with the average export quotas of each of the groups for 2002-2004.

more depreciated globally and consequently a higher price of international commodities. These prices are formed in dollars and therefore a weakened dollar stimulates a higher price of commodities internationally.

Another important and determining point was the growing demand for food by China. The growth of India's economy also increased world demand considerably not only for common products but also for more sophisticated ones.

As of 2013, global conditions began to change, and, as a result, directly affected the dynamics of the agricultural sector. In macro terms, the drop in international prices and the lower returns have removed some dynamism from agriculture and therefore planting and production areas have been reduced. In this way the agricultural sector is going through a market situation that in recent years has made it less attractive. Soybeans have remained stable in their level of activity, while other crops have had gone downwards as in the case of wheat. Other crops that contributed to the sector, such as barley and rapeseed, also appeared.

These factors had an impact on the exports of the main crops that place their production in the external market. Exports went from USD 2 777 million in 2013 to USD 1 420 million in 2016. In turn, the sector went from growing at an average annual rate of 6% between 2000 and 2013 to contract in the last four years at an average rate 10% per year according to BCU data.

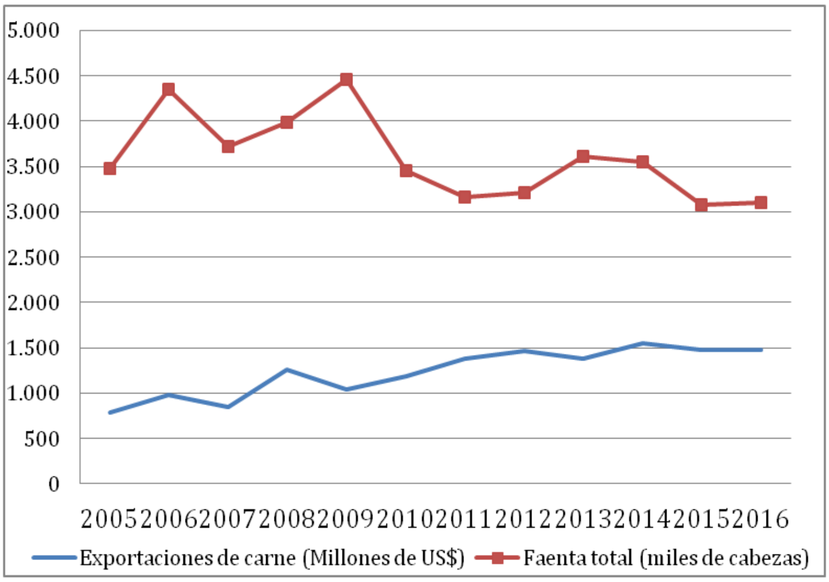
Anyway, the agricultural expansion that was registered in a large part of the study period generated important challenges for livestock production because it competed for land resource and this implies the need for an important modernization in the productive processes, in the search for a greater intensification. In this sense, dairy was an exemplary sector since it has been able to increase productivity per hectare in recent years.

In the same line, beef cattle suffered a loss of land that should have counteracted with a higher production of meat per hectare to achieve better profitability. The greater specialization of the producers makes the business more efficient and causes an increase in the scale of production based on more intensive fattening (supplementation). Added to this are the good sanitary and institutional conditions that allow improving access to international meat markets.

From 2000 to 2016, the livestock sector registered an average annual increase of around 0.9% on an annual basis. Although it was the sector within the agricultural sector that grew the least, it did not present large fluctuations in its evolution. The worst blow to the sector is at the end of 2001 with the foot-and-mouth crisis strongly affecting the meat industry. At that time the meat export markets closed, which reopened after a few months, boosting the recovery of the sector.

As can be seen in Figure 5 on exports of meat and slaughter of cattle and sheep, meat exports grew throughout the period of study. On the other hand, the slaughter, although it had its maximum peaks in 2006 and 2009, during the last 6 years (2011-2016), remained on average around 3.2 million heads. This behaviour of the main variables of the sector could have influenced the variability of livestock GDP.

Figure 5: Exports of meat and slaughter (cattle and sheep)



Source: Customs and INAC

Cattle activity peaked in 2006, when the slaughter reached the historical record of 2.5 million head slaughtered. The 2009 peak is mainly due to the sheep slaughter that was accompanied by an increase in the price to the producer throughout the year, after the sharp fall that occurred around the middle of the second half of 2008.

In short, the agricultural sector has grown in recent years, particularly in agriculture and forestry, which gave a very important boost to the economy of the country as a whole. In addition, this dynamic fostered a structural transformation that led to a substantial improvement in the dynamic competitiveness of production.

One of the strengths of this dynamic has to do with a more entrepreneurial agricultural sector. It is coordinated and worked among different specialized agents, structured in a network, in which companies that provide all kinds of services have been developed. Likewise, the growth of sectors based on natural resources is increasingly supported by knowledge-intensive activities. The development of synergies between the goods and services sectors generates structural competitiveness. The diversification of target markets also contributes to this dynamic. When compared in terms of markets, during the years 2000 and 2004, Uruguay was a country essentially concentrated in the region. 35% of exports were destined for Argentina, Brazil, Paraguay, Chile and Peru. In the period between 2013 and 2016, the destination matrix is more diversified. The region has lost importance, while the incidence of China and Russia as a destination for exports is growing.

To this external factor we must add the local context that allowed the productive expansion of the sector. Some elements that played an important role in this process were; the regulatory framework, public policies and the set of tax incentives that were deployed to stimulate investment. According to data from the Office of Programming and Agricultural Policy (OPYPA for its acronym in Spanish) it is estimated that, in the agribusiness sector, investments were promoted between 2008 and 2016 worth approximately USD 4 312 million. In addition, the participation of agribusiness in investments occupied between 20% and 29% of the total investments promoted by the Implementation Commission (COMAP for its acronym in Spanish) in recent years.

2. Analysis of the current framework of fiscal and pricing policy in the case of water

The objective of this chapter is to offer a systematization of the experiences of the use of fiscal policies related to the use of water for agricultural irrigation in Uruguay and the competition with the generation of hydropower.

2.1 Description of the application of fiscal instruments and pricing policies related to water consumption for agricultural irrigation and hydroelectricity in Uruguay

A set of fiscal instruments that are related to the promotion of the use of agricultural irrigation practices have been identified in Uruguay. Some of the benefits that irrigation projects have or can access are mentioned below.[14]

The Investment Promotion Regime (RPI for its acronym in Spanish) (Decree 455/007) proposes tax exonerations in order to promote productive investments in the country. At the end of 2007, the Executive Branch issued the new Regulatory Decree of the Investment Promotion Law of 1998 (Law No. 16906). With this, important differences are registered with respect to the one in force until then. In the first place, the possibility of access to tax benefits for all economic activities is generalized. Second, access to benefits is allowed to all corporate forms of companies. Third, criteria are established to link the amount of the benefit granted to the contribution of the projected investment to explicit national development objectives.

The Implementation Commission (COMAP) is created, within the orbit of the Ministry of Economy and Finance, as an advisor to the Executive Branch and coordinating with the corresponding sectoral ministries for the implementation of the regime (Carbajal et al., 2014). It is composed of representatives of the different ministries plus the Planning and Budget Office (OPP for its acronym in Spanish) and is responsible for the evaluation and monitoring of projects. The process, from the request of the promotion to the application of the benefit, comprises a series of stages guided by the regulation, as well as by resolutions of the COMAP and the General Tax Directorate (DGI for its acronym in Spanish).

The tax benefits extend to exemption of the Wealth Tax (IP for its acronym in Spanish) of civil works for eight years in Montevideo and ten years in the rest of the country, and of movable property of fixed assets for all their useful life. The IP is a tax levied on the assets, located in the country, of industrial and commercial companies and agricultural holdings at the end of the annual financial year. For the purpose of its determination certain debts are deducted from assets, valued according to fiscal rules, applying a rate of 1.5% to the difference. [15]

The exemption of the Value Added Tax (VAT) and the Internal Specific Tax (IMESI for its acronym in Spanish) is provided for the importation of the goods that form part of the promoted investment. VAT taxes the internal circulation of goods and the rendering of services within the Uruguayan territory, the imports of goods and the aggregation of value originated in the construction carried out on real estate. Exports are taxed at a zero rate (0%),

[14] A brief operational definition of fiscal incentives characterizes them as reductions in the tax burden, to stimulate the investment of certain companies and projects that the Government wishes to promote.

[15] In the case of banks and financial houses, the tax rate amounts to 2.8%.

so they are not effectively subject to VAT payment. The basic VAT rate is 22% and there is a minimum rate of 10% applicable essentially to basic necessities and medicines.

In contrast, the IMESI taxes the first sale made by producers and importers of certain products (cigarettes, alcoholic beverages, soft drinks, cosmetics, etc.) in the local market. Exports are not taxed. The rate varies for each taxable item and is generally set by the Executive Branch within parameters established by law.

In turn, the Executive Power is empowered to grant an accelerated depreciation regime for income taxes for the goods included in the objective scope. With regard to the amounts of benefits in the IRAE, the exemption will be defined based on the application of the indicator matrix and the score obtained in it, which will be defined in the following paragraph. The exonerated tax may not exceed 100% of the amount actually invested in the assets detailed in the project, nor the 60% tax payable in each of the years included in the promotional declaration.

As already mentioned, it is established that the amount of exemptions is determined by computable scores for each investment project derived from a matrix of criteria and ranges of anticipated performance. Regarding the evaluation criteria of projects for the granting of the benefit, these are: "generation of employment", "increase in exports", "increase in R+D+i", "use of clean technologies", "decentralization" and "sector indicators ".[16,17]

The criterion of the use of clean technologies dictates that the projects that include investments destined to cleaner production (CP), be favoured in points. In this sense, the law benefits not only the use of renewable and clean energy, but also all the businesses that make use of clean technologies, whether they avoid or mitigate the pollution derived from the productive processes (both water and air) that promote the efficient use of resources (water, energy, materials) and that properly manage waste.[18] That is why this law is an instrument that benefits and promotes the adoption of irrigation systems in agriculture.

Additionally, in 2012, as of Decree 002/012, the new methodology for evaluating investment projects comes into effect. One of the main objectives of the new regime, and that corresponds to the present analysis, is to "Increase the incentives for investments in Research, Development and Innovation, use of Cleaner Technologies and energy efficiency, enhancing the externalities that these investments generate" (UNASEP, 2012). To this end, the new regulations allow investments in irrigation systems for agricultural use to count both for the CP indicator as well as for the new sectoral indicator of the MGAP for adaptation to climate change. That is, now said investments are considered in two of the five indicators of the general matrix. This includes investments in water reservoirs (dams), water conduction systems, irrigation systems and water supply systems for animals, among others.

Figure 6 presents the number and amount in dollars of agricultural projects approved until 2016. Prior to 2008, very few agricultural projects were approved (4 in 2006 and 2 in 2007). As of 2007, with the change in the decree, there is an increase in the number of promoted projects belonging to this sector.

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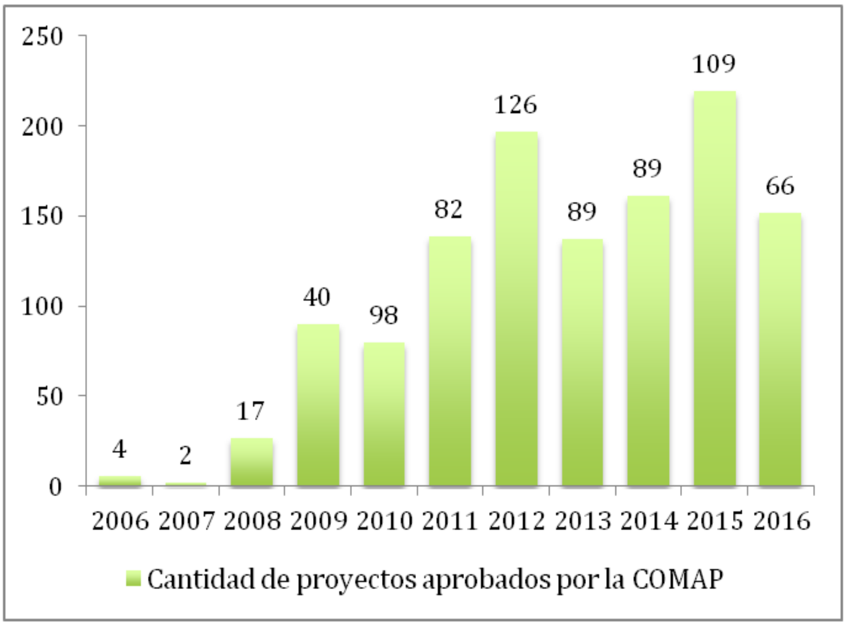
[16] Investment in Innovation and Development.

[17] Specific indicators that, according to the sector of activity of the investment project, companies may opt for a sectoral indicator.

[18] Following the definition of UNEP, this refers to the continuous application of an environmental, preventive and integrated strategy to productive processes and products and services, to increase global efficiency and reduce risks to humans and the environment.

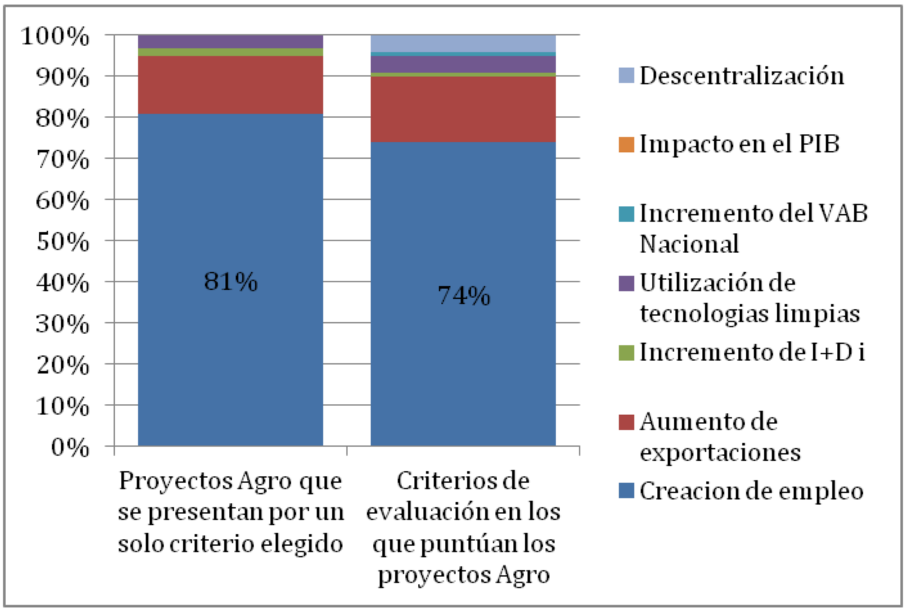
Figure 6: Number of projects approved by COMAP in the agricultural sector and total amount of investment in millions of USD



Source: Own elaboration based on data from COMAP-MEF and MGAP.

Figure 7, on the description of projects promoted between 2008 and 2010, presents the proportion of projects promoted in the agricultural sector in that period according to the evaluation criteria for determining the fiscal benefit (projects may request to be evaluated by specific criteria or scored in all) (Carbajal et al., 2014). It is observed that the seven criteria mentioned are incorporated very unequally in the mechanism of allocation of benefits.

Figure 7: Promoted projects between 2008 - 2010 according to evaluation criteria



Source: Data of Carbajal et al. 2014.

A very significant number of projects requested to be evaluated on the basis of job creation or increased exports and only 4% have requested to be evaluated based on the use of cleaner technologies.

If the investments promoted by the MGAP are analysed in the period 2008 - September 2016, the highest percentage in value is represented by the silos, followed by the investment in machinery (Table 5, Projects recommended by the MGAP according to the type of investment). Investments in irrigation projects and irrigation machinery occupy the third and fourth place in terms of the percentage of participation of the total investment, as described in the table below. The total amount of the investment in the analysed period in this type of projects (irrigation and sprinkling and machinery) totals USD 207 million, representing more than 20% of the total investments promoted by the MGAP. According to data from OPYPA (2016) the first place, in terms of the number of agricultural projects promoted, is in those projects where the main investment is in agricultural machinery and secondly in irrigation.

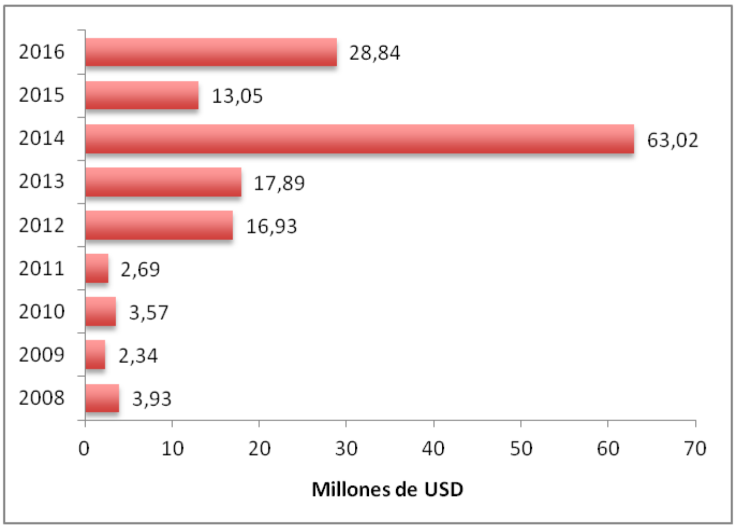
Table 5: Projects recommended by the MGAP according to type of investment (2008 - set 2016)

Classification by type of Investment	Investment in millions (USD)	Share in total investment
Silo	310	31%
Machinery	231	23%
Irrigation	110	11%
Irrigation and machinery	97	10%
Forestry machinery	96	9%
Dairy Farm	74	7%
Windmill	50	5%
Rest*	43	4%
Total	1.011	100%

Source: OPYPA (2016).
(*) includes: olive oil factory and machinery, rations factory, automatic cages for laying hens, packing, slaughterhouse and preparation of poultry rations, slaughterhouse for pigs, others

After Decree 02/2012 entered into force, irrigation projects and investments associated with this activity have increased (see Figure 8). In 2014, a project based on pasture irrigation, that represented 70% of the investments in irrigation of that year, stands out (OPYPA, 2016).

Figure 8: Evolution of investments promoted in irrigation (2008 - Set 2016)



Source: OPYPA (2016). (*) Only projects promoted whose main investment is related to the use of water in the agricultural sector are considered.

On the other hand, some products can be considered agricultural inputs and be exempted from the Tariff and Consular Fee by Decree 194/979. Also, through decrees 220/998 and 59/998 they will be exempted from VAT and IMESI in the acquisition of imported goods or in place that are related to irrigation.

2.2 Estimation of collection and costs of existing measures and programmes

Regarding the results of the evaluation of investment by projects promoted under the Investment Promotion Law, it is possible to compare the characteristics of the promoted projects and their externalities under the previous and current regulations (period January 2013 - October 2014). According to data from UNASEP (2015), the strong incidence of the CP indicator in the total of approved projects and investment amounts in said comparison is highlighted. The investment in CP reached USD 1 833 million in less than two years, which translates into an average investment in CP per project of USD 17.3 million, with 106 approved projects. To a large extent, this high amount is explained by the strong presence of wind farm projects with significant amounts of investment in this period. To better understand the behaviour of the indicator if the wind projects are deducted, which represent 79% of the total, the investment reaches USD 380 million. This corresponds to 84 projects, with an average of USD 4.5 million per project. It also highlights the inflow of investments in Adaptation and/or Mitigation of Climate Change (A+M) used by 32 projects, with an average investment per project of USD 2.4 million.

