This project is co-funded by the European Union

The Nexus between Water, Energy and Food in Latin America and the Caribbean

Planning, Policy Framework and the Identification of Priority Interconnections

Part of the Natural Resources and Infrastructure Series

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Naciones Unidas
CEPAL

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Published by
Nexus Regional Dialogue Programme (NRD)

c/o Deutsche Gesellschaft für Internationale
Zusammenarbeit (GIZ) GmbH

Registered offices Bonn and Eschborn, Germany

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The Nexus Regional Dialogue Programme (NRD)
is a programme funded by the European
Union and the German Federal Ministry
for Economic Cooperation and Development.

Date of publication
05, June 2017

Translation
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Photo Cover

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LIST OF ABBREVIATIONS

CEPAL (ECLAC in English)	Economic Commission for Latin America and the Caribbean
EU	European Union
FAO	Food and Agricultural Organization of the United Nations
SDGs	Sustainable Development Goals
WEF	World Economic Forum

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SUMMARY

This document analyses the Nexus between water, energy and food in Latin America and the Caribbean, focussing its attention on the current state of the matter, planning for its implementation, the articulation of the normative framework and the identification of the priority interconnections for the region. Based on a review of the most relevant background and histories of the Nexus concept and its current configuration at the global level, the key elements are considered to establish the current state of the issue in the region. Other relevant elements are also considered, such as the connection between Nexus and the Sustainable Development Goals (SDGs), financial aspects related to their components, and its importance in the risk society. The document later addresses the Nexus features in the region, identifying the key difficulties in its implementation, its incorporation in the legal framework for human rights and the definition of legal priorities for the use of water. Among the various interconnections (between water and energy, water and food, food and energy, and between water, energy and food), the interactions that can turn out to be priorities or critical for the region are identified. Those that stand out are: hydropower generation, mining and oil, expansion and modernisation of irrigation systems, overexploitation of aquifers, agriculture and food, drinking water and sanitation services, and biofuels. Finally, the conclusions include a series of institutional, organisational and sectoral proposals for consideration and possible implementation in the countries within the region. Among these proposals, a select group of public policy instruments of high regional importance are identified for implementing of the Nexus approach in Latin America and the Caribbean.

Throughout the various stages of its preparation, preliminary versions of this study were presented and debated in diverse expert meetings, notably in the "Regional Nexus Dialogues in Latin America" workshop (Subregional Headquarters of CEPAL in Mexico, Mexico City, Mexico, 31 March 2016) and the "Governance of the Water, Energy and Food Nexus: Agenda 2030 Challenges in Water and Sanitation" experts meeting (Antigua, Guatemala, 6 and 7 September 2016). The objectives were to disseminate information on the Nexus topic in Latin America and the Caribbean, to contrast the approach employed in the addressing the issues with other views and perspectives, as well as to enrich the conclusions and recommendations of the study.

INTRODUCTION

This work provides an overview of the Nexus between water, energy and food in Latin America and the Caribbean. The purpose is to detail, at a defined territorial space such as this region, the significance of the Nexus, which has been defined as: "a new model for action informed by the interconnections between different sectors. It builds on a long history of integrated management approaches. The main premise of the Nexus approach is that in our hyper-connected world water, energy and food are increasingly interdependent, with impacts in one sector affecting the others. In a planet under pressure from climate change and growing demand from larger and increasingly affluent populations, understanding and accounting for these interdependencies is vital for achieving longer term economic, environmental and social goals." (Bellfield, 2015)

The Nexus approach aims to provide mechanisms for decision making to achieve specific "economic, environmental and social goals", set in the context of "climate change pressures" and the demands of a growing urban population, a consequence of the increasingly pronounced presence of megacities (Hoff, 2011). Likewise, the Nexus suggests an approach to policies related to water, energy, agriculture, food security and nutrition and the environment in general, in which the relationships between water, energy, and food production and trade are present (sometimes only bilaterally and in many occasions trilaterally) from the outset and throughout the entire process (policy adoption, legislation, planning and management).

It is important to note that in the majority of literature, the three Nexus elements are not placed at a level of complete parity. Since the commencement of the theoretical Nexus construct, a key element has emerged out of the conceptual and strongly interrelated arrangement of the three components: "Water underpins both energy and food security. Water is also vulnerable to climate change and environmental degradation. Water is therefore often the first entry point for applying a Nexus approach." (Bellfield, 2015).

Although this connection between the three elements has always been present, the Nexus idea has been prominent in international debate since the Annual Assembly of the World Economic Forum (WEF) in 2008, which emphasised the need to develop a better understanding of how water is linked to economic growth through its connection with other issues, and the challenge that a commercial focus represents for food security in the management of water resources (WEF, 2011).

Set against this background, the conference titled "The Water, Energy and Food Security Nexus – Solutions for the Green Economy" was held in Bonn in 2011 (Martin-Nagle et al., 2012). It is understood that approaches such as that of the green economy and of the bioeconomy will lead to better human welfare, with social equity and significant reductions in environmental risks and ecological scarcities. Carbon dioxide production levels will be progressively lower, and the efficiency of resource use will increase. The connections that link the implementation of the Paris Agreement to the reduction of greenhouse gases emissions are evident.

The recognition of the Nexus reflects scientific and technological advances, which have made it possible to carry out medium and long-term projections.[1] Through these projections, the consumption (or demand) increases of water, energy and

[1] These are global projections that do not correspond to particular situations within distinct countries, regions, zones or basins. It is important to emphasise that implementation of public policy always must account for the disaggregation of data according to countries (territories), and also in catchment areas in large countries, due to the difficulty, high cost or inability to transport water across large distances. Therefore, these policies will be different for countries (regions and basins) with a predominant agricultural sector compared to those with an economy based on services or on industry.

food may be observed. The extent of these increases,[2] raises the need to formulate policies that can achieve their stated goals, or conversely, reduce these required quantities through a more efficient use of resources (see Figure 1). This assumes more efficient connections between the Nexus elements, which could be achieved through the utilisation of new technologies or energy production forms (eg. production and increased use of renewable energies and the use of agricultural and food biomass wastes in the production of biomaterials and bioenergy). On many occasions, recognising the frequency of catastrophic events (more prolonged and intense droughts, floods, etc.) and their damaging consequences is something that also elicits a consideration of adopting the Nexus approach.

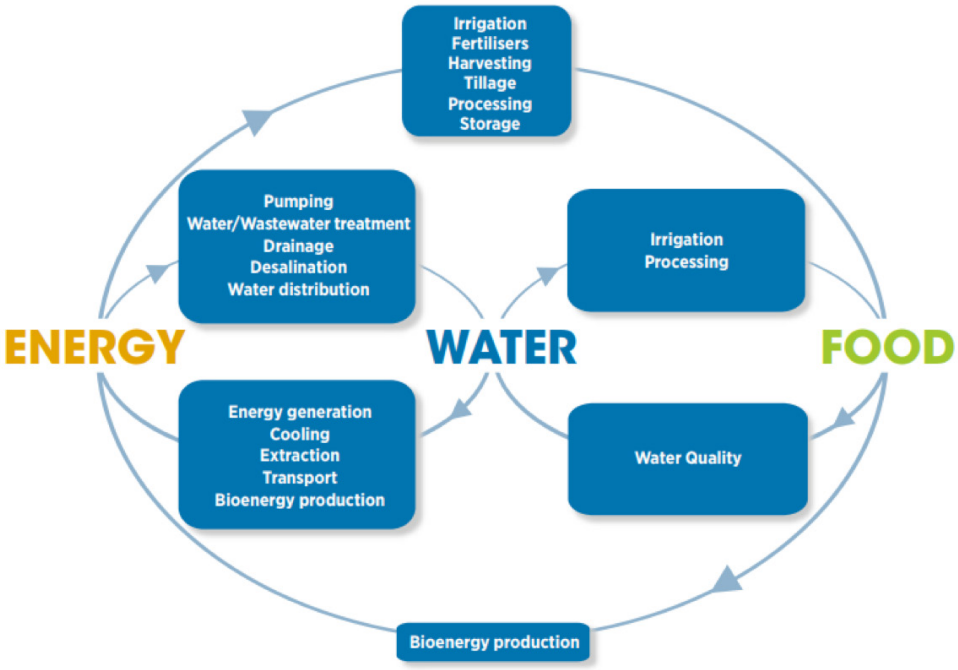

Figure 1: Overview of the interactions between the different Nexus elements

Source: International Renewable Energy Agency (IRENA) (2015), Renewable Energy in the Water, Energy & Food Nexus, adapted from Rabi Mohtar & Bassel Daher (2012), "Water, Energy and Food: The Ultimate Nexus", Dennis Heldman & Carmen Moraru (eds.), Encyclopaedia of Agricultural, Food and Biological Engineering, Taylor & Francis.