Table 6: CP indicator (January 2013 - October 2014 period)

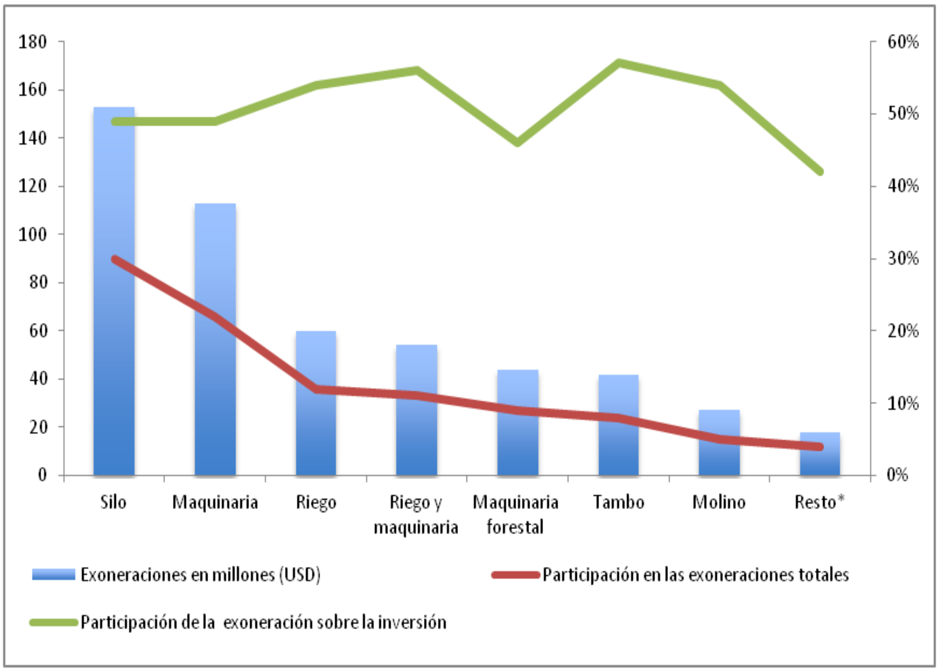
CP Indicator	Number of projects	Investment in millions of USD	Average per project in millions of USD
Only wind farms	22	1 452	12.7
Without wind farms	84	380	4.5
Total CP	106	1 833	17.3

Source: UNASEP Data (2015)

Regarding the fiscal benefits of existing measures and programmes that promote the adoption of irrigation systems in the agricultural sector, the investment promotion regime is the most significant. As it has already been pointed out after the changes in the criteria of the General Investment Promotion Regime (Decree No. 002/012), irrigation projects in the agricultural sector benefit, facilitating exemptions in income tax that may exceed 60% of the investment. The opportunity in this sense is to combine this investment in the irrigation system (with the benefits described above), with other investments in infrastructure, machinery, etc., in order to maximize the benefit for the company.

In the 2008 - September 2016 period, the exonerations on the investments promoted by the MGAP constituted 23% of the total exemptions of that period. The value of these amounts to USD 114 million (Figure 8).

Figure 9: Exonerations of the projects recommended by the MGAP according to type of investment in millions of USD (2008 – September 2016)



Source: OPYPA (2016).

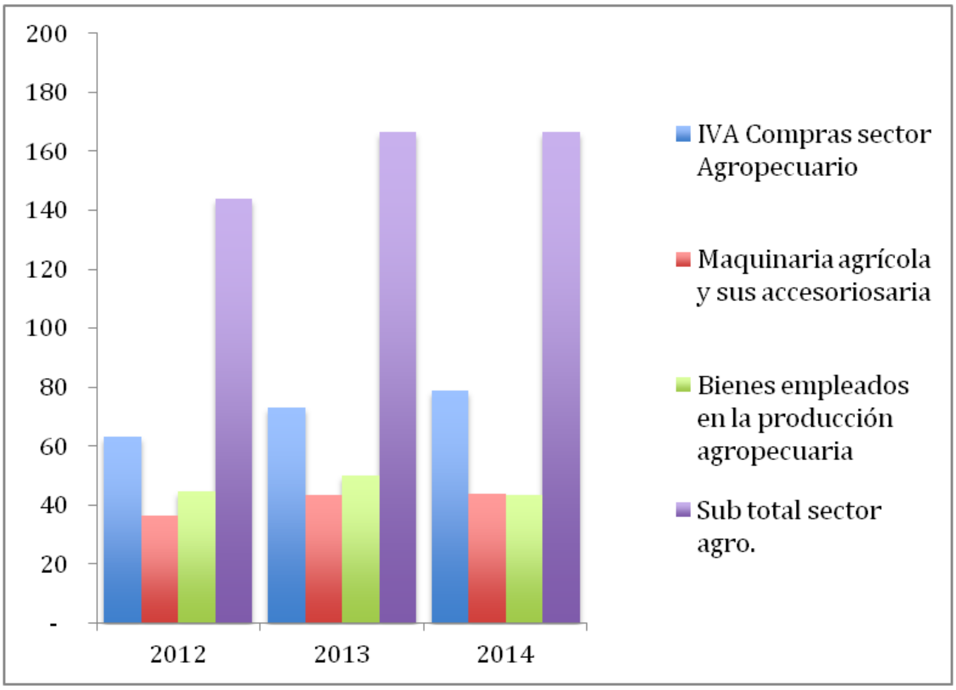
Regarding the percentage of participation of the amount of the exonerations on the amount of the investment promoted in these same projects, it is 55%, accounting for the high percentages of exemptions granted to the projects related to the management of water for agricultural use.

On the other hand, the Department of Economic Tax Studies of the DGI periodically prepares a report where they update the series of tax expenditure measurements (GT for its acronym in Spanish) of the country. In the last report covering the 2012 – 2014 period, the results obtained were analysed for the case of the different taxes (see Figure 10, VAT exemptions and Figure 11, VAT exemptions for 2014).[19] In relation to the VAT and the subject that corresponds to the present work, the collection losses in 2014 related to this tax and to the agricultural

[19] Tax expense is understood to be the loss of the resulting collection or fiscal sacrifice derived from the special tax treatments that seek to favour a sector or group through the reduction of the taxes that charge that activity.

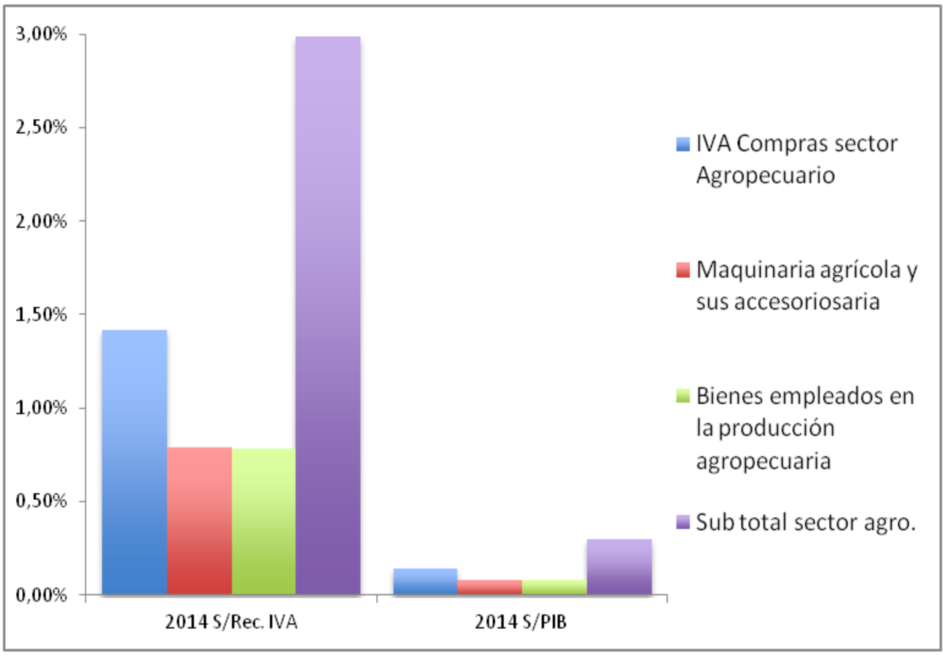
sector as a whole were estimated at 166 million dollars, reaching 0.30% of the product and equivalent to 2.99% of the VAT collection in that year. These exemptions include: the disposal of agricultural machines and their accessories, the disposal of goods to be used in agricultural production and raw materials for their production. Specifically, the VAT exonerations associated with the sale of agricultural machinery and its accessories reached, in 2014, 44 million dollars, representing 0.79% of the effective collection of the tax and 0.08% of the GDP.

Figure 10: VAT exemptions (in millions of USD)



Source: Own elaboration based on DGI data

Figure 11: VAT exemptions for 2014 (% on the total VAT collected and on GDP)



Source: Own elaboration based on DGI data

Regarding the tax benefits derived specifically from the exoneration of irrigation machinery, Failde et al. (2013) estimate the amount in dollars of imported irrigation equipment through VAT exemption procedures in 2010 and 2011. This represents 31.5% of the total amount of all imported irrigation equipment with exemption procedures from 1994 to 2011. The percentage highlights the importance that the larger equipment, destined to the irrigation of extensive crops, has acquired.

In the last 20 years, three projects have also been highlighted in relation to the promotion of irrigation with external financing that are worth mentioning. The first is the Management of Natural Resources and Development of Irrigation Programme (PRENADER for its acronym in Spanish), a project with resources from the World Bank (WB), the government and producers that was executed between 1994 and 2002. The Irrigation Development component had initially, among others subcomponents the: i) rehabilitation and modernization of existing public irrigation and drainage systems, ii) construction of new medium-sized collective irrigation works, and iii) construction of new irrigation works for small producers. The project achieved a growth of 20% of the area under irrigation in the country, which was considered a very important achievement at that time (Failde et al., 2013). The total cost of the Programme, initially estimated at 74 million, was 79.8 million dollars. The World Bank loan was 40.9 million dollars; the Government contributed 23.8 million and the beneficiaries, approximately 6 million dollars. Finally, the institutions that participated in the implementation of the Applied Research and Technology Transfer subcomponent (INIA, Faculty of Agronomy, AUSID) contributed a total of 9 million (in cash and in kind).

The second project under this category is the Responsible Production Project (PPR for its acronym in Spanish), which was also financed with resources from the WB, the Global Environment Fund (GEF), the government and producers. Its execution took place between 2005 and 2012. Although the project did not have irrigation promotion among its main objectives, it carried out some activities to support it. Although they were included among the activities that could be financed, irrigation systems in both extensive and intensive production, their activities related to the provision of water sources were basically aimed at improving the troughs at the level of small producers. According to Failde et al. (2013), the greatest impact of the PPR in relation to irrigation in quantitative terms, was achieved in the horticultural systems of the West Coast, where efficient irrigation systems were installed in 823 hectares (possibly complementing many water source projects carried out by PRENADER), which represented 36% of the total area of primary horticulture located there. The total cost of the Programme was close to USD 47 million. The World Bank's loan was 30 million and the (non-reimbursable) contribution GEF was 7 million; the government contributed 4.4 million and the beneficiaries approximately 5.2 million dollars.

Finally, the Reconversion and Promotion of the Farm Programme (PREDEG for its acronym in Spanish) (until 2008 there were very few) was financed by the IDB and executed between 1998 and 2005. PREDEG indirectly promoted the use of irrigation systems in fruit growing and viticulture. Through it, 2 636 hectares of deciduous fruit trees (98% of the target) and 1 767 hectares of vineyards were reconverted, which also represented 98% of the initial goal. The beneficiaries were about 500 producers of deciduous fruit trees and about 700 wine producers. The total cost of the Programme was initially estimated at 49 million dollars, of which the IDB would contribute 32 and the remaining 17 would be national counterpart resources. At the end of its execution, the total cost was 43.7 million dollars, and the IDB contribution was 28.1 million dollars (Failde et al., 2013.)

2.3 Summary of background to the impact of various fiscal policies related to the use of water in the agricultural sector and its effects on different variables such as employment, competitiveness, added value and water use

It is inevitable to ask about the effect of fiscal policies related to agricultural use on the consumption of the resource, as well as the impact on the main national and sectoral macroeconomic variables.

Carbajal et al. (2014) estimated the impact of the Law of investment promotion on investment, employment and labour productivity, differentiating between large sectors of activity. Due to representativeness problems, the disaggregated analysis of the Agro, Tourism and Construction sectors was discarded so it cannot be used for the present study.

On the other hand, the private sector support unit (UNASEP for its acronym in Spanish) prepared a report where it analysed the investment projects promoted between 2008 and mid-2015 in the framework of the Investment Law (UNASEP, 2015).

In the case of agricultural projects, the compliance of only two of the evaluation indicators, the increase in exports and the generation of employment is analysed. Exports of agricultural companies will increase USD 1.2 million at the end of the term. There are no cases of companies that have completed their 2014 export calendar. [20]

When analysing the amount of employment committed and the amount of employment actually generated by the agricultural companies that obtained approval of their investment projects submitted through the COMAP - MEF, it is observed that at the end of the term 67% of the committed employment will be generated.

There is no data on the impacts of the policies applied in relation to water use in the agricultural sector and its effects on GDP. Therefore, it was decided to use the scenarios evaluated in the document "Strategy for the Development of Irrigated Agriculture in Uruguay" prepared by the MGAP (2015). This work has a preliminary evaluation of the economic impact, at the national level, of the application of a portfolio of projects that would accelerate the current rate of growth of irrigation, considering three scenarios (between 2014 and 2043). The first is a trend scenario where the growth trajectories of irrigated hectares currently observed are continued. The second and third consider that, within the framework of the irrigation development strategy, a greater impulse to carry out different types of projects is generated, where the third scenario presents growth rates of the irrigated hectares that are more ambitious than the second.

The analysis considers an initial situation where the area under supplementary irrigation in Uruguay is 55 000 ha (without considering the hectares of rice under integral irrigation that are considered constant for the analysis). Regarding the impact on the irrigated area, for a 30-year horizon, it would pass from the current situation to 97 050 hectares in the trend scenario, to 271 657 hectares in the medium scenario and to 363 000 hectares in the high growth scenario.

[20] Given that investments are taken as the deadline on March 31, 2015 and that the indicators of employment and exports are evaluated at a closed year, the last data for these is taken on December 31, 2014.

According to the irrigation trend scenario, the national GDP would increase by USD 17 million (at 2013 prices) through direct and indirect impacts, representing 0.03% of the national GDP and 0.50% of the agricultural GDP. On the other hand, under the average growth of irrigation scenario, it is estimated that the national GDP would increase by USD 80 million (at 2013 prices). This would represent around 0.14% of GDP and 2.31% of agricultural GDP. The scenario of high growth of the area under irrigation, would allow the national GDP to increase by approximately USD 120 million (2013 prices), representing 0.21% of the national GDP or 3.46% of the agricultural GDP.

2.4 Systematization of the current situation of the proposed royalty for water use.

In July 2016, the process of building the National Water Plan through citizen participation was launched which proposes, in one of its programmes, the application of specific economic instruments to improve the management of water resources. Specifically, the Plan proposes the incorporation of a royalty for the use of water, which aims mainly at managing the resource.

Although said instrument is mentioned in the Water Code (1978) and in the National Water Policy Law (2009), it was never regulated. Specifically, as part of the programme that involves the application of particular management instruments, the plan presents the design of a proposal for the incorporation of the royalty for use of water within a period of 2 years to start in 2017. For this reason, there has been no fiscal waiver, in the sense that there were no previous revenues to the state for this concept. In this line, the work proposed in this study, including an economic valuation of the water would allow an estimate of possible levels of the royalty, that would inform the expected collection and magnitude of the waivers if not implemented, to be carried out.

3. Design of a baseline for the ex-post evaluation of implementing the royalty on water use in the agricultural sector

Different proposals are identified for the design of an ex-post evaluation of the implementation of a royalty for the use of water in the agricultural sector in Uruguay, as well as other variables of interest. The possible approximations are detailed first, to finally discuss possible sources of information that can be used for the construction of the baseline. The next steps are to present the alternatives to the counterpart, agree on which evaluation design to proceed, and build the baseline.

In this sense, it is first necessary to refresh the objectives of the National Water Plan, which would serve as a frame of reference for an evolution. In particular, the objectives of the National Water Plan (PNA) are (MVOTMA 2017):

1. **Water for human use**
   1.1 Ensure the inhabitants the exercise of the fundamental human right of access to drinking water and sanitation.
   1.2 The first priority in water use is the supply of drinking water to populations and the provision of drinking water and sanitation services which should be done by putting social reasons above those of an economic nature.
2. **Water for sustainable development**
   Provide water in quantity and quality for the achievement of social and economic development of the country and for the conservation of biodiversity and the functioning of ecosystems through integrated and participatory management.
3. **Water and its associated risks**
   Prevent, mitigate and adapt to the effects of extreme events and climate change through risk management and planning.

The possibility of applying economic instruments as royalties to help achieve the objectives of the PNA and for the use of public waters intended for irrigation, industrial or other uses is established in the Water Code of 1979, and is reiterated in the Law of National Water Policy of the year 2009.

According to this last law, the royalty for the use of water will have two main objectives:

1. Promote an efficient use of water
2. Ensure the environmental sustainability of said use.

To evaluate compliance with the objectives, associated with the implementation of the royalty, it is necessary to define an indicator that approximates the compliance of each of them. In relation to the use of water in the agricultural sector, it is expected that the introduction of the royalty will reduce the pressure on the use of water resources. This would help achieve objectives 2 and 3 described above. The evaluation of ex-post policies is a tool to evaluate the degree of scope of the policy objectives based on the empirical evidence of what has really happened once it has been implemented (Gertler et al., 2017).

The ex-post evaluation can be divided into two: an evaluation that takes place immediately after the execution of the policy, and another that takes place sometime after the execution has been completed. The first focuses on the early results, while the second evaluates the consolidated results over time and focuses on the policy's impacts. In general, public policy managers focus on the measurement and reporting of inputs and immediate outputs of policies, such as collection (in a case such as the royalty), spending, the number of taxpayers, and the beneficiaries of the measures among other results.

According to the above, it is important to clearly identify the possible direct effects of the application of the royalty, as well as to identify the effects that may occur as a result of the use of the collection obtained from the application of the royalty. This section describes the impact of the evaluation of the policy, and in the next section a methodology is developed to assess the immediate effects of the policy.

The evaluation of ex-post policies focuses on evaluating the achievements of the policy with respect to the products and results of the same. This is important for various reasons. On the one hand, it serves to evaluate the results of pilot experiences regarding the scope of the policy objectives prior to a large-scale implementation. This allows improving the effectiveness in making adjustments to it prior to a universal implementation, as well as the efficiency in public spending in order to achieve specific objectives. On the other hand, once the policy is implemented on a large scale, it allows the monitoring of the results achieved, in order to advise future adjustments, and provide performance indicators to policy makers in order to improve accountability of the programme and define future budget allocations.

In general, the ex-post impact evaluation measures the average impact of the programme or policy impact. For example, it provides information on whether the introduction of the royalty for the use of water in the agricultural sector decreased the amount of water demanded by this sector. Thus, a fundamental challenge in carrying out this approach is to identify the causal relationship between the programme or policy, and the result (Angrist and Pischke 2009). In order to identify this effect, it is necessary to establish a baseline, and design a method for evaluating the policy from impact measurement based on evidence data. For this, it is very desirable to establish both the design of the policy evaluation and the baseline prior to the implementation of the same. The choice of the impact assessment method is determined by the operational characteristics of the programme, such as whether the programme will be universal or will be focused in part on the possible individuals that may be targeted, and whether the policy will be applied once to all the individuals, or if it will be applied sequentially (that is, first to some, and then expanded to the rest of the agricultural producers, in the case that concerns us).

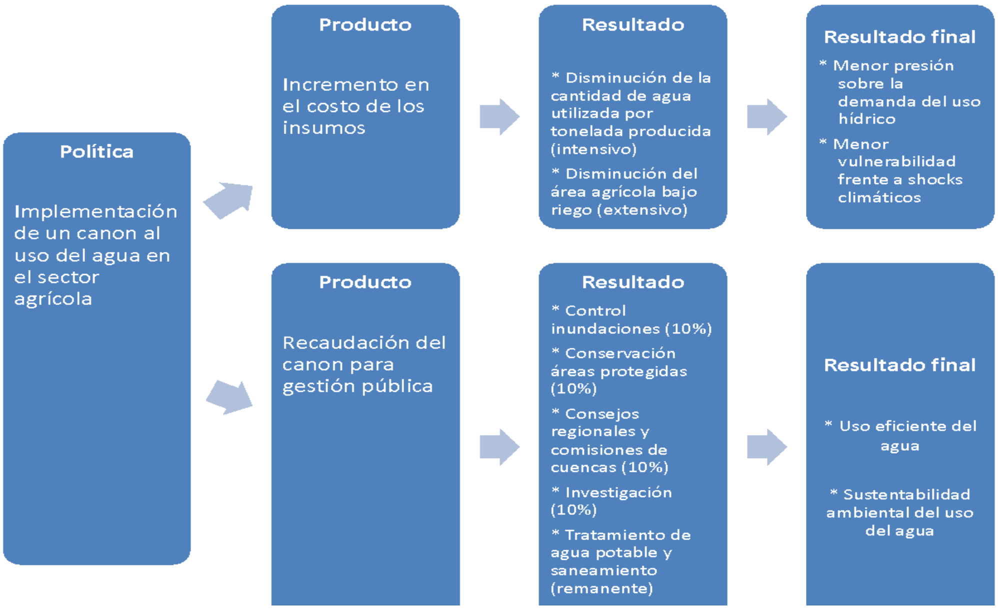
Throughout this chapter we will follow the statements made by Angrist and Pischke (2009) and Gertler et al. (2017) regarding the design of impact evaluation of programmes and policies. There are several approaches to design ex-post policy evaluations. We review in this chapter only those that we believe are pertinent regarding the implementation of the royalty for the use of water in the agricultural sector. In the next section we will analyse the causal mechanisms through which the implementation of the royalty for water use in the agricultural sector can help in achieving objectives 2 and 3 of the PNA. Section 2 of this chapter presents the possible feasible approaches to be implemented for the design of the evaluation of the royalty for the use of water in the ex-post agricultural sector. Section 3 identifies possible heterogeneous effects of the policy among productive sectors, possible effects on the use of water by those agents that are not the object of the policy, as well as possible unwanted effects of the policy. Section 4 discusses possible ways to approach the measurement of the outcome variable in the case of water consumption for agricultural use in Uruguay, and its sources of information.