Water appears at the centre of the interactions presented in Figure 1, which represents its central role in Nexus studies and policies. This is because of the importance of water in food production and in the many sources of power generation (one of these being hydropower, the most pertinent to Latin America). Water is also placed in the centre for its role in developments that have been based on an intense exploitation of water resources (especially the aquifers), driven by very low prices (or rates), both of the water resources and of the energy necessary for the extractions (which are often subsidised), as well as in the regulation and control policies including the implementation of the rights of use or consumption, which are very weak.

For this reason, water "bubbles" are considered as events that have occurred in many places (WEF, 2009). As is the case with every bubble, a series of seemingly positive effects have been produced at an early stage, but they can later transform into negative effects. This phenomenon, such as the housing construction or stock market bubbles, delivers a short-term sense of wealth to the markets and to the

[2] In the year 2050, the global energy needs will have increased by 80%, the water needs by 55% and the food demands by 60% (IRENA, 2015). 70% of the worldwide water extraction is for agriculture, i.e. for food production (FAO, 2011a), and the food production and supply chain requires approximately 30% of the total energy consumption (FAO, 2011b). The current imbalances and deficits in energy and water needs are expected to exacerbate in the future (AIE, 2010). In this manner, food production will need to increase by 60% to be able to feed the world population in the year 2050. Energy consumption will have increased by up to 50% in the year 2035, and the total worldwide water extraction for irrigation will have increased by 10% by the year 2050.

involved citizens, enables the transformation of drylands into irrigated lands, also increasing profits for farmers in the short or medium-term, and facilitates recreational uses that generate economic gains to the beneficiaries. But later on, similar to all bubbles, the problem is maintaining the situation (i.e. its sustainability). The overexploitation cannot continue indefinitely, and environmental problems often result in salinisation of lands, lowering of the water table and groundwater contamination. This means that it is not possible to indefinitely continue this provision of water for irrigation, recreational uses and other activities, given that human consumption inevitably has a priority over the other uses, and is threatened as a result of those other uses.

This situation is the basis of the debate that has taken place within hydrological science, and is based on the idea of overexploitation, or more recently, the intensive utilisation of groundwater. The scientific disputes illustrate the potentialities and problems identified here: overexploitation can generate short-term benefits, but its continuance becomes unsustainable over time (Custodio, 2002; Custodio and Cortina, 2009; Sahuquillo et al., 2005).

The central role of water within Nexus considerations is based on the recognition that "unlike energy, … water does not have substitutes or alternatives", hence water is at the heart of social, economic and policy matters, including "agriculture, energy, cities, commerce, finance, national security and livelihoods" (Miralles-Wilhelm, 2014). There are also minority views on an equality that should exist between the three Nexus components: "the Nexus approach … considers the different dimensions of water, energy and food equally, and recognises the interdependencies of different resources uses in order to foster sustainability" (FAO, 2014b).

A factor that must be considered in every Nexus analysis needs to be emphasised: financial matters in general,[3] and more specifically, the state of the economy at the time. For this reason, reference must be made to the prices of energy, food or water at the time of conducting the studies, and above all, the corresponding policy conclusions or recommendations are to be adopted. Considered from this perspective, the years 2007-2011 saw elevated oil and food prices. Contrary to this, we currently find ourselves in a situation with relatively low prices for oil, the majority of foods, and other raw materials.

In this context, renewable energies are competitive in a scenario of high petrol prices, and therefore the recommendation to increase the use of these energies is understandable in this scenario from a simple financial viewpoint (i.e. not only environmental considerations). These renewable energies include wind, solar, hydroelectric, and the energy yield of biomass from agricultural wastes, under the concept of biorefinery. However, it can be more costly to accept their use from a completely financial perspective when, in contrast, there exists a scenario with low oil prices. This is due to the higher costs in the generation of the majority of renewable energies until now, very likely because the environmental impacts or externalities from traditional forms of energy production are not always considered in the comparison of costs.

From another point of view, low food prices can pose a problem for exporting countries. However, for importers, they represent an increase in well-being for their citizens. In any case, these relatively low prices are a major obstacle to the implementation of some policies whose usefulness for the Nexus are often emphasised. For example, this occurs with the policy of modernising irrigation that, in theory, encourages high efficiency in water use. Yet in many cases it leads to an intensification in water consumption (which results in a reduction in return

[3] The study of the Nexus has been of special interest for financial institutions (ADB, 2013), as well as to energy companies, which is explained by the fact that many investment decisions are influenced by the Nexus evaluation.

flows or in aquifer recharge, and a subsequent reduction in water availability for downstream uses and users), water quality deterioration (from effluents contaminated with agrochemicals), and a concurrent increase in energy demand for the implementation of technical irrigation systems (drip or sprinkler irrigation). Lastly, this overall situation demands a level of investment that farmers producing food at low prices may not be able to sustain in the long-term.

Generally, the economic cycle is sensitive to Nexus considerations.[4] The economic crisis, which started in the United States in 2007 and in Europe in 2008, extended to various geographical areas at different stages, with implications for the Nexus manifestations which must be taken into account by those responsible for developing public policies, and considered in combination with their future projection. However, all Nexus considerations are paradoxically based on permanent growth of economic metrics at the global scale, on which the projections of an increasing demand in water, energy and food are underpinned. Nevertheless, the experiences of the prevailing economic crisis should warn us about the possibility that the future growth may not be as dynamic as it has been in practically the entire first decade of the 21st century. The impact that the drop in oil prices has had on the region, particularly on countries heavily dependent on hydrocarbon exportation such as Bolivia, Venezuela or Ecuador, is an instructive example of the need to diversify this development model (Arroyo and Cossío, 2015).

Another factor to be accounted for is the secondary economic importance of water-related transactions compared to the energy and food markets, especially when considering countries where no "water market" exists, as is the case in the majority of the world. The cost of water is typically included implicitly in other products and services (food and energy prices), which can lead to the dominance of water in the global Nexus consideration being distorted by the unequal economic ranges encompassed by the respective markets. This carries the risk of overexploitation of the resource, which serves other purposes or other Nexus elements (Mohtar, 2016).

The role of research and innovation in the pursuit of new technologies for the production and distribution of food, water and energy must also be considered (Hoff, 2011; Mohtar, 2016; European Commission, 2012). Innovation is linked to the contingency of meeting high water, energy and food demands in the projections for the years 2030 and 2050.

Finally, the instruments and formulated policies regarding the Nexus should also aim to contribute to the prevention and solving of multiple socio-environmental conflicts concerning water, which are often linked with the other two Nexus elements (Martín and Justo, 2015). Water conflicts in general, and particularly those within the region, are indicators of priority and especially problematic Nexus interactions; hence they are the expression of local conditions that present specificities whose approach requires flexibility and innovation. Therefore, they must be met on a preferential basis and in an urgent manner.

[3] For example, electricity consumption reduced in a number of countries during the economic crisis, which suggested lower greenhouse gas emissions and other positive environmental effects. These types of impacts need to be considered in any Nexus analysis.

I. WATER, ENERGY AND FOOD POLICIES

The awareness of the Nexus connecting water and food is very old, and its origin is probably linked to the same natural human knowledge from when society transitioned from hunters and collectors to agricultural workers. However, the recognition of the connection between water and energy is much more recent. A method of confirming this understanding is through an analysis of water laws in terms of the hierarchical order of water usage priorities for human consumption, energy production or food.[5] The interactions limit the ability to group the water uses in a hierarchical order. In cases where applicants contest water use, the hierarchical order can be used to decide the primacy between different possible uses. This grouping is typically performed in isolation by the water authority, for every application for water use, and often happens without an integrated vision, and rarely with an evaluation of the development of these interactions and their effects over time (even though there may be public reporting procedures, submissions of claims, opposition to certain requests for resource utilisation, etc.).[6] This is understandable when one considers that the basic knowledge about water (energy and food) that characterised the first water laws. It suffices to point out that the hydrological cycle was unknown until the end of the 19th century, and even now, some regulations divide the natural water cycle for management purposes (eg. in many cases, surface waters and groundwater are treated separately).

A. The Nexus in Traditional Policies

The first water laws have been a useful instrument to both substantiate the initial acknowledgement of the Nexus between water, energy and agriculture and attest to the inadequacies of this original form of its application.

The Spanish Water Law from 1879, the immediate predecessor to the majority of water laws in Latin America (Embid and Martín, 2015), stipulates that in "the awarding of the special uses of public water will adhere to the following order of preferences: 1st, domestic water supply; 2nd, supply for rail; 3rd, irrigation; 4th, navigation channels; 5th, mills and other factories, crossing boats and floating bridges; 6th tanks or ponds for nurseries or fish farms". This law presents a hierarchy between distinct water uses, headed by urban uses. There is also a reference to food, and energy is mentioned lower down in the form of mills.[7] Hence, this law clearly recognises the Nexus between water, energy and food, since it defines the means to resolve disputes between applicants for a water volume that is insufficient to fulfil the needs of all. These disputes and their resolutions are based on the principle of the order of priorities. Thus, in the event of a dispute between an application for a licence for irrigation or for aquaculture or another energy use, according to the law, the competent authority should grant the rights to irrigation purposes and refuse that of "mills" or aquaculture.