3.1 Measurement of the impact of the implementation of the royalty in the agricultural sector for the fulfilment of the objectives of the PNA

When carrying out the evaluation of the impact of a programme or policy, it is necessary to define the target variable through which the result of the programme will be measured, and which is the mechanism to reach that objective through the implemented policy.

Figure 12 describes the mechanism through which the implementation of the royalty for the use of water in the agricultural sector would lead to compliance with objectives 2 and 3 of the PNA. In this case, the activity carried out is the implementation of the royalty, which will have as an immediate result the increase in the costs of inputs to agricultural producers.[21] In order to fulfil the objectives of the PNA, it is possible to reduce the pressure on the water resource through two channels. On the one hand, a possible direct result of the introduction of the royalty will be to increase efficiency in the use of the resource through improvements in infrastructure to contain the water (fixed improvements, dams, lagoons, etc.), which we will call the intensive margin.

Figure 12: Identification of relevant results for the fulfilment of the objectives of the PNA through the implementation of the royalty for water use in the agricultural sector



On the other hand, lower pressure on the use of the resource can occur through the decrease in water demanded as a consequence of a reduction in agricultural activity under irrigation (what we will call extensive margin). The two routes lead to a decrease in the amount of water used, and therefore, the pressure on the use of the water resource decreases, increasing the availability of the resource for other uses.

Although the desired outcome variable on which to measure the impact is the consumption of water for agricultural production, this variable is not easy to measure in the absence of water consumption metres. Due to this, it is necessary to think of alternative variables that can approach the desired outcome to be measured.
Possible alternative variables on which to measure the result of the policy can be:

- Hectares under irrigation by type of crop per agricultural producer → Extensive

[21] Following Gertler et al. 2017, in this document we will use the following concepts: Inputs: the resources available to the project; Activities: The actions undertaken or the work done to transform the inputs into products; Products: Tangible goods and services produced by programme activities (directly controlled by the executing agency); Results: The results that are expected to be achieved when the population benefits from the project's products (in general, they are observed between the short and medium term and are not usually controlled directly by the executing agency; Project objectives were met or not (normally, the final results depend on multiple factors and occur after a longer period).

margin.

- Energy consumption (electricity or fuel) for pumping water → Intensive margin.

On the one hand, it is possible to measure the impact of the introduction of the royalty on the water use of the agricultural sector by observing the impact on changes in the amount of hectares under irrigation. On the other hand, a possible way to approach the consumption of water for agricultural use is through the measurement of energy consumption (electric and fuel) used for pumping water. The advantage of this approach is that it is possible to measure it through the electricity consumption provided by the energy supplier companies.

However, using this variable as an approximation to the results raises several challenges. First, not all producers who use irrigation systems for agricultural production use pumping for the provision of water, some do it through gravity (for example, according to DIEA in the 2016/17 harvest 37% of the irrigated area in the country was done by gravity). Second, pumping is often used to fill reservoirs the use of which is then shared among several producers. Third, there may be a situation in which the electric power used for pumping is not provided by the electric power supply company, but produced on the farm by fossil-fuelled engines. In this sense, it is necessary to evaluate in detail the scope of these variables as a proxy of the expected outcome variable.

3.2 Methods for the design of ex-post evaluation of the implementation of the royalty for the use of water in the agricultural sector

When designing an ex-post impact evaluation there are two concepts to consider that are essential: the causal inference and the counterfactuals (Gertler et al., 2017). The concept of causal inference refers to the fact of analysing the cause and effect between an intervention and its result. For example, does the implementation of the royalty decrease the amount of water per unit of product in the agricultural sector? Perhaps, agricultural producers would have decreased their water consumption anyway, even if they had not been subject to the policy, as a consequence of their possible efforts to reduce their vulnerability to extreme weather shocks, the introduction of a very viable production technology for improving yields with lower water consumption, or other possible factors that may influence the water consumption of the agricultural sector. The ex-post impact evaluation allows attribution of causality based on empirically determining to what extent that programme or policy (and only that programme or policy) produces a change in the result of interest.

The impact (Δ) of a policy (P) on a relevant outcome variable (Y) can be written as:

$$(1)\ \ \Delta = (Y|P=1) - (Y|P=0)$$

that is, the difference between the result (Y) when the policy has been implemented (P=1) and the same result (Y) without the policy being implemented (P=0). For example, measuring the consumption of water for irrigation of an agricultural producer in the absence of a royalty for the consumption of agricultural water, and comparing it with the consumption of water for irrigation from the same producer when there is a royalty for the consumption of agricultural water. This involves measuring two different realities of the same agricultural producer at the same time. If this were possible, we could attribute all differences regarding water consumption to the implementation of the policy, since comparing the behaviour of an individual with himself at the same time would eliminate any external factor that could also explain the difference in the consumption of water. In that case, we could say that the relationship between the policy and water consumption per unit of production is causal.

While the idea is simple, the problem arises on trying to evaluate two different realities at the same time. This is impossible in practice, since it is impossible to observe two different realities of the same producer in the same moment of time. That is, although we can accurately measure the water consumption for irrigation of the producer once the policy is implemented, $(Y|P = 1)$, there is no information to establish what the result would have been in the absence of the policy $(Y|P = 0)$.

This brings us to the second key concept, which is the definition of the counterfactual. The counterfactual is what would have happened (what would have been the result *Y*) in the absence of the policy *P*. In Equation 1, the counterfactual is represented by the term $(Y|P = 0)$. In general, when carrying out an impact evaluation, the term $(Y|P = 1)$, which we will call the result under the treatment, is easy to observe (once the appropriate variable has been defined). However, under the impossibility of directly observing the second term of Equation 1, $(Y|P = 0)$, it is possible to define a strategy to estimate it.

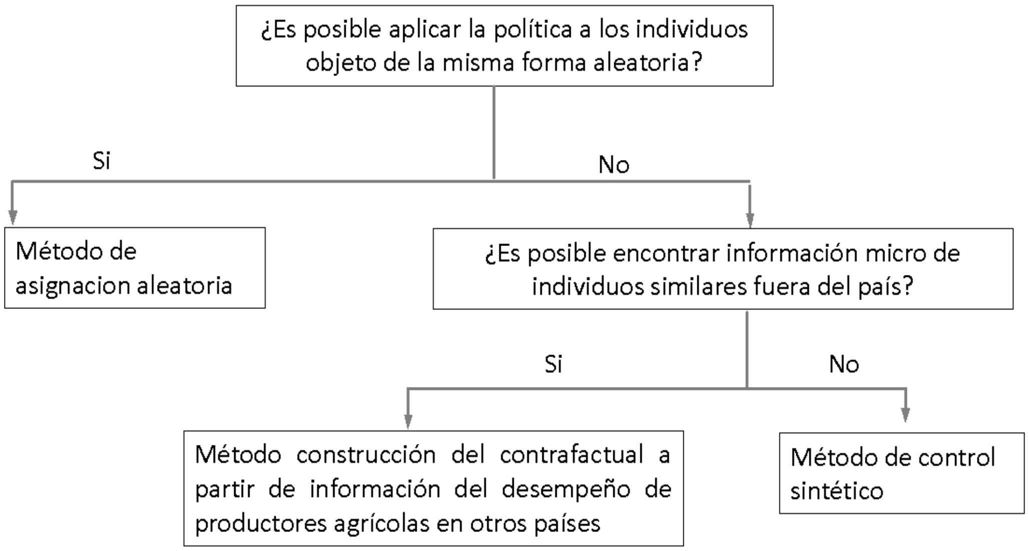
In this sense, the key to carrying out an ex-post evaluation that manages to measure the causal effect of the policy on the results, is to design the evaluation in order to estimate the counterfactual as accurately as possible. Therefore, it is necessary to move from thinking at an individual level (the agricultural producer in our case) to the group of treated and untreated individuals. That is, despite not being able to rely on a perfect clone of each individual, it is possible to generate two groups of people with certain statistical properties, such that, if the number of individuals is large enough, they are indistinguishable from each other at a group level in relevant variables. This implies applying the policy to a part of the population, which is called a *treatment group*, and monitoring their performance, as well as another group with the same characteristics from the statistical point of view, to which the policy has not been applied (*control group*). The performance of the control group is interpreted as the performance that the treatment group would have had if it had not been submitted to the programme.

In this way, the main challenge lies in creating the valid comparison group. In particular, the treatment group and the control group must be the same in at least three aspects: i) the average characteristics of the control group and the treatment group must be identical in the absence of the programme (e.g., size of the producers, age of the producer, etc.), ii) the treatment would not have to affect the comparison group directly or indirectly, that is, those to whom the royalty applies should not receive resources from whom it is not applied, nor the cost of other inputs should be affected by a drop in the demand for them by those who have to start paying a cost for the use of water, and iii) the results of the producers in the control group should change in the same way as the results in the treatment group if both groups were treated (or not). Under these three conditions, the difference in the result, as a consequence of the implementation of the interest policy, will be explained exclusively by it.
The design of the impact evaluation can be done prospectively, that is, designed in conjunction with the design of the programme or policy implementation, or retrospectively, that is, designing the evaluation strategy after the policy has been implemented. The advantage of the first is that the baseline data is collected before the programme is implemented, both in the treatment group and in the control group. This allows more credible and robust results to be achieved since the composition of the groups is controlled in advance.
The objective of this chapter is to design a baseline for the ex-post evaluation of the implementation of the royalty for the use of water in the agricultural sector. In that sense, it is possible to design the implementation along with the evaluation, in order to achieve the most credible evaluation possible. There are several strategies to design the ex-post evaluation jointly with the implementation of the policy. While some approaches may be

more robust regarding the degree of validity of the counterfactual, they may be less feasible to be implemented since the policy must be applied at the same time throughout the territory, or all productive sectors.

There are several approaches in the literature to design an ex-post impact evaluation strategy. In this chapter we will only focus on those relevant to the case that concerns us. Figure 13 shows the tree of possible strategies to be implemented for the evaluation of the introduction of the royalty for the consumption of water for agricultural use.

Figure 13: Strategy tree for the design of the ex-post evaluation in the case of the introduction of a royalty for the use of water in the agricultural sector



3.3 Randomisation method

The method of randomisation involves applying the policy to the individuals who are the object of it (who form a large eligible population) through a draw. Thus, all agricultural producers are equally likely to be selected to be the object of the policy. Once the part of the population, to which the policy will be applied, has been randomly selected information must be collected both from the agreed parties and from a sample of those to whom it is not applied (the control group), whose characteristics serve to form the counterfactual, as indicated in the previous section. When the policy is implemented in a random way, it is possible to estimate in a robust way the counterfactual, and therefore, the impact of the programme.

Randomisation is the ideal framework to carry out an ex-post impact evaluation. However, it is not feasible to think that it is possible to design the implementation of the royalty for the use of water in the agricultural sector through a mechanism like this, since it would generate great controversies between the implementing agency and the producers who are subject to it. Those producers who have the royalty applied to them will feel prejudiced and discriminated against by the applied policy. Therefore, this method is presented in this chapter only as a reference with respect to the 'ideal' allocation method. All alternative methods will provide a less robust estimate of the counterfactual, but this is no less relevant. However, the method of randomisation is not an idyllic method that can never be applied. Many times, the randomisation of a programme or policy can be derived directly from the operating rules of the programme. One could think, for example, of a programme of subsidies or benefits for the adoption of technologies for saving water consumption for agricultural use. If the programme funds exceed the number of participants in it, the subsidy could be provided to a part of the producers in a random way, under the argument of not having funds for all.

3.4 Construction of the counterfactual based on information on the performance of agricultural producers in other countries

When the implementation of the policy is unfailingly universal for the entire national territory, it is impossible to build a counterfactual within it. However, given the scale of Uruguay, and the similarities with respect to climatic characteristics with producers in southern Brazil and parts of Argentina, it is possible to find similar producers in these countries from which to build the counterfactual. In addition, producers in these regions of neighbouring countries have the advantage not only of the similarity in climatic and geographical terms, but also the distinction is not too broad in cultural terms (as it could be, for example, with respect to producers of USA, Canada, New Zealand or Australia).

Although this method is robust and widely used in the impact evaluation literature, (for example, Ferraro 2009 presents an exhaustive review of conservation policy evaluation methods, where such an approach is usual), it presents greater challenges than the previous approaches. On the one hand, it is necessary to build a micro data base, as in the national approaches, linking information of characteristics of agricultural producers with the outcome variable that is to be measured. This is a challenge in itself with respect to domestic producers. On the other hand, it is necessary to access micro data from agricultural producers in the relevant regions and crops in neighbouring countries. In turn, this information must have the same information related to the outcome variable to be evaluated. This represents a challenge since the sources of information can be very heterogeneous.

Even if it is possible to have all this information, we must bear in mind that producers from neighbouring countries face different realities with respect to trade policies, subsidies to production, institutional, etc. However, in this instance, it is possible to apply statistical methods, such as matching to build a counterfactual that is closer to the reality of the national producers.

In order to apply this methodology, it is necessary to have data at the producer level (micro data). For this, the existing information on the performance of agricultural producers in neighbouring countries such as Argentina, Brazil and Paraguay was reviewed. In order to reduce the differences between the producers of these countries and the Uruguayan producers, it is convenient to consider only some regions of each country, especially considering the extent and diversity of Argentina and Brazil. Entre Ríos and Corrientes in Argentina and Rio Grande do Sul in Brazil. In the case of Paraguay, the departments that concentrate the highest production of irrigated rice are: Itapuá, Misiones and Caazapá.

According to the data search, there is information on the performance of producers in neighbouring countries (Table 7).

Table 7: Information and data sources for each country

	Source	Information	Data	Comments
Uruguay	DIEA-MGAP	Agricultural surveys	Microdata	
Argentina	Ministry of Agribusiness	No producer surveys are carried out	Satellite images	No response to queries

	INDEC			
Brazil	IBGE	Systematic survey of agricultural production	Microdata	No response to queries
	Embrapa	Without access to application form	-	
	Emater		-	
	IRGA		-	
Paraguay	DCEA-MAG	Agricultural surveys	Qualified informants	

However, the information is not accessible directly to the public. Direct consultations were made with the responsible agencies of the three countries, but no response was obtained. In any case, it is expected that the communication will improve if the consultations are carried out by the Uruguayan government.

It is possible to determine if it is feasible to use the existing information for the ex - post evaluation by reviewing the questionnaires of the surveys of the neighbouring countries (where available), and comparing them with the information produced at the national level. That is, from the agricultural surveys conducted in our country by DIEA-MGAP, to consolidate in a single database information on producers in Uruguay and producers in the region, applying statistical methods to build a counterfactual that reflects the reality of the national producers.

DIEA conducted three surveys to agricultural producers: i. Spring agricultural survey, ii. Winter agricultural survey, and iii. the rice survey. In the first survey, the panel of informants constitutes a representative sample of the universe in which the researched crops are produced: wheat, barley, oats, rapeseed, soybean, corn and sorghum, destined for dry grain. On the other hand, in the winter survey the information refers only to the dry grain harvest. The rice survey is based on a representative sample of the universe of farmers who produce rice.

In the case of Argentina, the difficulty found in the availability of data was greater. The National Institute of Statistics and Censuses (INDEC for its acronym in Spanish) is in charge of the Agricultural Production Survey (EPA for its acronym in Spanish). However, the last available year of this survey is 2007, and it has no temporal continuity. In turn, the updated information available, both in INDEC and in the Ministry of Agribusiness, is built from satellite images, and not through continuous surveys of agricultural producers. This would imply that there is no micro data in this country that can be used for our purposes. Queries were made to corroborate the previous information but it was not possible to obtain a response.

In Brazil, the Brazilian Institute of Geography and Statistics (IBGE for its acronym in Spanish) performs a systematic survey of agricultural production, which provides information on the sown area, harvested area, production, yield, unit price and irrigated area, by type of crop and for each municipality (see Annex 2). On the other hand, the Brazilian Agricultural Research Company (Embrapa) generates information on harvested area, production and yield, distinguishing the irrigated area. The Instituto Rio Grandense de Arroz (IRGA for its acronym in Spanish) also provides statistics on rice cultivation, but it was not possible to have access to the questionnaire applied to the producers. It is necessary to communicate with these institutions in order to know exactly what information they generate and if they actually conduct direct surveys to producers.

The Directorate of Agricultural Census and Statistics of the Ministry of Agriculture and Livestock in Paraguay (DCEA-MAG for its acronym in Spanish), developed a Statistical Summary of Agricultural Production, for which it used as sources of information surveys to qualified informants and other collection techniques (telephone calls, interviews, email, etc.).[22] It carried out surveys to agricultural organizations with the objective of obtaining information on: sown area, production and harvested yield for winter and summer crops. In the case of rice, it distinguishes rain fed rice and rice under irrigation (see Annex 2). Here it is also necessary to establish an interinstitutional communication to deepen the available information since it is not clear if there are direct surveys to producers and the existence of microdata.

As a consequence of the above, initially we will only consider Brazil to construct the counterfactual from microdata. Table 8 shows the variables that we have available in the surveys conducted by DIEA and those that arise from the form obtained for the survey carried out by the IBGE.

Table 8: Comparison of DIEA, IBGE and DCEA surveys

Uruguay (DIEA-MGAP)	Brazil (IBGE)
Spring Survey	**Systematic survey of agricultural production**
Variables	**Variables**
Total exploitation area	✓
Production	✓
Yield	✓
Sown area	✓
Area to be sown	
Exploitation activities	
Weed problems	
Winter Survey	**Variables**
Variables	
Sown area	✓
Harvested area	✓
Production	✓
Irrigated area	✓
Irrigation system	
Water sources	
Sown winter crops	
Intention to sow summer crops	
Rice Survey	
Variables	
Sown area	✓
Production	✓
Yield	✓

22 http://www.mag.gov.py/Censo/SINTESIS%20ESTADISTICAS%202016.pdf

Varieties
Sow dates
Irrigation methods
Price of land and water
Labour

It is important to note that what was done in this section consisted of an exploratory analysis on the possibility of access to information on the performance of producers in the region. It is fundamental, in order to to apply this methodology, to be able to establish an exchange of information between the countries so as to expand what has been achieved so far and to carry out the corresponding procedures to access the microdata.

In turn, the systematic survey of agricultural production of IBGE does not have information on the socioeconomic characteristics of producers. Therefore, it is difficult to match the information with that of the Uruguayan producers beyond the size of the farms. In that sense, it would be relevant to obtain the information for both countries with as much detail as possible regarding the geographical location of the farms. This would allow the matching of areas with respect to the biophysical and climatic variables, in order to compare groups of observations the most homogeneous as possible with respect to the characteristics of the productive system.

3.5 Synthetic control method

Even in the case where the policy is applied universally, that is, at the same time throughout the national territory, and that it is not possible to estimate the counterfactual from micro-information of similar zones in geographic and climatic terms of the neighbouring countries, it is possible to estimate the impact of the policy at the aggregate level. That is, observe the change in the outcome variable at the national level.

It is important to note that this is not simply a *before and after* comparison. If we performed this procedure, we would run the serious risk that other factors, different from the policy we want to evaluate, would explain the change in the outcome variable. For example, if at the same time there is a fall in the international prices of irrigated crops, and therefore, a decrease in the consumption of water for agriculture and the hectares under irrigation at the national level, a *before and after* comparison would wrongly indicate that this change is a consequence of the policy.

To carry out this analysis we must build a counterfactual that emulates Uruguay's behaviour "as if" the policy had not been implemented. This can be carried forward by constructing a counterfactual through the synthetic control method. This method was proposed by Abadie and Gardeazabal (2003) to evaluate the economic costs of terrorism in the Basque Country. With regard to the evaluation of a policy, Abadie et al. (2010) use it to assess the impact of a policy on tobacco use in the state of California. As the policy had been implemented only in that state, the authors constructed a synthetic counterfactual from the characteristics of other states. Thus, the impact of the policy was estimated by comparing the number of cigarette packs sold in California with respect to their synthetic counterfactual, before and after the policy. Once this difference is obtained, it must be evaluated to see if it is significantly different from zero. The quality of synthetic control is measured by the close relationship between the weighted synthetic results and the results for the unit treated in the years prior to treatment (Sills, et al., 2015).

This method was recently used by Sills et al. (2015) to estimate the impact on the deforestation rate the inclusion of the municipality of Paragominas, Brazil, in a black list for non-compliance with the deforestation goals set at the national level. The inclusion in the black list led the government of this municipality to face restrictions on access to credit and certain markets. As a consequence, local compliance with measures to control deforestation was strengthened. Since this municipality was the only one included in the black list, the authors constructed a synthetic counterfactual to evaluate how its performance would have been if it had not been included in the list.

The main advantage of working with this method is that, as in the case that concerns us, many public policy interventions affect macro or aggregate units and macro or aggregate data are more common than micro or disaggregated data. The main problem is that there is a lot of ambiguity regarding the selection process of the control group and the statistical inference does not reflect uncertainty about the quality of the control group.

Given the above, it is feasible to think about applying this method to evaluate the performance of the outcome variables of interest at the national level, and to build a synthetic counterfactual based on the performance of a group of countries relevant to the agricultural sectors of interest to be evaluated.

The construction of the baseline from which we will obtain the synthetic counterfactual for Uruguay was prepared considering a group of relevant countries with respect to the agricultural sectors to be evaluated.

With respect to the definition of the outcome (Y) and control variable, we initially consider the irrigated area by type of crop as an outcome variable. As control variables, it was considered to include yields by type of crop, relative prices, and indicators of the level of economic growth, importance of the primary sector in the economy, and the size of agricultural establishments by country, in order to reflect the characteristics of the productive process of the crops.

On the other hand, an attempt was made to include variables that would help to control the different meteorological conditions in different countries (e.g., rainfall), and finally variables that reflect the differences in socioeconomic characteristics between countries.

Table 9: Variables considered for Synthetic Control and their data sources

Variables	Included in the model	Data sources
Dependent variable		
Area irrigated by type of crop		n/d
Total irrigated area		Faostat, Aquastat
Area of rice harvested / farmed area	✓	Faostat
Dependent variables		
Yield by crop	✓	Faostat

Price of producer by crop	✓	Faostat
Supplies		n/d
Meteorological controls		n/d
Agricultural surface area (%)	✓	Faostat
Arable land and permanent crops (%)	✓	Faostat
Added value of the agricultural sector (%)	✓	World Bank
GDP per capita	✓	World Bank
Rural population (%)	✓	World Bank
Gini Index		World Bank
Net production per capita	✓	Faostat

However, the reduced availability of public access data imposed an important limitation to create the baseline from which synthetic control for Uruguay is built. In addition, the availability of information determined which variables could be used. Table 9 shows the variables considered and their respective data sources. It is important to highlight the disadvantages found for each variable in each data source given its influence on the selection of the variables to be included in the model. In the case of the dependent variable, it was not possible to obtain data on the irrigated area by type of crop, leading to consider the total irrigated area for each country. FAOstat includes in its database the area effectively irrigated for each country. However, the variable presents many missing values for the period of time considered, even varying between countries. This prevents the construction of a data panel for the countries considered and to consider the total irrigated area as an outcome variable. Aquastat also provides information on the irrigated area, but this information appears for periods of 5 years for each country, with a frequency of two or three periods per country. However, even if we wanted to assemble the synthetic using five-year data, there is no country that has information for more than two five-year periods. In turn, many times the five-year periods for which it is available are not overlapping in time. Therefore, we cannot use this source of information to analyse the effect on the area under total irrigation.

As a consequence of the lack of data on the irrigated area, the proportion of harvested area of rice over the total agricultural area is considered as a dependent variable, assuming that all rice cultivation is carried out using irrigation. Thus defined the outcome variable, it is possible to obtain data for all the countries included in the baseline. Given that the rice sector makes the greatest use of irrigation in Uruguay, the selection of countries was made using the following criteria. First, those countries producing rice were filtered. Then those years in which there is information on agricultural land under irrigation is filtered. Next, only those countries for which the area under irrigation was equal to or greater than the harvested area of rice, were selected. This enables us to approach, with greater certainty, to include in the counterfactual only countries that practise the cultivation of rice under irrigation. Although, this filter is not perfect, it is a good approximation to leave out of the construction of the synthetic countries with a large area of rice cultivated under rain fed conditions. As a result, the counterfactual has 32 countries in the period 1980 - 2014 (Table 11 shows the countries chosen, and their participation in the synthetic counterfactual).

With respect to the control variables, all the desired variables could not be included and there is even missing data for some of the ones included in the model, causing them to be taken for certain periods of time.

Faostat provides information on the producer's price by crop type, but this variable has missing data for the period considered and for the different countries. As a result of the foregoing, we could only include in the model the variable producer's price of rice for some periods.

No information could be obtained on the use of inputs in the production process, nor variables that reflect meteorological conditions. Annual rainfall is included in the World Bank database, but defined as a fixed value for the considered period. However, at a future stage this information can be incorporated from processing maps of geographic information. Although, under the assumption that all the activity is carried out under irrigation, rainfall would have a minor role in the area of this crop. On the other hand, the following economic and socioeconomic indicators provided by the World Bank were used: added value of the agricultural sector as a percentage of GDP, GDP per capita and the percentage of rural population in each country. The Gini index could not be included since it presented missing data for most countries.

On the other hand, agricultural land was included as a percentage of the total land area of the country, as well as the percentage of arable land and permanent crops, as variables that reflect land use in each country. The agricultural production index shows the relative level of the overall volume of agricultural production each year compared to the base period 2004-2006. They are based on the sum of the weighted price amounts of the different agricultural products produced after deducting the quantities of seeds and animal feed weighted in the same way. The final aggregate represents the production available for any use without including seeds and animal feed.

Finally, the control variables that were included to define the synthetic counterfactual for Uruguay are presented in Table 10.

Table 10: Average value of the control variables: current vs Synthetic Uruguay

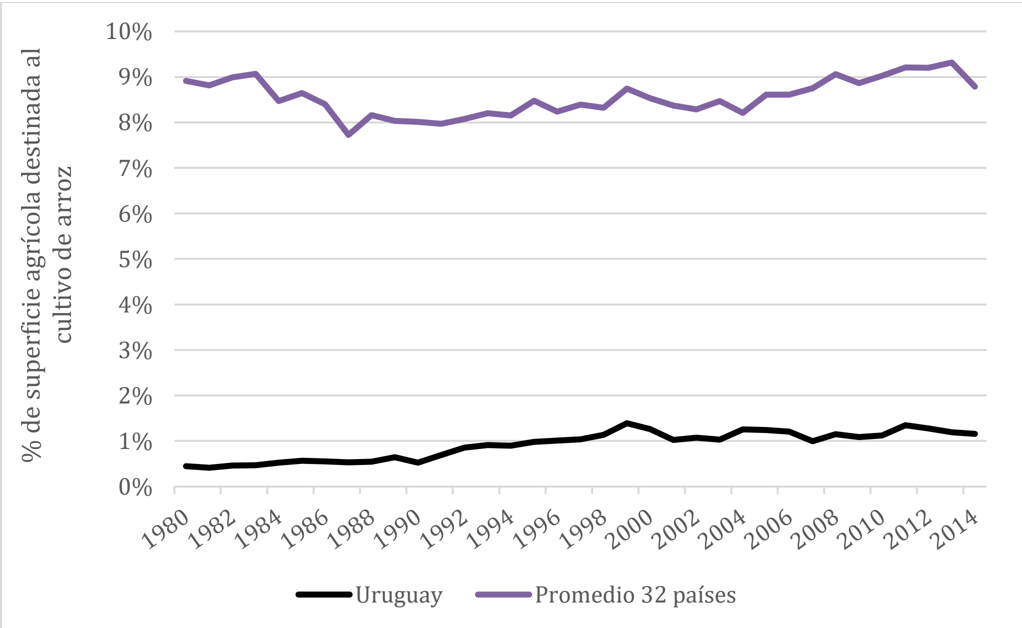
Variable	Uruguay		Average of the 32 control countries
	Real	Synthetic	
Rice yield (kg/ha)	5984	5318	4213
Corn yield (kg/ha)	2787	4138	3443
Price of Rice Producer (1998-2014) (USD/ton)	202	212	367
Net production per capita	84.06	90.34	92.75
Agricultural area (%)	0.85	0.44	0.38
Arable land and permanent crops (%)	0.09	0.10	0.17
Added value agric. sector (1997-2014) (%)	9.03	7.80	13.65
GDP per capita (USD)	5885	7865	6386
Rural population (%)	9.28	18.61	44.91
Y(1980)	0.004	0.005	0.09
Y(1985)	0.006	0.006	0.09
Y(1990)	0.005	0.008	0.08
Y(1995)	0.010	0.011	0.08
Y(2000)	0.013	0.010	0.09
Y(2005)	0.012	0.011	0.09
Y(2010)	0.011	0.012	0.09

Source: own elaboration based on data described in Table 9

In addition to the control variables related to the productive process and the socioeconomic characteristics of each country, delays of the outcome variable are included (Y = proportion of rice harvested area over the total agricultural area) in order to obtain a better control group.

Table 10 shows the average value of the control variables for the synthetic counterfactual obtained for Uruguay and for the rest of the 32 countries considered. It can be observed that there are important differences between the average value of the control variables for Uruguay and the same variables for the average of the 32 countries. In addition, as shown in Figure 14, the behaviour of the outcome variable in Uruguay also shows a different behaviour from the average value of the proportion of the harvested area of rice.

Figure 14: Harvested area of rice as a percentage of the agricultural area



Source: Own elaboration based on FAOSTAT

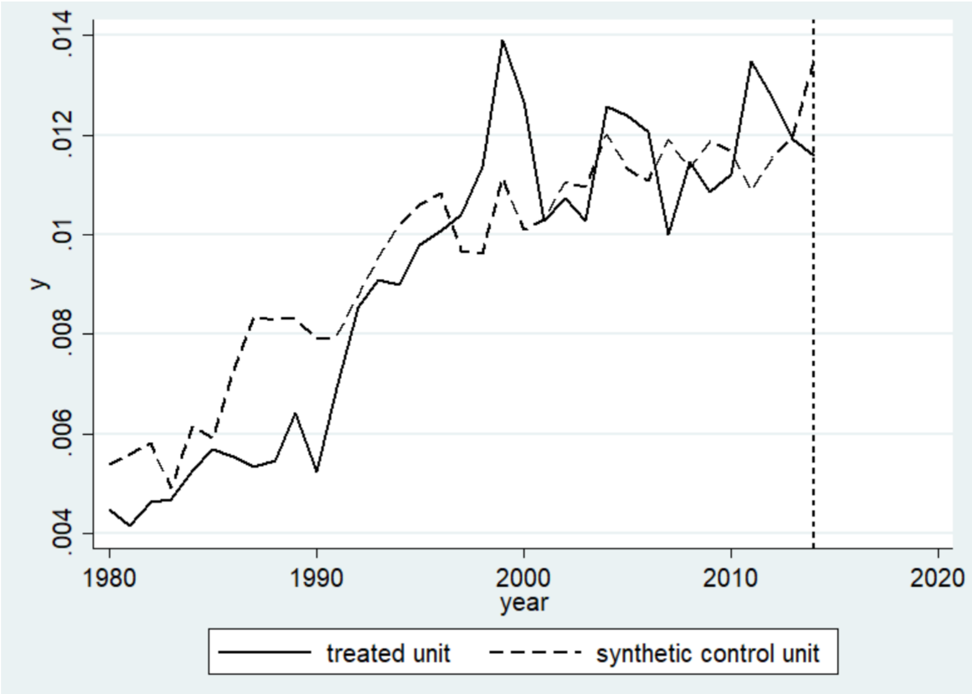
Given the different trajectories of the outcome variable in Uruguay and in the rest of the countries, the synthetic control method aims to define the set of countries that best represents the performance of said variable in Uruguay in the period prior to the intervention, so that it can be used as counterfactual after the intervention is implemented. The countries that were selected, and their participation in the synthetic counterfactual for Uruguay are presented in Table 11. In turn, the second column of Table 10 shows the average of the control variables prior to the treatment for the synthetic counterfactual. Clearly, after proceeding with its development, their values approximate the ones for Uruguay, constructing a valid synthetic counterfactual to compare the behaviour of the variable of interest once the treatment is implemented.

Table 11: Countries that constitute the synthetic counterfactual

Country	Weighting factor
Argentina	0.62
Australia	0.13
Bolivia	0
Brazil	0
Burkina Faso	0
Cambodia	0
Cameroon	0
Chile	0
China	0
Costa Rica	0
Ecuador	0.15
Egypt	0.07
Spain	0
U.S.A	0
Guinea-Bissau	0
India	0
Indonesia	0
Iran	0
Italy	0
Japan	0
Mexico	0
Mali	0
Malaysia	0
Nicaragua	0
Pakistan	0
Paraguay	0
Peru	0.08
Dominican Republic	0.01
Sri Lanka	0
Thailand	0
Turkey	0
Venezuela	0

Figure 15 shows the behaviour of the harvested area of rice as a proportion of the agricultural area for Uruguay and the average of said variable for the 32 countries considered in the synthetic between 1980 and 2014. According to Table 11 and Figure 15, the synthetic control adapts very well the trajectory of the interest variable prior to the treatment. However, there are still significant differences between the behaviour of the outcome variable for Uruguay and its synthetic in part of the period, mainly from the mid 80's and early 90's. One of the main causes for this mismatch is the lack of price information, both for rice and other crops, during this period. Thus, it is not possible to adjust the demand for the good. In the face of an ex-post evaluation, it is important to try to complete that information (nowadays that information is not publicly available), or to shorten the period of analysis or access other control variables.

Figure 15: Uruguay and synthetic Uruguay



Source: Own elaboration based on FAOSTAT

There may be a slight improvement in the adjustment of the synthetic with respect to the treatment unit. However, Uruguay has some characteristics that are unique with respect to the countries included in the counterfactual, such as the high proportion of the national territory that is allocated to agricultural activities, the high yields in the rice sector, and the low proportion of the population living in rural areas. We believe that this can be refined in the final evaluation, indicating the relevance of the method for this analysis.

3.6 Other objective variables, heterogeneous effects, spillover effects, and unintended effects

There are different aspects that have to be taken into account when designing the ex-post impact evaluation. On the one hand, it is important to know not only the impact of the introduction of the royalty for water consumption for agricultural use, but also other outcome variables that may be of national interest. On the other hand, there are some methodological details that must be considered, which highlight the virtues or weaknesses of some of the evaluation methods described above. We put forth in this section only those that are relevant to our case study.

Impact on other outcome variables

The introduction of the royalty for the consumption of water for agricultural production can affect other results that are of national interest, beyond those results related to the objectives of the PNA. In particular, it would be desirable to evaluate the impact on:

- Productivity per hectare by type of crop
- Employment (No. of hired workers)

To do this, it is necessary to evaluate the feasibility of having information regarding each of the variables at the time of assembling the baseline and the subsequent data collection. In turn, there may be specificities regarding employment for each sector, due to possible characteristics related to the seasons of each of the crops. While the productivity per hectare could be approached through the synthetic control method, in the case of finding information, there is none that allows the evaluation regarding employment for any of the two methods to be carried out.

Heterogeneous effects

When the evaluation is done in an aggregated form for all crops (e.g., taking as a result variable the area under irrigation in the country) there is a risk of estimating the aggregated effect, when in reality, it is very different for different types of crops (sub populations). The way to calculate this is estimating the impact (constructing detailed counterfactuals for each of them) with respect to the types of crops (rice, soybean, sunflower, and corn). One can also think about making cuts in the evaluation regarding the size of the producers. However, each new cut brings more complexity to the design of the evaluation.

Spill effects

A *spill* effect occurs when an intervention affects an individual in the untreated group. Following Angelucci and Di Maro (2015), there are four types of spill effects:

- Externalities: the effect on those treated brings greater (less) well-being also to those not treated. For example, if part of the population is vaccinated against the flu, the unvaccinated will be less likely to be infected.
- Social interaction: individuals interact in common circles where they share information and goods, as a consequence of the treatment that affects the behaviour of those not treated.
- Context equilibrium effects: This occurs when an intervention affects the behavioural or social norms within a certain context, such as a treated area.

The effects of general equilibrium occur when interventions affect the supply and demand of goods and services, for example, by changing their market price.

For our case in particular, the only relevant ones are the effects of social interaction and context equilibrium effects for the case in which an evaluation design is applied in stages in different regions. It is very difficult to isolate the interaction between producers in such a small country and also when they have high levels of association (especially in the rice sector). This can present a great challenge when implementing this policy.

In case a decrease in water consumption in one region increases the water available in another region that could also be thought of as the presence of an externality. However, since most of the production is exported, we are considering only extensive crops, such as rice, soybean, corn, or sunflower, and Uruguay is too small to affect international prices. It might be thought that there would be no effects of general equilibrium.

In the case of facing the possibility of spill over effects, a lot of care must be taken when designing the counterfactual, looking to have representativeness of a part of the population that is not affected by it. In such a case, there could be three comparison groups, the: i) treated ii) untreated ones not affected by the spill over effects, and iii) untreated ones affected by the spill over effect. In this way, one could estimate the direct and indirect effect of the policy.

Unintended effects

When an impact evaluation is carried out, it may happen that unintended responses are induced in the behaviour of the population in study. There are four types of unintended effects (Gertler et al., 2017):

i. Hawthorne effect: occurs when individuals behave differently than they would simply because they know they are being monitored.
ii. Anticipation: if a randomized evaluation design is implemented in stages, individuals in the untreated group who expect to be subject to the policy may begin to change their behaviour prior to being treated.
iii. Substitution bias: it happens when individuals in the non-treated group find good substitutes thanks to their own initiative (this is relevant, mainly, in programmes that provide benefits to the population, such as training unemployed people).
iv. John Henry effect: it refers to changes in behavior by members of the non-treated (control group), who may adopt a more competitive behavior towards the treated group, reducing the validity of their role as a control.

For our evaluation design, the only relevant ones are the John Henry effect and the Anticipation effect, only in the case of following the path of phased implementation by regions. For example, if as a consequence of the implementation of the royalty some producers (in the case of the random design) or in some regions (in the case of implementation by regions) the producers, that have not yet been treated, change their behaviour regarding the consumption of water for agricultural use as a consequence of being ahead of an intervention that will affect them. In that case, the assumptions regarding validity at the time of estimating the counterfactual would not be met, and the impact of the estimated policy would be biased. In these cases, the comparison group has to be designed very carefully, so that it is isolated from unintended effects.

Imperfection in compliance

Compliance flaw occurs when some of the individuals in the treatment group do not receive the treatment, or when units assigned to the control group are treated. In our case, it may be that despite the royalty being applied, in reality it cannot be charged. That would be an effect of the policy itself, since it is not because the producers do not change their behaviour, but because of a failure in implementation. However, it would not allow us to correctly estimate the impact of the policy. This is a problem that can affect any of the designs discussed above. The correct estimate of the effect on those treated could be recovered by making an adjustment to them depending on who actually applied the treatment.

3.7 Evaluation of projects implemented with the collection of the royalty

As established in section 3.1, an immediate result of the establishment of the royalty will be the collection generated by it that will be used to promote the efficient use of water and its environmental sustainability. For this, what is collected will be used primarily for the following uses: works or services related to flood control and water regulation (up to 10%); works or services related to the conservation and management of protected areas and the restoration of the environment (up to 10%); strengthening the Regional Councils and Watershed Commissions (up to 10%); knowledge and research on environmental and water issues (up to 10%); the remainder will be used for works or services related to treatment for drinking water and distribution systems, and sanitation and effluent treatment systems in the interior of the country.

According to what is established by the Logical Framework of ECLAC, it is necessary to carry out monitoring and evaluation activities in order to reduce the difference between the planning of a project and its results. It is important to evaluate the results obtained and their proper assignment, as well as to analyse their sustainability and justification.

Monitoring is a systematic procedure used to corroborate the efficiency and effectiveness of the process of implementing a project and it is carried out at the stage of its execution. It seeks to identify the achievements and weaknesses that will serve as inputs to make recommendations on corrective measures to improve performance and optimize the desired results.

The evaluation is carried out during all stages of the project, even after implementation of what corresponds to the impact evaluations. The evaluation involves making a systematic assessment and reflection on the design, execution, efficiency, effectiveness, processes and results or impact of a project in execution or finalized.

Following the Logical Framework of ECLAC, we can identify two types of evaluations: i) the formative evaluation, which is carried out when the project is being executed and provides information and inputs that allow learning and making modifications to obtain a better final result, and ii) the summative evaluation, which is implemented once the project is finished, or several years later, if it is an impact evaluation. The main objective of the summative evaluations is to obtain information on the results obtained that allow improvement for future programmes or projects. It is recommended that both intermediate and ex post evaluations be carried out by specialized professionals, not involved in the implementation of the programme, in order to obtain a more objective evaluation.

In this section, the design, implementation and performance evaluations (DID for its acronym in Spanish) are presented, as a methodology that complements the monitoring and follow-up carried out by the institution that is responsible for implementing the programme.

The DID evaluations are short evaluations (approximately 5 months), carried out in our country by external evaluation teams with the technical support of the Management and Evaluation Directorate (DIGEV for its acronym in Spanish) of the Planning and Budget Office (OPP for its acronym in Spanish). The main objective of the DID evaluations is to provide technical inputs for the analysis of public interventions aimed at facilitating organizational learning, promoting actions to improve public services, and supporting the decision-making process[23].

In this context, DID evaluations imply a virtuous relationship between monitoring and evaluation, and consist of specific studies to generate and systematize information on the performance of a public intervention, emphasizing its design, implementation and context. It is important to note that DID evaluations are different from impact evaluations, since they do not imply the creation of baselines or control groups to analyse the change generated by the intervention. On the other hand, the DID evaluations allow the identification of strengths and/or opportunities for improvement in the implementation of the intervention.

DID evaluations focus on design, implementation and performance. The design is analysed in relation to the problem to be overcome through the intervention, and the internal logic of said intervention strategy. With respect to implementation, the aim is to improve it by observing fundamental elements, such as the organizational structure, the coordination mechanisms existing in the executing institution, the criteria used for the allocation of

[23] Public interventions are defined as the smallest links of public policies and are generally carried out by an Executing Unit.

resources, and the planning, monitoring and evaluation activities. Finally, DID evaluations analyse the performance and achievements of a public intervention, emphasizing processes, products, and eventually results.

It is important to emphasize that the DID evaluations do not require generating new information, but are based on existing information held by the executing institution. This information is systematized and analysed, and can be complemented with in-depth interviews with key informants.

In the implementation of the royalty for the use of water in the agricultural sector, DID evaluations can be carried out in order to complement the monitoring and evaluation effected by DINAGUA, the executing unit.

As described above, these evaluations will identify opportunities for improvement in the design, implementation and performance of the intervention. Likewise, the DID evaluations may be used to evaluate the early and immediate results of the implementation of the royalty, unlike the impacts generated by the long-term intervention that will be evaluated using an adequate impact evaluation methodology.

The final chapter presents two alternatives to carry forward the design of the ex-post evaluation of the implementation of a royalty for the use of water in the agricultural sector in Uruguay on the consumption of water in said sector: i. the evaluation through the comparison of the behaviour of the producers with respect to what happens in neighbouring countries, and ii. the evaluation at the aggregate level for the whole country through the creation of a synthetic counterfactual.

At the same time, different alternatives of information sources were presented that can be used to design the baseline. However, its construction cannot always be done directly, and sometimes needs coordination with the DIEA of the MGAP.

Due to this, sources of available information were collected, and questions of the different surveys that could be used for the construction of the database were integrated for the evaluation proposal based on the comparison with the behaviour of producers in neighbouring countries. However, the information is not freely accessible, to date we have not received a response to the continuous consultations we conducted with the institutions of neighbouring countries. It is expected that, having already identified the necessary information, it can be accessed through the Uruguayan government when carrying out the evaluation.

On the other hand, all the accessible information was collected for the aggregate evaluation for the whole country through the synthetic control method. A thorough review of the available information was made, and a database was created that is delivered attached. Based on this information, it is concluded that it is only possible to evaluate the evolution of the area for rice production, under the assumption that it always occurs under irrigation in all countries. At the same time, its application was illustrated, proposing a configuration for the construction of the synthetic counterfactual. This should be appraised for the final evaluation.

4. Systematization of the different methodologies and identification of the necessary information for the ex-ante evaluation of the introduction of a royalty for water use

In the study for the design, implementation and evaluation of public policies it is advisable to conduct an analysis of the expected impacts of the intervention before it happens (ex-ante) and also based on observations of subsequent changes (ex-post) to the project execution (Freeman, Herriges and Kling, 2014). This is because the decision maker, in shortage conditions, faces a series of policy options that compete for resources. Usually, the ex-ante analysis includes the prediction of physical and/or economic consequences of the implementation of policies based on models of the processes involved. It includes comparing two states of the world, one with politics and another without it, and carrying out a comparison based on a pre-established criterion such as net economic efficiency (Freeman, Herriges, and Kling, 2014). The ex-ante evaluation and central theme of this chapter helps to decide which project or combination will produce the greatest impact on the target population according to what is expected from the plan.

The application of the royalty tries to promote adequate economic incentives to modify behaviours and that users of the resource utilize it efficiently. Although the magnitude of the impacts is an empirical question, on which information will be provided through modelling and simulation exercises, economic theory allows us to make some predictions in terms of directions of the changes. In this sense, the conceptual framework of production theory allows, through analysis of comparative statics, the prediction of the direction of change (if any) in some variables of interest to the analyst. According to this theory, it is expected that the producers that use irrigation, reduce the consumption of the input that becomes more expensive in relative terms, favouring other inputs or activities that are less demanding in terms of this resource. This reduction in consumption would relieve pressure on the resource. Likewise, it is also expected that the implementation of the royalty, beyond generating resources that the state will define how to use, also reduces revenues to the sectors that are water users at present. In any case, the royalty applied to the resource not only affects the demand for irrigation water, but also has other effects of an economic, social and environmental nature. Therefore, it is necessary to carefully implement the policy, the amounts to be defined, and the careful allocation of resources that the state obtains in this way, to uses that improve the welfare of the population as a whole.

This chapter will focus on the ex-ante impact assessment of a specific policy, in particular, of the expected effects on the agricultural sector as a result of the introduction of a water use charge. As mentioned above, ex-ante evaluations of an intervention attempt to simulate in some way the effect of the project, policy or intervention before it is put into practise. In this way, we obtain information that allows us to determine the impact of the interventions and the most efficient ways of achieving the proposed objectives (Navarro et al., 2006). In these evaluations it is necessary to define a counterfactual, or situation in the absence of intervention, in order to determine what happens in the absence of intervention, the status quo, or the "business as usual". In the case of the ex-ante analysis, direct observations can be used as the status quo or to establish a baseline scenario (i.e. the evolution in time of the variables of interest expected in the absence of interventions). Likewise, the base scenario can be established if it is a future projection through the use of simulation models.

Once the situation that would result in a "business as usual" is established, the situation of the economy after the implementation of the measure is simulated. This way it is possible to measure the impact of the intervention on variables of interest such as the difference between the two scenarios.

We must not lose sight of the limitations of the application of this methodology, which includes assuming and including in the analysis economic models and/or causality relationships. However, the results obtained are valuable to inform the current situation of the producers and have a first measurement of the possible effects of the application of the royalty (Navarro et al., 2006). Another important consideration is that ex ante and ex post analyses (discussed in Chapter 3) should not be seen as competing alternatives or substitutes, but rather as complements to adequate policy formulation and validation. Beyond the evaluation of impacts with observations of what actually happened, the ex-post also allows the exercise of checking on the validity of ex ante analysis. This is without losing the perspective that this comparison does not imply simply comparing the prediction against the current results since our inability to project relevant economic variables (price levels, exchange rates, income, etc.) may be behind some of the potentially observed deviations.

For the ex-ante impact evaluation, it is necessary to begin with a diagnosis of the producers that use irrigation. Who are these producers? What is the amount of hectares that use irrigation? Before this, the conceptual framework and the methods to be used are outlined here.

4.1 Brief introduction to the conceptual framework: Theory of Production

A producer combines inputs and other production factors with a given technology to obtain a given product. The maximum levels of production that can be achieved with different combinations of inputs are represented by a production function. The production function can be written as:

$$y = f(x_1, x_2, \dots, x_n)$$

Where *y* is the level of production, $x = (x_1, x_2, \dots, x_n)$ is the amount of each of the *n* inputs used, and $f(\cdot)$, indicates the available technology, which is assumed increases at decreasing rates in the use of each input. The decision maker also faces a vector of prices, $P = (p, p_1, p_2, \dots, p_n)$, where the first element represents the price of the product obtained and the rest the price of the *n* inputs to be used. In this context we assume that the objective of the decision maker (producer) is to maximize benefits through the combination of inputs, given the available technology and the price vector. For simplicity of presentation, we limit ourselves to the case where there are only two inputs, but the problem is easily generalizable to the case of *n* inputs. In this situation the problem of the decision maker is:

$$\underset{x_1, x_2}{\text{Max}}\, \pi = pf(x_1, x_2) - p_1 x_1 - p_2 x_2$$

To achieve its objective, the producer will select the levels of inputs (x_1, x_2) that maximize the function of π benefits. For this to happen, the level of use of each input must satisfy that the value of a marginal change in the use of the input is equal to its cost (first order conditions, where, $f_i = \frac{\partial f(x_1, x_2)}{\partial x_i}$, *i = 1,2*).

$$\pi_1 = \frac{\partial \pi}{\partial x_1} = pf_1 - p_1 = 0$$
$$\pi_2 = \frac{\partial \pi}{\partial x_2} = pf_2 - p_2 = 0$$

Additional conditions must also be met to ensure that the extreme point found is indeed a maximum (these are the sufficient second-order conditions).[24] We can then find the demands of the inputs $\left(x_1^*(p,p_1,p_2), x_2^*(p,p_1,p_2)\right)$ that maximize the benefit for each combination of prices of products and factors. This tells us directly that in the face of changes in the prices of products or inputs, the decision maker will adjust (if possible) their use to continue maximizing benefits in the new scenario. In particular, for the considered case, changes in the price of water (as a result of the introduction of a royalty) would potentially affect the use of inputs, the level of production, and benefits obtained from the activity.

This conceptual framework with the assumptions made allows us, through the analysis of comparative statics, to make some directional predictions in some variables of interest in the face of changes in the environment faced by the producer. In particular, and of interest for this work, are the following: [25]

$$\frac{\partial x_1^*(p,p_1,p_2)}{p_1} < 0$$
$$\frac{\partial x_2^*(p,p_1,p_2)}{p_2} < 0$$

That is, the level of use of each input will be reduced when its price increases. In turn, this model indicates that the benefits for the producer would be reduced. As mentioned above, although this conceptual framework allows for directional predictions, it does not inform about the magnitude of the changes.

To obtain approximations to them, it is necessary to introduce more structure to the model in terms of production functions calibrated to the situation of interest. This is what is intended in this ex-ante analysis. Some crops or activities for which irrigation is not a fundamental input, production could be benefited in terms of area as a result of a relative increase in the production of activities demanding irrigation. While other crops use the resource for productive purposes (transpiration and biomass accumulation), rice cultivation uses it in a wide range of ways. In any case, it is expected that the application of the royalty for water consumption in agricultural production in our country will improve and encourage an efficient use of the resource. Therefore, it is necessary to analyse the impacts generated by this action on users of water for agricultural purposes.

4.2 Methods of economic valuation of water

Public policies related to the supply and quality of water can have consequences on households, communities, agricultural production and companies. Faced with changes in the availability of the resource as a result of climate change and variability, as well as increasing pressure on it associated with the growth of demand and production, it is becoming increasingly important for water managers and government agencies to understand the value of the resource in alternative uses in order to make the most of a limited supply. In other words, once the basic needs of the population are met, it is desirable to efficiently allocate the available water to maximize its value to society.

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[24] The second order sufficient conditions for a maximum are:
$\pi_{11} < 0, \pi_{22} < 0$ y $\pi_{11}\pi_{11} - \pi_{12}^2 > 0$

[25] The reader interested in the mathematical analysis that allows making these predictions is referred to microeconomics texts such as Varian (1992) or Silberberg (1990).

Water is distinguished from most other resources by a series of special characteristics and generates challenges for the design and allocation of resources (Young and Loomis, 2014). In addition, water is for the most part a non-tradable good with a high exclusion cost where it is usually difficult to fix prices. Also, in the market there are different users of the resource whether formal or informal, as well as different regions. These characteristics make it a public good, although a rival one, since extraction by some represents a decrease in availability for others. This point makes the intervention of a regulatory agent necessary if the assignation of a more efficient use of the resource is desired. The implementation of a royalty for water use could be an instrument with the potential to help improve the efficiency of resource management.

Neoclassical theory sustains that the value of a good is given by its marginal value. That is, the value of assigning the resource to the next best alternative. This approach acquires relevance in diverse works where the benefits of water use are evaluated in relation to the productivity of the crops with which they are associated (Molden el al, 1998). However, these approaches do not incorporate the interactions between the different uses and the multifunctionality of water, which limits its assessment (Barbier et al, 1997).

When the objective of valuing the resource is associated with a pricing policy or the application of a royalty, it is important to consider the costs of water availability and the alternatives of use. Furthermore, when their valuation is related to investment decisions, distribution or management of the resource, the externalities that their use may generate in society must also be considered.

Most water valuation methods fit into two broad categories that differ from basic mathematical procedures. The first, called inductive techniques, uses inductive logic as formal statistics with econometric procedures. These techniques are the most applied among public environmental goods and involve a process of reasoning from the particular to the general, that is, from particular observations to general relations.

The limitation of this method is that it is a behaviour observed from variables and historical data. It is difficult to infer future demands and estimated values from past information. The collection of new data or surveys to complement the model can also take time and be expensive. In short, this restriction makes it difficult to make inferences of future assessments and behaviour based on past information.

The other group of valuation techniques can be classified within the deductive method, which implies a logical process to reason from general conclusions to specific or particular ones. Deductive techniques employ models that comprise a set of behavioural postulates (that is, maximization of profit or utility subject to certain restrictions) and empirical hypotheses appropriate to the case in question. It is important to build an empirical system and a behaviour model, from which specific parameters or shaded prices are deduced. This technique is one of the most used to assess water and is crucial to perform an ex-ante analysis (Young and Lomis 2014).

There are several valuation methods, both inductive and deductive, that are presented in Table 12. There are different ways of measuring the economic value of water. In the inductive there is a series of methods to determine the value of water ranging from observations of the market of water transactions, econometric models to hedonic methods.

On the other hand, in the deductive method that starts from general to specific propositions, there are different methodologies to determine the value of water.

Table 12: Water valuation methods

Inductive Method	Description of the Method
Observations in water transaction markets	Observe transaction prices and sale of water ownership rights.
Econometric estimation of production and cost function	Primary and secondary information on industry and agriculture analysed with statistics and regressions.
Water econometric estimation and demand function	Water use information with statistical methods.
Variant cost method	Revealed preferences, using variations and econometric analysis to estimate demand.
Hedonic pricing method	Revealed preferences using econometric methods. Varying water availability and quality.
Defensive behaviour method	Revealed preference through reductions in the costs of the actions that people take to mitigate externalities.
Damage cost method	Maximum WTP (willingness to pay for water) as a monetary value to avoid damage.
Contingent valuation method	Preference method, using statistical techniques and surveys.
Choice model	Preference method using statistical techniques to infer in WTP (willingness to pay for water).
Transfer benefits	Estimated benefits for one or more existing evaluation studies are used to calculate benefits in other sites or policy proposals.
Benefit transfer function/meta-analysis	Analysis information in similar situations and statistical synthesis.

Deductive Method	Description of the Method
Residual value method	Models to obtain farm net income or water rent via budget analysis.
Network change income	Residual models elaborated for the estimation of the net income of the producers or payment of the water.
Mathematical programming	Models to obtain income or marginal costs of water use. Optimization models.
Added value	Construction of a model of producer income or income attributable to water via added value
Computable general equilibrium model	Construction of a model derived from direct and secondary income or income attributable to water via optimization of the model.
Alternative costs	Value attributable to the cost savings of the next best service alternative (for example, water supply, electricity, transportation).

Source: Own elaboration based on Young and Lomis (2014)

4.3 Identification of the main agricultural sectors where irrigation represents a fundamental input for production

According to data from the last rice survey, rice cultivation in Uruguay since its inception has developed more than 70% on leased fields, and under irrigation. Most of the lease contracts are made under the form of payment in fixed amount of product (base of rice husk). In the 2016/17 harvest, the price paid for the use of land and water nationwide was 31.1 bags of rice. The payment of water for irrigation per hectare averaged 19.9 bags of rice husk.

In the 2015/16 harvest, the area irrigated in the country according to data from the rice and agricultural survey, covered an area of 180 thousand hectares, which represents 10% of the area of cereal and industrial crops. Of the total irrigated area, 90% corresponds to the production of rice.

One of the activities competing for the use of water with irrigation agriculture is the generation of hydroelectric energy. Hydroelectric plants are one of the main water industries and their plants are often operated by public sector agencies.

Hydroelectric energy is more flexible and, in some aspects, more ecological than thermal energy generation. Hydropower does not produce air pollution or carbon dioxide emissions like power plants fed by fossil fuels, therefore they add benefits for human health and contribute to the reduction of climate change. On the other hand, reserving available water for the production of hydroelectricity implies limiting the expansion of agricultural production under irrigation in some areas of the country. This "trade-off" can be evaluated through intersectoral water allocation analysis.

The analysis of the intersectoral allocation of water implies isolating the marginal value of water. In short, water can be reallocated between sectors and the allocation that maximizes the welfare (or that produces greater aggregate benefits) of the target population, can be evaluated.

4.4 Compilation of existing information

The analysis unit is the Enumeration Area (EA, minimum territorial unit) of the General Agricultural Census 2011 (CGA 2011). For the different EAs, six main activities were defined, which have an area of more than 15 million hectares destined for production. The activities included in the work are: cattle and sheep farming, extensive crops (with and without irrigation), afforestation, dairy and rice.

The data:
The CGA 2011 provides production information by activity (with the exception of milk), so the production estimate was based on yearbooks, surveys and other sources, as detailed below in each activity.

- The activity of **cattle and sheep**. The area is declared as the main activity according to the CGA 2011. The production data was obtained from the 2012 Statistical Yearbook of the Directorate of Agricultural Statistics (DIEA for its acronym in Spanish). Beef production results from the sum of the slaughter (commercial and property), standing exports and stock variation. Sheep production was also obtained in the same way. The only difference was that for production, the concept of equivalent meat was used, that is, the production of wool was converted to equivalent meat production.

For the cattle category, the price arises from the monthly data of the 2010 and 2011 Statistical Yearbook, synthesized in an average price in two large categories (steers and others). In ovine activity, the concept of equivalent price was taken into account, which considers the total income of the producer divided by the equivalent meat production.

Production costs in USD/ha come from the Livestock Companies Monitoring Programme of the Agricultural Plan Institute.

- **Extensive Crops**. The effective area declared in the 2011 CGA of cereal crops was used, adding the first and second crops. The production of rain fed crops was obtained from the 2012 Statistical Yearbook of the DIEA. The crops considered are: soybean, corn, barley, wheat and sorghum. For extensive crops with irrigation, corn and soybeans were added. The price information comes from the 2010 and 2011 Price Yearbooks of the MGAP and monthly data is used to consider the simple average of the agricultural year. The costs (USD/ha) were provided by the Rural Union of Flowers and the Uruguayan Chamber of Agricultural Services (CUSA for its acronym in Spanish).

Irrigated crops were also considered according to data from the 2011CGA. To obtain the production with irrigation, data was taken from the yields of the 2016 and 2017 Agricultural Survey of the DIEA.

- **Afforestation**. The total area corresponds to the area occupied by artificial forests according to the 2011 CGA. With regard to wood production, data from the extraction of wood at a simple average national level in 2010 and 2011 (extraction of roundwood in 1 000 m^3) was used from the General Forestry Directorate (DGF for its acronym) source.

The price is determined as the quotient between the gross value of production and production, while for the costs the "Estimated Costs of Afforestation" of the DGF (General Forestry Directorate, MGAP), for the period 1/7 / 09 - 30/6/10 are considered.

- **Dairy**. Both the surface area and milk production were obtained from the 2011 CGA, whose main activity is dairy. The price is obtained from the 2014 Agricultural Statistics Yearbook of the DIEA. The cost is expressed in litres per hectare and was provided by the National Milk Institute (INALE for its acronym in Spanish).

- **Rice**. The effective area declared in the 2011 CGA was used and has as its main activity rice. The production was obtained from the 2012 Statistical Yearbook of the DIEA. The price comes from the 2010 and 2011 Price Yearbooks of the MGAP. The Rice Price Agreement is used in USD/ton (includes tax refund). It appears as a simple average of the prices (monthly data) corresponding to the agricultural calendar year. The costs were contributed by the Association of Rice Growers (ACA for its acronym in Spanish) and reflect those of an average farm and therefore are non-existent.

As we have the data of all the production in volume at national level, for all the activities, the participation of the EA in the total area was determined and with this frequency the listed production per area is obtained.

All this information is necessary to be able to calibrate the models to an observed, realistic situation, where the policy is not being applied. This calibration point can potentially be used as a base or counterfactual scenario, which as mentioned above is necessary for ex ante evaluations.

4.5 Proposed methodology for the estimation of the ex-ante impact of the royalty for the use of water and on production in the agricultural sector

The work will address the valuation of water through the mathematical programming method. This method has been used extensively to analyse the effects of policies applied to agriculture. Positive Mathematical Programming (PMP) is a mathematical programming technique that allows the calibration of models from the distribution of crops observed in a reference year, under the assumption of behaviour that the decision maker aims at maximizing benefits (or cost minimization). It uses deductive valuation using water supply data, production costs and cultivated area and use of production factors. For example, it allows analysing the changes in the income of agricultural producers under irrigation as a consequence of changing the availability of the resource. Also, this technique can be used to analyse changes in relative prices or policy interventions (as would be the case of the introduction of a royalty) among others, and their impacts on economic variables of interest. An additional advantage is that the PMP does not require large databases like other econometric methods.

The most common models of PMP are based on Howitt (1995a and b) who uses a production function with constant scale profits and presents costs as a quadratic function. However, in this work it will be used in a model with constant elasticity of substitution (CES) in production (Merel, Simon, and Yi 2011). Constant elasticity is a property of some production functions and refers to an aggregate function that combines two or more types of productive inputs in a given quantity. This implies that the technology of production has a constant percentage in the change of the factors of production used. Another change in the model is the strict concavity of the objective function that comes from the production relation with decreasing yields to scale. These yields determine that before a change in the productive factors, the obtained product varies in smaller proportion.

The changes have at least three important points. First, the objective function is interpreted as the difference between the relationship of production and linear costs as required in economic theory. Second, for each activity there is only one parameter that controls the elasticity of supply, which is a less severe model than the case of the quadratic cost function[26]. And finally, in the generalized model with constant elasticity of substitution (CES), the source of concavity in the income of the producers complies with all the inputs used in the model and not only to one such as the quadratic model.

First, a simplified model is presented, where the production function consists of the use of a single input by the producer who tries to maximize its benefits, in the presence of restrictions on the availability of resources. Later the model will be generalized to other inputs following Merel, Simon, and Yi (2011).
The necessary and sufficient conditions for the exact calibration of the model stem from the first model. A benefit function is maximized subject to the amount of land and water available. In these situations, the calibration solution is unique and can be easily interpreted. In this line the problem of the producer is

$$max_{x_i \geq 0} \sum_{i=1}^{I} (p_i \alpha_i x_i^{\delta_i} - (C_i + \lambda_{2i}) x_i)$$

[26] This quadratic function uses all the coefficients of the cost matrix.

(1)

Subject to: =

$$\sum_{i=1}^{I} x_i \leq X$$

where *i* is the set of activities that can be carried out, x_i the surface area of the crop *i*, price of the crop *i* (p_i), C_i cost of the crop *i*. *X* is also defined as the total availability of land. The areas and production observed for each activity *i* are written as x_i and q_i, respectively.

At the same time, the model with the water resource as an additional factor in the production *i* will be extended. The shaded values of water and land in the reference period will be implicitly defined.

In the model presented in equation 1, the total production of the activity *i* is $q_i = \alpha_i x_i^{\delta_i}$. The coefficient δ_i takes values between 0 and 1 and is used to calibrate the set of elasticities $\bar{\eta}$, while the specific parameter of the crop λ_{2i} is introduced to allow the model to calibrate accurately to the base year $(\bar{q}_i, \bar{x}_i, \overline{\lambda_1})$.

For a set of given parameters (δ_i), the first-order conditions of the maximization programme for the calibration to be achieved involve satisfying the production, area and shade value of the land *$(\bar{q}_i, \bar{x}_i, \overline{\lambda_1})$*.

$$\forall\, i, i = 1,2, \ldots, I$$

(2)
$$\begin{cases} p_i \bar{q}_i \delta_i = (C_i + \lambda_{2i} + \bar{\lambda}_1)\bar{x}_i \\ \alpha_i \bar{x}_i^{\delta_i} = \bar{q}_i \end{cases}$$

From equation 2, the parameters α_i y λ_{2i} are determined and as a function of the base year and the δ_i parameters. Following the procedure of Merel and Bucaram (2010), the elasticity of crop supply *i* can be derived as:

$$\eta_i = \frac{\delta_i}{1-\delta_i}\left[1 - \frac{\frac{\bar{x}_i^2}{p_i \bar{q}_i \delta_i (1-\delta_i)}}{\sum_{J=1}^{l} \frac{\bar{x}_j^2}{p_j \bar{q}_j \delta_j (1-\delta_j)}}\right]$$

The equation shows that the elasticity depends on the base year and δ_i but not on the parameters α_i and λ_{2i}. A vector of target supply elasticities ($\bar{\eta}$ =($\eta_1 \ldots \eta_2$) where $\eta_1 > 0$), proposed by the analyst, allows the parameters δ_i to be obtained numerically.

The calibration of the exogenous supply of elasticities can be rewritten independently of the base year. Defining b_i as the parameter that represents the ratio between area and gross income per area, the calibration system can be written as:

(3)
$$\bar{\eta}_i = \frac{\delta_i}{1-\delta_i}\left[1 - \frac{\frac{b_i}{\delta_i(1-\delta_i)}}{\sum_{J=1}^{l} \frac{b_j}{\delta_j(1-\delta_j)}}\right] \forall_i = 1, \ldots, I$$

where, while the first term of the equation represents the elasticity of the supply of crop *i* keeping the price of the land constant, the second captures the effect in the change of the shade value induced by a change in the price of the crop *i.*[27]

Since equation 2 has a solution for all values of δ_i between 0 and 1, calibration will be feasible when system 3 has an acceptable solution, that is, $\delta = (\delta_1 \ldots\ldots \delta_I)$ in such a way that $\delta_i \in (0,1)$ for all $i = 1, \ldots, I$.

Suppose there are more than two activities (I≥2). The calibration solution of system 3 has a solution between 0 and 1 if and only if:

(4) $$\forall_i=1,\ldots,I\ ;\ b_i\bar{\eta}_i < \sum_{j\neq i} b_j\bar{\eta}_j(1+\frac{1}{\bar{\eta}_j})^2$$

If this condition is satisfied, the set of δ calibrated parameters is unique for all $i=1,\ldots\ldots I$.
The model presented up to here will be expanded next to include the limitation on water availability, through which the competition for water between agricultural uses and the reserve for hydroelectric generation could be captured. In this first approach, a restriction is included that represents the availability of water for intakes and extraction for agricultural uses.

(5) $$max_{x_i\geq 0} \sum_{i=1}^{I}(p_i\alpha_i x_i^{\delta_i} - (C_i + \lambda_{2i})x_i)$$

Subject to: =

$$\sum_{i=1}^{I} x_i \leq X$$

$$\sum_{i=1}^{I} \gamma_i x_i \leq A$$

Thus, the restriction that reflects the possible need to limit the availability of water for agriculture, through limits in the extraction authorizations, is added to the previous model due to uses that are in competition for the resource such as hydroelectricity, industrial, or others. In particular γ_i denotes the water consumption per hectare assigned to activity *i,* and *A* represents the total availability of water for agriculture in area under analysis.

As discussed earlier in this document, due to legal restrictions reserving the resource for hydroelectric generation, there is currently no availability to increase permits for the extraction of water in the Rio Negro basin for agricultural uses. This justifies in principle the assumption to be used in the empirical implementation by which the availability of water for agricultural uses is limited (restriction in problem (5)) to the uses that were given in the year of calibration of the model (2011). Higher or lower reserves for hydroelectricity can be captured through modifications in the parameter *A* in the above model.

In the following, a discussion of the information and data sources available for the analysis and a summary and discussion of the main results obtained through the numerical models constructed and calibrated, are presented. The discussion of results will be made first for cases in which only the soil factor is considered limiting, and impacts and expected collection through the implementation of different levels of the proposed royalty are analysed. This analysis is carried out on a detailed spatial scale (more than 600 sub regions of the country).

[27] It is a way to avoid the myopia that the model can have. This myopia implies that when the model is calibrated, the change in the shadow price of water caused by variations in the price of any other activity is ignored.

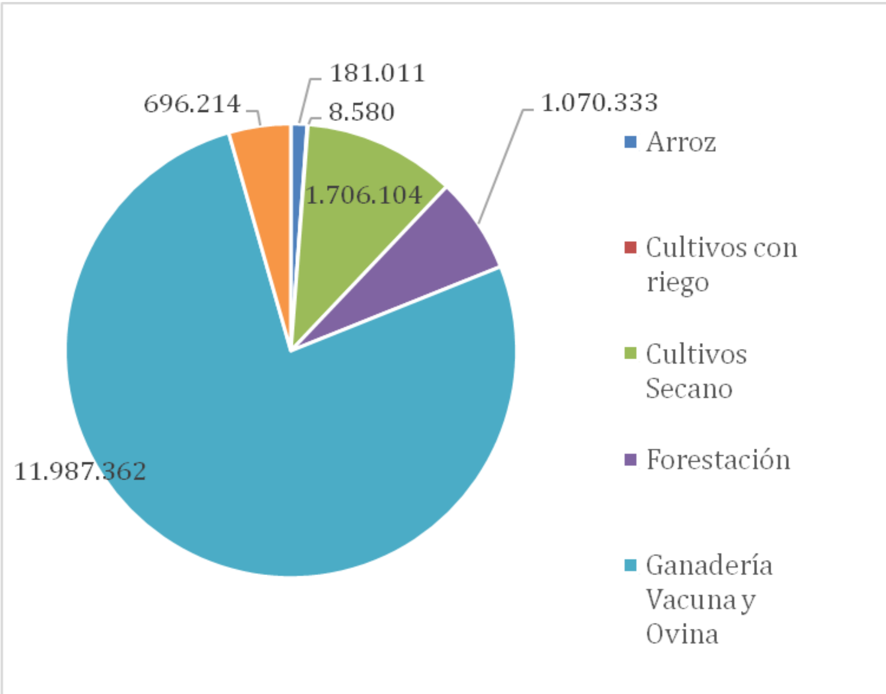
Subsequently, the restriction on water availability is included, and that availability is varied to study the impacts on the benefits of the agricultural producers located in the upper Rio Negro basin, and in particular the basin of the Gabriel Terra dam, where competition for water between the agricultural sector and hydroelectricity is customary.

4.6 Empirical Implementation and Results

The proposed model was calibrated using the data on land uses, production, prices and costs described in the previous section. In other words, and following Merel, Simon and Yi (2011), the free parameters were selected in such a way that the solution to the PMP problem replicated exactly the land allocation and production observed at the calibration point, in the last 2011 CGA.

Although the model works on a spatial scale of enumerated areas, the following figure is presented to give a general idea of the relevance of the areas destined for each activity at the national level, in terms of occupied surface (Figure 16). In particular, it is important to highlight that the activities related to livestock (beef, sheep, and dairy cattle) occupy approximately 80% of the area of more than 15.5 million hectares considered. On the other hand, extensive activities with irrigation occupy an area that does not reach 2% of the hectares considered in this study, which represent almost the entire country (approximately 16 million hectares).

Figure 16: Areas designated for agricultural activities considered in 2011



Source: CGA 2011

Each of the activities has its own dynamics within each of the departments. For example, livestock activity is found in all the departments of the country and the main producers are precisely those that have a larger area dedicated to the activity. On the other hand, Montevideo, San José and Colonia have the lowest level of production at the national level with 0.05%, 1.5% and 1.7% respectively.

Extensive crops with and without irrigation represent 11% and are located mainly in: Soriano, Rio Negro, Paysandú and Colonia. The five main departments concentrate 65% of the national production.

Afforestation represents 7% on the area considered. Paysandú, Rio Negro, Rivera, Cerro Largo and Tacuarembó have 60% of the afforested area (Table 14). Again the main departments concentrate the highest production and produce more than 6.7 million m^3 of wood.

Dairy represents 4% of the area. San José, Florida and Colonia are the main departments with 150 000, 149 000 and 131 000 hectares. In addition, production is strongly concentrated in the three departments that have 67% of the national production. In Florida some 424 million litres are produced, followed by San José with 388 million litres and Cologne with another 378 million litres.

Rice activity demands around 180 000 hectares (1% of the area considered). Treinta y Tres is the department with more hectares with 48 000, followed by Cerro Largo, Rocha and Artigas with 37 000, 32 000 and 29 000 hectares respectively. In terms of production, the first four departments account for 82% of production.

4.7 Model with restriction on the availability of land resources

Once established that the model is capable of replicating the reality observed in 2011, in terms of assigned areas and production, the implementation of 3 different scenarios was conducted based on the introduction of 3 different levels of royalties for water use. The levels of the modelled royalties included increases of 25%, 50%, and 100% on the costs paid on average per cubic metre of water destined for irrigation by rice producers.[28] In particular, the levels of royalties included in this analysis were 0.0045 USD/m^3, 0.090 USD/m^3, and 0.018 USD/m^3. It is also assumed that the cost of the royalty is passed on to the producers as an additional to what they were already paying for access to water (by lease or by direct intakes).

As indicated in the conceptual part, it is expected that the introduction of a royalty will result in a reallocation of land use and a reduction in the use of water in agriculture. In particular, it is expected that activities that use water for irrigation reduce its area, which will be distributed among activities that do not irrigate. Areas of the country where activities that make intensive use of water for rice or irrigated crops occupy a significant proportion of the area. They will suffer the greatest changes in land use with the introduction of these royalties for the water use. At the same time, it is expected that the introduction of royalties will reduce the benefits obtained by the sector as their costs in these areas increase.

The results confirm these expectations derived from the conceptual framework and models used in the analysis. The activity where the greatest reductions are observed both in terms of absolute number of hectares and percentage is in rice, activity that uses irrigation water with greater intensity of all those considered in the study (Table 13). Likewise, and given the geographical and land conditions where the different activities are carried out, it is observed that there is a substitution of areas that depend on each region of origin of the liberated areas. In particular, Table 13 and Figure 17 show that the area released by rice is mostly transferred to livestock activities. On the other hand, areas released by non-irrigated crops pass mostly to

[28] In particular, the price per cubic metre was established based on information from the Association of Rice Growers and the MGAP, which indicate that the payment for water amounted in 2011 to 20 bags of 50 kg per hectare, with a price of 12.63 USD/bag. It also assumes an average water consumption per hectare of rice of 14,000 m^3 (Crisci and Terra, 2014)

rain fed agriculture and dairy farming (where forage crops are also grown to provide food for the herds).

Table 13: Changes in land use at the aggregate level

	Rice	Crops with irrigation	Dry crops	Forestation	Cattle breeding and sheep farming	Dairy
	Hectares					
Royalty 1	-24,952	-628	404	632	24,395	149
Royalty 2	-44,453	-1,182	721	1,130	43,517	266
Royalty 3	-72,766	-2,113	1,185	1,863	71,393	439
	Percentage					
Royalty 1	-13.8	-7.3	0.0	0.1	0.2	0.0
Royalty 2	-28.5	-14.9	0.0	0.1	0.4	0.0
Royalty 3	-53.3	-28.6	0.1	0.2	0.6	0.1

Although the conceptual model used and calibrated makes it possible to estimate these changes at the enumeration area level, Table 14 shows the changes at the national level. These same changes are presented at the departmental level in Tables 14 and 15, and the enumeration area for activities selected in Figure 17. To conserve space, only the results for the first level of the royalty in the Table and the second level in the Figure are included.

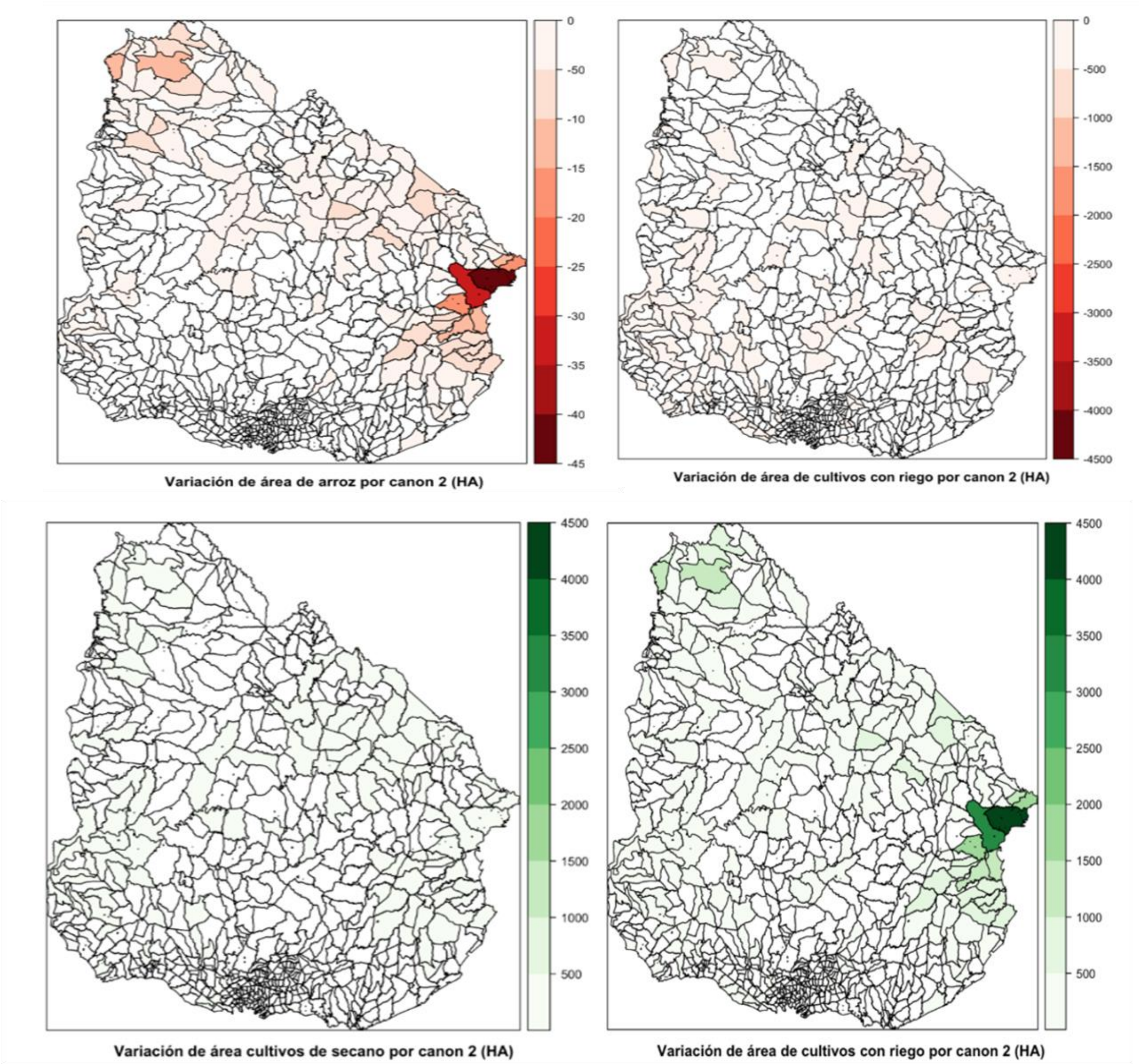
Table 14: Change in the number of hectares dedicated to the different activities as a result of the introduction of royalty 1 (0.0045 USD/m^3) for water use

	Rice	Crops with irrigation	Dry crops	Afforestation	Cattle breeding and sheep farming	Dairy
	Hectares					
Artigas	-4101	-31	24	28	4056	24
Canelones	0	-17	0	1	15	1
Cerro Largo	-5110	-36	127	185	4793	42
Colonia	0	-16	2	0	13	1
Durazno	-91	-5	3	2	90	1
Flores	0	-2	0	0	2	0
Florida	0	-2	0	0	1	0
Lavalleja	-848	-38	18	14	844	11
Maldonado	0	0	0	0	0	0
Montevideo	0	0	0	0	0	0
Paysandú	-176	-15	6	9	175	1
Río Negro	-31	-79	13	16	80	1
Rivera	-493	-58	12	23	513	3
Rocha	-4538	-14	43	54	4445	10
Salto	-1042	-24	11	9	1031	15
San José	0	-51	4	2	42	3
Soriano	-54	-134	34	14	139	1
Tacuarembó	-1919	-38	32	106	1784	35
Treinta y Tres	-6548	-68	76	167	6373	1

Table 15: Percentage change in the number of hectares dedicated to the different activities as a result of the introduction of royalty 1 (0.0045 USD/m^3) for water use

	Rice	Crops with irrigation	Dry crops	Afforestation	Cattle breeding and sheep farming	Dairy
	Percentage					
Artigas	-13.8	-6.7	0.3	0.5	0.4	0.9
Canelones	0.0	-3.7	0.0	0.0	0.0	0.0
Cerro Largo	-17.2	-7.8	1.8	3.0	0.5	1.6
Colonia	0.0	-3.5	0.0	0.0	0.0	0.0
Durazno	-0.3	-1.1	0.0	0.0	0.0	0.0
Flores	0.0	-0.5	0.0	0.0	0.0	0.0
Florida	0.0	-0.4	0.0	0.0	0.0	0.0
Lavalleja	-2.9	-8.3	0.3	0.2	0.1	0.4
Maldonado	0.0	0.0	0.0	0.0	0.0	0.0
Montevideo	0.0	0.0	0.0	0.0	0.0	0.0
Paysandú	-0.6	-3.3	0.1	0.1	0.0	0.0
Río Negro	-0.1	-17.0	0.2	0.3	0.0	0.0
Rivera	-1.7	-12.5	0.2	0.4	0.0	0.1
Rocha	-15.3	-3.0	0.6	0.9	0.4	0.4
Salto	-3.5	-5.2	0.2	0.1	0.1	0.6
San José	0.0	-11.0	0.1	0.0	0.0	0.1
Soriano	-0.2	-29.0	0.5	0.2	0.0	0.0
Tacuarembó	-6.5	-8.2	0.4	1.7	0.2	1.3
Treinta y Tres	-22.1	-14.8	1.0	2.8	0.6	0.0

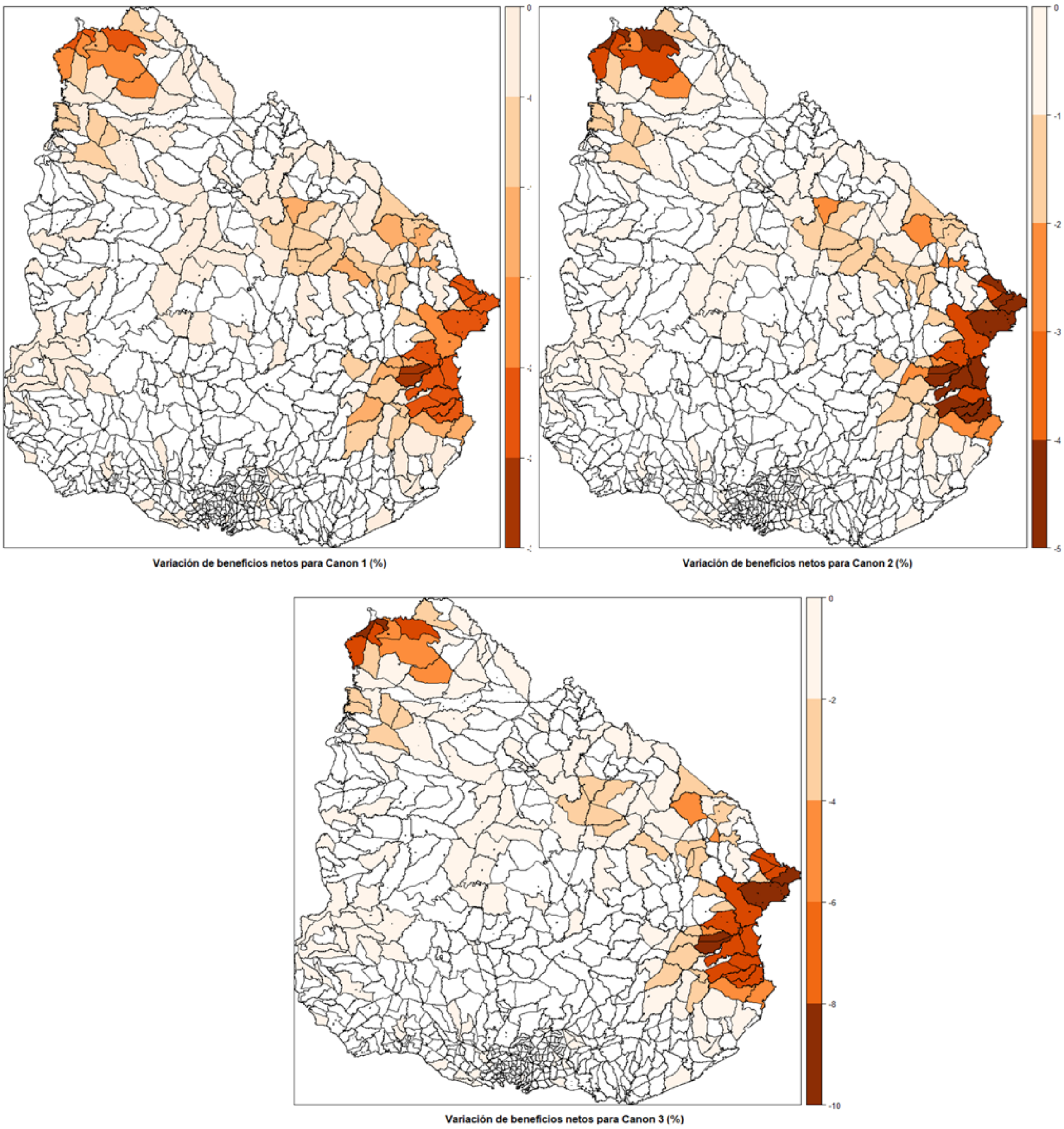
Figure 17: Expected change in the number of hectares of different agricultural activities in the scenario with royalty 2 per enumeration area



These variations in areas dedicated to the different activities, due to the introduction of the royalty, would also generate changes in the net benefits associated with agricultural production. Changes in the net benefits of the producers, expressed as percentage variations taking as a reference the base case, or without a royalty, are shown in the following figure (Figure 18). As expected, the largest percentage reductions, in terms of net benefits in relation to the base case, occur in areas where rice is predominant. Minor changes in relation to the latter occur in various areas of the country where, although there is production of crops under irrigation, they occupy smaller areas in the enumeration area that houses them.

In aggregate quantitative terms, the calibrated model indicates that the reduction of benefits for producers (in relation to the baseline scenario) would be around 10.8, 20.1, and 35.7 million dollars for royalties 1, 2, and 3, respectively.

Figure 18: Expected variations in net benefits of the agricultural producers at enumeration areas level (in %)



Three water royalty levels evaluated (Royalty 1 = 0.0045 USD/m^3, Royalty 2 = 0.0090 USD/m^3, Royalty 3 = 0.018 USD/m^3)

The reduction of net benefits added at the departmental level for different levels of the royalty is presented in Table 16. In short, the table gives figures for the information presented above in the form of a map, confirming that the departments where extensive crop production with irrigation is located, and rice in particular, would be the most affected in terms of the net benefits to be obtained by agricultural producers.

Table 16: Change in the net benefits expected by the producers of each department for the three royalty levels evaluated

	Royalty 1	**Royalty 2**	**Royalty 3**
Department	1000 USD		
Artigas	-1744.7	-3260.0	-5782.0
Canelones	-3.9	-7.5	-13.9
Cerro Largo	-2186.9	-4087.7	-7253.0
Colonia	-4.0	-7.7	-14.3
Durazno	-39.3	-73.5	-130.5
Flores	-0.6	-1.1	-2.1
Florida	-0.4	-0.7	-1.4
Lavalleja	-366.4	-684.9	-1215.6
Maldonado	0.0	0.0	0.0
Montevideo	0.0	0.0	0.0
Paysandú	-77.0	-144.0	-255.7
Río Negro	-32.1	-61.2	-112.0
Rivera	-220.8	-413.2	-734.8
Rocha	-1926.6	-3599.7	-6383.8
Salto	-443.3	-828.1	-1468.4
San José	-11.9	-23.0	-42.9
Soriano	-55.4	-105.5	-193.1
Tacuarembó	-815.6	-1523.7	-2701.9
Treinta y Tres	-2832.0	-5296.2	-9404.3
Total	**-10761**	**-20118**	**-35710**

Part of these reductions in private benefits will be transfers to the public agencies that receive the royalty. After the introduction of the royalty, activities that carry out irrigation must pay the agency that administers them based on the volume of water committed.[29] The spatial distribution of the different levels of collection that would be obtained in each enumeration area is presented in the following maps (Figure 19).

[29] For simplicity we assume here that the volume used coincides with the authorized, so the area planted of different crops under irrigation to determine the amount of water needed, also determines the royalty to be paid (once the price per m3 is established).

Figure 19: Expected levels of collection at the enumeration area level (in thousands of USD), for three water royalty levels evaluated (Royalty 1 = 0.0045 USD/m^3, Royalty 2 = 0.0090 USD/m^3, Royalty 3 = 0.018 USD/m^3)

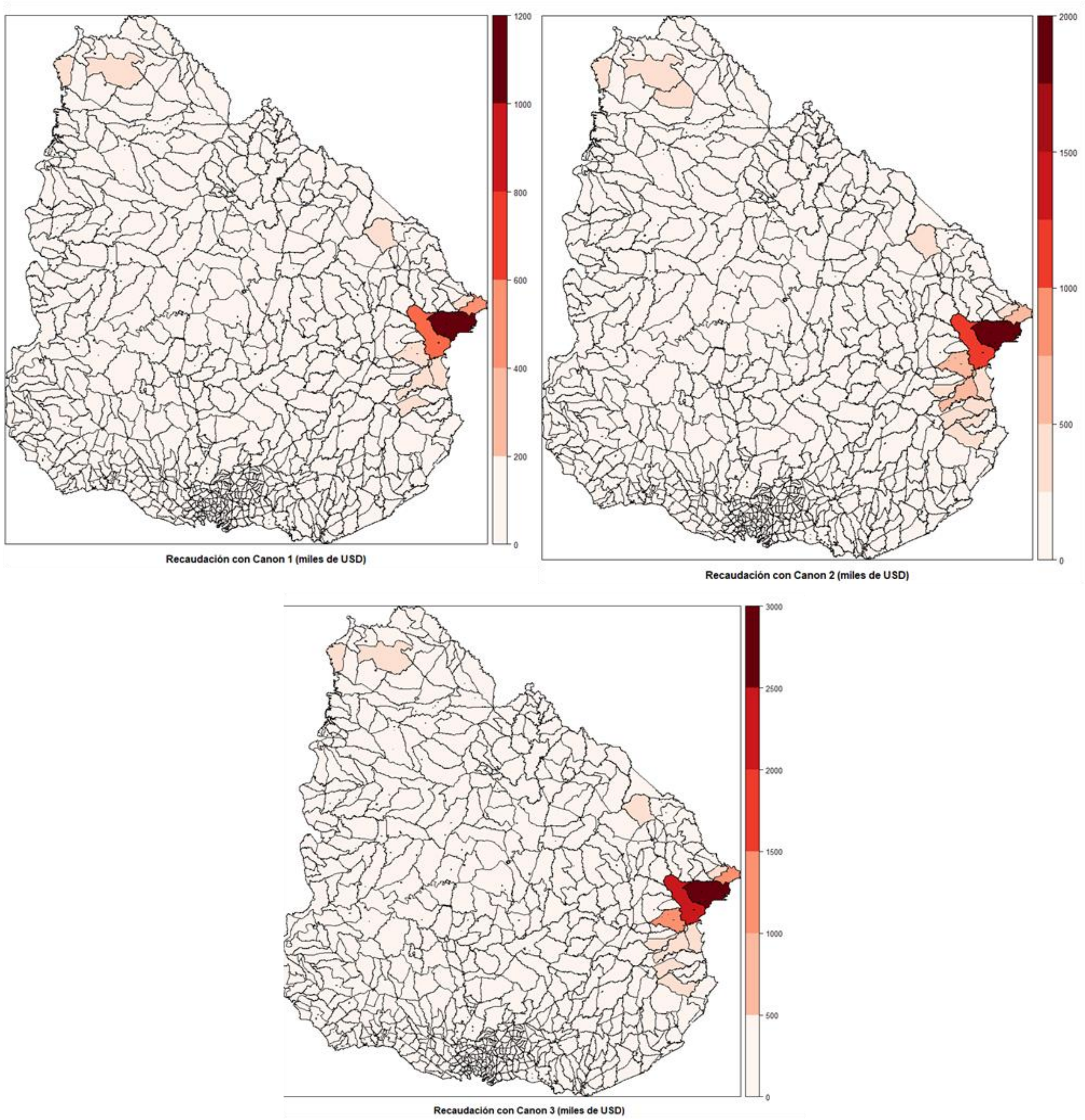


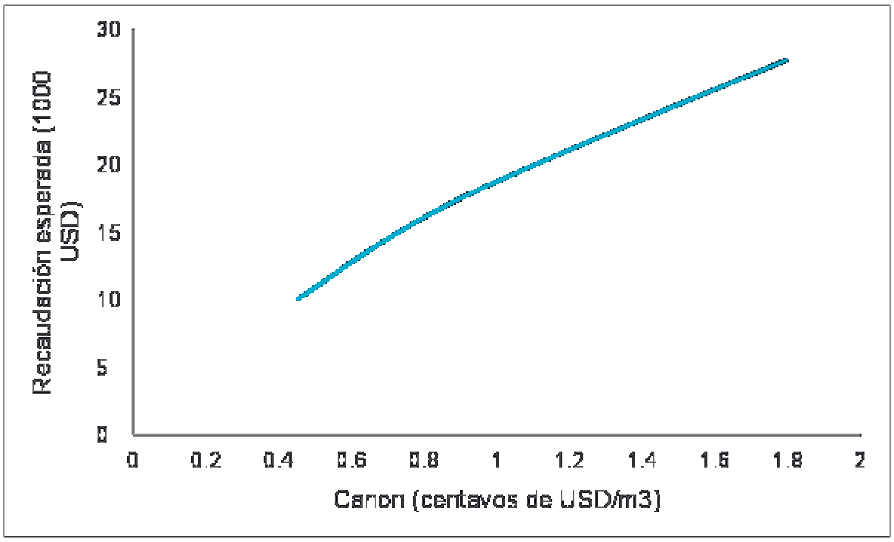
Table 17 is presented in a complementary way and to provide figures for the expected collection through these two activities with irrigation, and their distribution by department. As can be seen in the table and consistent with the maps, most of the collection through the considered royalties would occur mainly in departments where the country's rice production is concentrated. In particular, the highest levels of collection would be concentrated in Artigas, Cerro Largo, Rocha, Tacuarembó and Treinta y Tres. In aggregate terms, the royalty levels would raise between 19 and 27 million dollars.

Table 17: Expected collection for water use for irrigation in rice and irrigated extensive crops (corn and soybeans) (Royalty 1 = 0.0045 USD/m^3, Royalty 2 = 0.0090 USD/m^3, Royalty 3 = 0.018 USD/m^3)

	Royalty 1	Royalty 2	Royalty 3
Department	**1000 USD**		
Artigas	1620.3	2829.2	4485.8
Canelones	3.7	6.9	12.0
Cerro Largo	2031.9	3549.7	5631.1
Colonia	3.8	7.1	12.5
Durazno	36.5	63.9	101.6
Flores	0.6	1.1	1.9
Florida	0.4	0.7	1.2
Lavalleja	340.4	594.9	944.8
Maldonado	0.0	0.0	0.0
Montevideo	0.0	0.0	0.0
Paysandú	71.6	125.1	198.9
Río Negro	30.5	55.3	93.2
Rivera	205.4	359.7	573.7
Rocha	1789.1	3123.6	4951.2
Salto	411.5	718.4	1139.0
San José	11.5	21.3	37.1
Soriano	52.6	95.3	160.7
Tacuarembó	757.2	1321.8	2095.6
Treinta y Tres	2632.9	4604.2	7312.3
Total	**10000**	**17478**	**27753**

These results also allow us to evaluate how the expected collection changes in the face of modifications in the royalty level (Figure 20). The figure shows that the expected collection would increase at decreasing rates in the face of increases in the proposed royalty. We can also use the aggregated numbers of the table to calculate the implicit elasticity of the collection, against changes in the level of the royalty. It follows that the elasticity against changes in the royalty evaluated by taking the first level as a reference, implies that every 1% increase in the level of the royalty (starting from 0.45 USD/m^3) would result in an additional income of 0.74%. Calculated using 0.9 USD/m^3 as the reference value of the royalty, the elasticity drops to 0.59. In percentage terms, the increase in collection declines as we face higher royalty charges.

Figure 20: Relationship between the level of the royalty and the expected collection

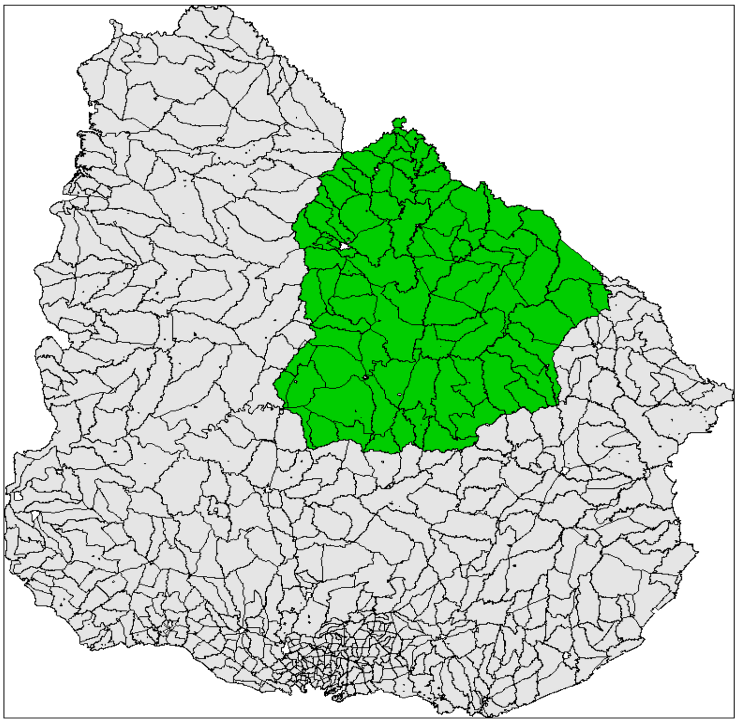


4.8 Extended model with restriction on the availability of land and water resources

In the following, results of an extended model are presented, which allows the incorporation of multiple restrictions to the PMP used so far (Garnache and Merel, 2011). In this line, in addition to the restriction in terms of lands, an additional limitation provided by the total availability of water for the agricultural activity is incorporated here. Modifying this limitation upwards or downwards allows us to identify the impact that this restriction has on the allocation of land and on the net benefits or profitability of production. In this way the cost associated with reserving water for hydroelectric generation, or the impact of this competition on the sector can be estimated.

For the analysis, the basin of the Gabriel Terra dam (a sub-basin of the Rio Negro) was selected, where the authorizations for the extraction of water for agricultural uses are close to the maximum allowed by the regulations due to water reserves for the production of hydroelectricity. The location of this basin and its area in relation to that of the country can be seen in Figure 21. Comparing this figure with previous maps it can be observed that the area of the basin overlaps in an important way with rice areas. Therefore, restrictions on the extraction and storage of water will directly affect this item and other irrigated crops in the area, which occupy smaller areas.

Figure 21: Location of the G. Terra basin in Uruguay



The scenarios considered here capture different intensities of competition between agricultural activity and other uses such as hydroelectricity, recreation activities, conservation of ecosystem flows and others. For the analysis, the same baseline is established as in the previous section, calibrated to the data on land uses surveyed in the 2011 CAG. Based on the land uses of the basin, and in particular the areas of rice and of other extensive crops under irrigation, the extraction and use of water for agricultural irrigation was calculated.[30] From this scenario, three alternatives are generated that imply the reduction of the amount of authorized water to 90%, 80%, and 70% of that available in the baseline or reference scenario. Given the implementation of the scenarios, in each one the amount of water that is available varies for the agricultural activities considered. The availability for the base case, as well as for each of the scenarios (and in relation to the base scenario) is presented in Table 18.

Table 18: Water available in the scenario and base and changes in the different scenarios of water restrictions for agriculture

Scenario	Water available for irrigation in different scenarios (Hm^3)	Change in available water in relation to the base scenario (Hm^3)
Base	461	
90%*	415	-46
80%	369	-92
70%	323	-138

* Refers to 90% of the water available in the base scenario, or alternatively a 10% reduction in the available water. $Hm^3 = 1{,}000{,}000\ m^3$

[30] From the literature and consultation with experts, the assumptions of water use of 140 00m^3/ha for rice production and 4080 m^3/ha for other irrigated crops emerge.

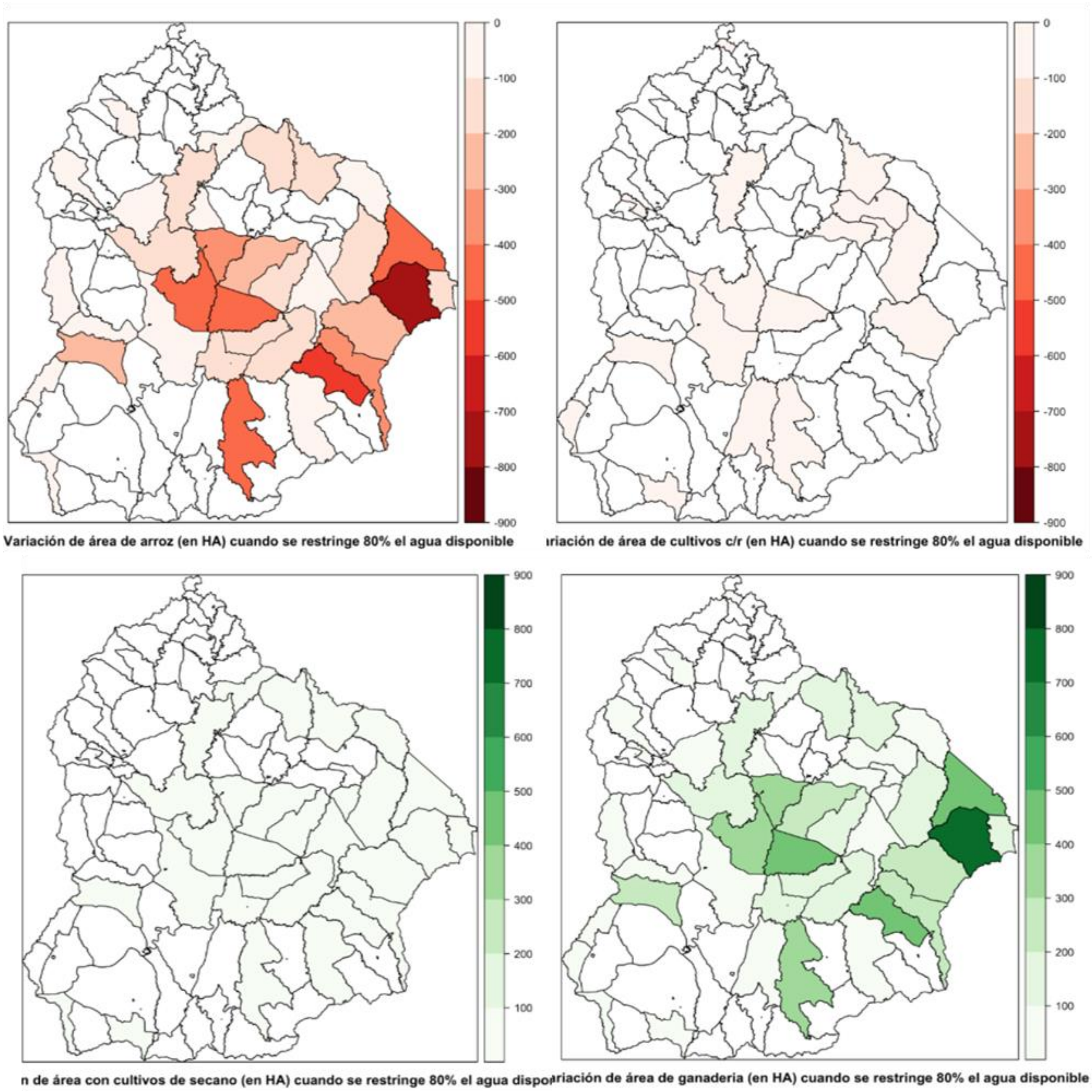
For each of the considered scenarios, the model reallocates areas to the different activities, restricted by the total availability of land and changes in water availability. As a result, new land allocations by census enumeration area, and changes in the benefits expected by producers are obtained. These changes in terms of areas assigned to the considered activities are presented at the aggregate (basin) level in Table 19 and for each enumeration area in Figure 22.

Table 19: Changes in the area dedicated to agricultural activities in relation to the base scenario (%)

Scenario	Rice	Crops with irrigation	Dry crops	Afforestatio n	Cattle breeding and sheep farming	Dairy
90%*	-10.05	-6.43	0.05	0.02	0.11	0.18
80%	-20.10	-13.31	0.09	0.05	0.22	0.34
70%	-30.13	-20.72	0.14	0.07	0.33	0.50

* Refers to 90% of the available water in the baseline scenario, or alternatively a 10% reduction in available water.

Figure 22: Changes in the area dedicated to agricultural and livestock activities selected in relation to the base scenario (hectares)



The simulations carried out also allow the calculation of changes in net benefits expected by the agricultural producers of the basin at the enumeration area level for each scenario and in relation to the base. Given the changes in expected benefits, depending on the availability of water, the maximum amount the producers of this basin would be willing to pay can be approximated. These results are presented at the aggregate level in Table 20. It cannot be overemphasized that these values should be interpreted with extreme caution and as absolute maximums in the context in which they were obtained. Among the factors that lead us to recommend this precaution are the following; a) the model used is still in stages of construction and validation of parameters, b) in this sense it could be that not all the relevant local costs are incorporated correctly, c) it assumes changes without friction between different activities disregarding, in particular, necessary investments to be reconverted between activities, financial costs for idle capacities of fine investments, among other considerations. Likewise, changes in general market conditions, and rice and livestock, in particular, can significantly alter the payment possibilities mentioned here.

Table 20: Changes in expected net benefits (% in relation to the baseline scenario) at basin level according to different scenarios and implicit water value for each scenario

Scenario	Net benefits	Implicit water value
	%	USD/m^3
90%*	-0.12	0.020
80%	-0.27	0.023
70%	-0.45	0.025

* Refers to 90% of the available water in the baseline scenario, or alternatively a 10% reduction in available water.

In this section of the study, an approximation is provided to some costs of the agricultural producers that would result from restricting the authorizations for the extraction of water for those uses. In order to evaluate whether these reductions in the possibility of extracting water are recommendable, the benefits in terms of ecosystem services that this generates at the aggregate level should be estimated. These benefits would be, in principle, in the possibility of releasing water more abundantly for other uses, which would result in higher levels of hydroelectric generation, possible better opportunities for recreational activities, and possible improvements in the hydrological cycle and riparian ecosystems of the basin of the Rio Negro. Clearly, the existence and possible magnitude of the economic benefits of these ecosystem services should be evaluated to obtain an approximation that reports a cost-benefit analysis.

5. Final Considerations

The present work has two specific objectives. First, to propose a methodology for the ex-post evaluation of the introduction of the royalty for water for agricultural use in Uruguay, and to advance in the construction of its baseline. Second, to present an ex-ante evaluation of the impact of the introduction of the royalty for water for agricultural use on the area under irrigation, the income from agricultural activity, and the collection. In turn, two initial chapters are incorporated, describing the problems related to the provision of water for the achievement of the Sustainable Development Goals (SDGs), their challenges in the water sector in Uruguay, and the current framework of fiscal policy and of prices in the case of water. At a global level, in 2015, 6.6 billion people (91% of the world's population) used improved sources of drinking water (UN, 2016). This proportion increased by approximately 10% in relation to the situation in 2000. However, in 2015 it was estimated that 663 million people continue to use unimproved sources or surface waters. In terms of access to sanitation, between 2000 and 2015 the proportion of the world´s population that accessed improved sanitation increased from 59% to 68%. However, 2.4 billion people have been left behind, among which 946 million people continue to practise open defecation (UN, 2016). In this context, Uruguay presents a high level of compliance with regard to the goals related to access to drinking water, sanitation services and the role of the State, offering official assistance for their provision.

The main challenges for the countries of Latin America and the Caribbean are related to the quantity and quality of water. In the case of Uruguay, the percentage of the population with access to drinking water is among the highest in Latin America and the Caribbean, although challenges remain in the extension of the service and in the generation of strategies for small rural housing centres and for the dispersed rural population. The country also presents a disturbing trend in terms of deteriorating water quality. With regard to water quality, this can be directly affected by the development of various human activities. Either by the drainage of a city, industry, concentrated activity (dairy farms, feed lots, etc.) or the discharges by surface runoff of agrochemical compounds or natural nutrients derived from land use.

The productive structure of Uruguay is closely linked to the development of activities based on natural resources. In general terms and from a historical perspective, there is a positive correlation between growth of the economy and growth of the agricultural sector. Despite the low weight in the national GDP (6%), the primary sector is very relevant in terms of foreign currency entering the country through exports. For example, 28% of national exports are products of primary origin (BCU, 2016). Among these, cereals and oilseeds (wheat, corn and soybeans mainly) and meat (cattle and sheep to a lesser extent) stand out. Even though the agricultural sector has a smaller direct impact on GDP and employment, it is a sector that presents linkages with other sectors and employment and product multipliers, which are important. In short, when defining sectoral, commercial or macroeconomic policy priorities, the government should take into account the impacts on this sector.

In this regard, in the agricultural sector, the predominant use of surface water corresponds to agriculture under irrigation systems. Rice cultivation is the main consumer of water, with 80% of consumptive use of water resources. Price policies for water consumption have a great challenge in setting a price to water when its consumption cannot be measured and especially in relation to water for agricultural irrigation.

We must bear in mind that the Investment Law has played a very important role in the incorporation of this technology in the sector. If the investments promoted by the MGAP in the 2008 - September 2016 period are analysed, the investments in irrigation projects and irrigation machinery occupy the third and fourth place in terms of the participation of the total investment. The total amount of the investment in the analysed period in this type of projects (irrigation and machinery) is USD 207 million. On the other hand, the MGAP is carrying out a project of Agriculture Development under irrigation systems in Uruguay, within which the Development Strategy for Irrigated Agriculture in Uruguay has been drafted.

Another activity that competes for water resources is the generation of hydroelectricity. The Gabriel Terra hydroelectric dam is located at the closure of the upper basin of the Rio Negro, downstream from which the hydroelectric dams of Baygorria and Constitución are located consecutively. In this particular basin, authorizations for the extraction of water for irrigation are limited through regulations that reserve water for hydroelectric generation.

Among the challenges that countries face, in terms of compliance with the SDGs, is the need to mobilize internal resources for their financing. It is very important to elaborate proposals to achieve a better integration and greater coherence between the environmental policy and the set of public policies, with special emphasis on the fiscal aspects and the national budget with the environmental policy objectives. The objective of environmental policies in relation to the use of water, should be to reduce pollution, encourage efficient management, and improve its access and quality.

The main instruments used for water management in Latin America range from the application of a tariff as in Uruguay to the application of a royalty for the use of water as it exists in Costa Rica. However, there are not many instruments designed to manage the efficient consumption of the resource, especially in different sectors of the residential area. On the other hand, with respect to the instruments for the control of environmental quality, in general the most recent adoption of this class of instruments in water management is associated above all with the problems of polluting discharges to water bodies. While all actions seek to change the behaviour of agents, there is usually no single solution, or a single fiscal instrument that achieves the desired objective. Often it is the combination of instruments that provide the incentives, sanctions and information necessary to achieve environmental quality objectives.

In short, the increase in demand for water as a result of new scenarios of agricultural and forestry production within the Rio Negro basin, the increase in the demand for electricity that has been recorded in the country in recent years and the strong inter-annual variability of rainfall, that characterizes the climate of Uruguay, highlight the need to have instruments for managing the use of the resource efficiently.

Methodologies and baseline for the ex-post evaluation of the royalty assessment in the agricultural sector

Chapter 3 identifies different proposals for the design of an ex-post evaluation of the implementation of a royalty for the use of water in the agricultural sector in Uruguay, and advances on the construction of the baseline of the same. On the one hand, the introduction of the royalty for water use in the agricultural sector would have an impact on the producers' costs. This may have implications for the intensive margin (amount of water per hectare or unit produced), and on the extensive margin (number of hectares under irrigation). On the other hand, the introduction of the royalty represents an increase in the collection of the State, resources that can have different effects according to their allocation.

Regarding the impact on agricultural producers, in order to establish a baseline for the ex-post evaluation, it is necessary to identify a group of producers to whom the royalty (treaties) is applied, and a group of producers to whom it is not (counterfactual). As a consequence of the fact that the royalty is universally applicable, that is, to all producers in the country at the same time, it is not possible to build a counterfactual with producers in Uruguay. For this, two complementary strategies are proposed: i) build the counterfactual by comparing the behaviour of producers in Uruguay with respect to the behaviour of similar producers in Argentina and Brazil, and ii) evaluate the impact of the policy on aggregate variables at the level of the whole country, building a synthetic counterfactual combining other countries. At the same time, it was identified that, with the available information, it is viable to carry out an ex-post evaluation only regarding the extensive margin. There is no information, at the country level, that allows us to evaluate the intensive margin, nor build its counterfactual with information from other countries.

With regard to the construction of the counterfactual using micro-data from neighbouring countries, it was found that such information exists only for Brazil. This is compiled through the systematic survey of agricultural production of the Brazilian Institute of Geography and Statistics (IBGE for its acronym in Spanish), which is released monthly, and from which information regarding the intention of sowing, harvesting, and the irrigated area is compiled. This information could be combined with the surveys of intention to sow and harvest the different crops that the Directorate of Agricultural Statistics (DIEA) of the Ministry of Livestock, Agriculture and Fisheries (MGAP) reports on a monthly basis. Neither of these two sources of information is available publicly, but their forms are. Thus, Chapter 3 compares the information available in each of them, and how they should be linked when making an ex-post evaluation. There is no information in Argentina that can be used.

With regard to the evaluation based on the construction of a synthetic counterfactual, it was detected that there is no information on the added irrigated area at the country level for a number of countries and period of time which would permit analysis. In this way, it is suggested that only the policy with regard to rice cultivation be evaluated. Rice is the main crop grown under irrigation in the country. This evaluation assumes that rice develops under irrigation in all countries considered as candidates for the synthetic. In this way, a database prepared from different sources is provided, containing information regarding the participation of rice cultivation of the total agricultural area in the different countries, together with other control variables. At the same time, its use is exemplified, and a case that serves as a base is provided. This should be fine-tuned when performing the analysis.

Finally, it is expected that the collected revenue will be used primarily for the following uses: works or services related to flood control and water regulation (up to 10%); works or services related to the conservation and management of protected areas and the restoration of the environment (up to 10%); strengthening the Regional Councils and Watershed Commissions (up to 10%); knowledge and research on environmental and water issues (up to 10%); the remainder will be used for works or services related to drinking water treatment and distribution systems, and sanitation and effluent treatment systems in the interior of the country. However, it is not possible to design here an ex-ante evaluation of the potential impact of the use of collection, because the specific actions to be developed with it are unknown. The implementation of the actions to which these funds are destined, previously planning a design, implementation and performance evaluation protocol (DID) is recommended. Chapter 3 describes its main stages. In turn, the Office of Planning and Budget (OPP) of the Presidency of the Republic has a department specialized in designing them, which can help the correct implementation. At the same time, when the collection is destined to projects and activities that are expensive to implement, and of high importance, it is important to design an ex-post evaluation strategy from the design of the implementation of the same. This should be specific to each action, and ideally, applied in a random manner.

In summary, the main messages regarding the construction of the baseline for the ex-post evaluation are:

- Effect links with the Brazilian Institute of Geography and Statistics (IBGE) to merge its information with that of DIEA. This method would provide a very rigorous evaluation.
- Evaluate the impact on the agricultural area destined to the cultivation of rice from the construction of a synthetic counterfactual. This would only need to complement the information provided with information after the implementation of the royalty.
- Execute the projects and activities financed by the collection of the royalty through programmes that have a design, implementation and performance evaluation protocol.
- Design an ex-post evaluation strategy for each of the main actions financed with these funds.

Ex-ante evaluation of the implementation of the royalty in the agricultural sector

As mentioned before, for the design and implementation of public policies it is always advisable to conduct ex-ante analysis of expected impacts of the interventions. An advance in this direction in relation to possible applications for extractive water uses in the agricultural sector is presented in Chapter 4. However, as discussed in the chapter, this does not substitute a complete ex-post evaluation (for the execution of the project), they are in fact complementary, besides improving the chances of achieving the desired impacts. The decision maker can have more than one policy option to achieve the same goal. In the usual environments of scarcity of resources, a correct ex-ante analysis allows us to compare different policy options in terms of their cost-effectiveness in order to achieve the desired objectives. In other words, it helps identify the interventions that will produce the greatest impact in the direction expected from the plans.

In this work the ex-ante impacts of the possible application of a royalty for the extraction of water for irrigation were studied. The objective of these royalties is to promote economic incentives to modify behaviours so that users make use of water in the most efficient way possible. Likewise, the royalty generates resources that can be used by policy makers to potentially advance other environmental objectives. Although economic theory allows us to predict the directions of changes in the use of water and soils, the intensity of these changes can only be determined empirically. With this objective, the study was launched to construct positive mathematical programming models that allow estimating or calculating those changes, based on deviations from a base scenario. Two models were constructed, the first one analysing the response in terms of substitution of land uses against different levels of the royalty. The second adding restrictions regarding the availability of water for agricultural irrigation.

The results of the first portion of the analysis allow the calculation of expected amounts of collection for different levels of the royalty, and the other, in the losses in terms of economic benefits for the producer’s subject to the royalty. As expected, producers react by reducing the area of activities that make more intensive use of water for irrigation, and this results in lower expected net benefits for agricultural production. The model that includes the restriction regarding the physical availability of water for irrigation, allows us to calculate the implicit shadow price, or what is the maximum value that agricultural producers could pay for water for irrigation. As discussed in Chapter 4, the calculations made in this component should only be considered as indicative at this stage and with extreme caution. This is because the models are still under construction and should be evaluated more deeply. Likewise, frictions due to changes in activities such as the need to rebuild fences and repopulate when going from agricultural to livestock activities, or the costs generated by having capacities, infrastructure and machinery idle, among others, are not included. Beyond this, the behaviour of these models proved its usefulness and opened the doors to continue improving and extending their analysis capacity to other policy questions and activity sectors.

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Annex 2: Statistical forms

IBGE
Instituto Brasileiro de Geografia e Estatística
Diretoria de Pesquisas
Coordenação de Agropecuária

AGÊNCIA

MUNICÍPIO

LEVANTAMENTO SISTEMÁTICO DA PRODUÇÃO AGRÍCOLA
UNIDADE ESTADUAL - XX GCEA
SUPERVISÃO ESTADUAL DE PESQUISAS AGROPECUÁRIAS
QUESTIONÁRIO DE CULTURAS PERMANENTES
DATA: DD/MM/AAAA
HORA: HH:MM

NOME DO PRODUTO	INFORMAÇÃO ANTERIOR													INFORMAÇÃO ATUAL												
	ÁREA (ha)								%	IRRIGADO				ÁREA (ha)								%	IRRIGADO			
	TOTAL	PLANTADA NO ANO	NÃO PRODU-TIVA	DESTINADA A COLHEITA	COLHIDA NO MÊS	PRODUÇÃO (t) (*)	REND. MÉDIO (kg/ha)	PREÇO UNITÁRIO (R$)	COLHIDO ACUMU-LADO	S/N	% ÁREA	OCORRÊNCIA	FASE	TOTAL	PLANTADA NO ANO	NÃO PRODU-TIVA	DESTINADA A COLHEITA	COLHIDA NO MÊS	PRODUÇÃO (t) (*)	REND. MÉDIO (kg/ha)	PREÇO UNITÁRIO (R$)	COLHIDO ACUMU-LADO	S/N	% ÁREA	OCORRÊNCIA	FASE

Ocorrência: (0) Não informada, (1) Excesso de chuvas, (2) Falta de chuvas, (3) Geada, (4) Granizo, (5) Praga, (6) Doença, (7) Erradicação/Abandono, (8) Outra, (9) Nenhuma.
Fase: (0) Não informada, (1) Intenção de plantio, (2) Preparo de solo, (3) Plantio, (4) Tratos culturais, (5) Colheita em andamento, (6) Colheita concluída, (7) Comercialização, (8) Germinação, (9) Floração, (10) Frutificação, (11) Entressafra.
(*) **Coco da baía** - produção em mil frutos, rendimento médio em frutos/ha e preço unitário em R$/mil frutos.

Membros do Colegiado

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Técnico de Pesquisa
Em / /
Assinatura e Carimbo

Chefe da Agência
Em / /
Assinatura e Carimbo