This law also contains selection criteria for applications for water grants for uses that are found at the same hierarchical level: "within each class there will be preference given to the enterprises of greater importance and utility, and if all circumstances are considered equal, it will be awarded to that which applied first." It also adds that shared uses will always be upheld as preferential. The "importance and utility" are undetermined legal concepts that must be defined in each moment by the competent public authority (for example, allowing the creation of jobs). Ultimately, and in the case that all circumstances are equal, the time criteria should be

[5] This linking is primarily related to legislation from arid countries which must introduce such an order to the varying water demands and to define criteria for allocation and utilisation.

[6] In multipurpose projects (eg. reservoirs), the priority order is typically defined by the project itself (approved by law or decree).

[7] "Mills" is certainly an early reference used to designate energy uses. However, it is noted that the first Spanish nuclear power stations were authorised water concessions based on the reference to "mills" as energy uses.

used to assign priority: the awarding will be granted to those who first applied for the use.

Of special interest is also the reference to provision of "shared uses" which are to be "always" upheld in the granting of concessions. In these uses, a clear precedent of what currently constitutes the "human right to water" exists, as the matter concerns the ability to use water to drink, wash clothes, bathe and provide water for livestock – in accordance with the existing regulations – without needing to possess a special title. With this, the Nexus elements are not only contained within this law, but they are also a precursor of what is now known as the human right to water. This order of priorities is the materialisation of a values system in which society believes: a dominance, without discussion, of urban uses that implies not only the right to a water supply, but also something much broader and one that includes irrigation for parks and gardens, water to clean streets, and water use by small industries linked to the urban network, and the hierarchical priority with respect to (all) other uses.

This type of law lacks any sophistication in the configuration of Nexus and the relationships between its components. The only consideration concerns the allocation of water for one use ahead of potential competition for other uses. In this sense, there is an underlying consideration of the productivity of resources that will continue being present in legislation and water infrastructure policies (construction works to facilitate access to water) until reaching the significant changes that occurred in the last third of the 20th century, and especially those that operate at present (Embid, 2012).

This consideration, which is purely in terms of productivity, is also characteristic of the policies and legislations in agriculture and energy that developed mainly in the 20th century, even though at the present time, the substantial beginnings of a change in orientation are observable (Embid and Martín, 2015). These early laws and policies lack any form of environmental consideration and have been shaped in complete isolation from each other, without any form of communication channel, either formal or informal. For instance, the policies and regulations related to agriculture fundamentally address the subsidies and grants for agricultural activities, assuming that in general, the cheap water and energy have historically constituted an indirect subsidy to agriculture, agrarian reforms, and the redistribution of property to foster a more efficient use of agricultural activity (land consolidation).

In the same manner, the policies and regulations related to energy (mainly in production, but also in its transport and distribution) are based on favouring energy production and distribution, but until now, their connections with the other Nexus elements are barely visible. The regulation of industrial activity comes first in this consideration. Otherwise said, identifying which institutional body must authorise the installation and operation of energy production plants, where in the case of hydropower, there is often a dominance of the electrical concession (or permission) over the water concession. This situation even extends to determine a certain supremacy (even hierarchical) of the authorities in the energy sector ahead of those in the water sector, as is commonly observed in some Central American countries (Espinoza Rodríguez, 2016). This phenomenon coincides with what is also observable throughout history in countries where the water authority could have been the energy or agriculture representative, with a disregard to specific needs in the management of water as a natural resource or as linked with human consumption, and its consequent submission to the policy needs from the energy or agricultural sectors.[8]

[8] Water management should act as a separate organisational unit, with administrative tiers with functional responsibilities for specific water uses or for the development of its use (Solanes & Getches, 1998). When the water authority depends on a user sector, the sectoral interests inevitably tend to control water management and the investments linked to it. This generates the risk of producing a departure from the administration, that the management system develops a bias, and that shortcomings occur in the assessment of projects (Solanes & Jouravlev, 2005).

Attention is drawn to how the hydroelectric use of the major transboundary rivers has preceded any other matter in international treaties concerning its utilisation, aside from navigation, which is normally at the heart of international waterway law. This is accompanied by a submission of the other Nexus elements to that of hydroelectricity use, because of the higher rank of international treaties compared to internal regulations (Espinoza Rodríguez, 2016; Barberis, Armas Pfirter and Querol, 2002; COMIP, 1992).

It can be concluded that traditional legislation and policy does not have much importance beyond the regulation of a hierarchical order of water uses, and that this is typically the only Nexus interconnection that can be tested. There is no insight given into the interactions, and the coordination of the different uses is completely absent, whether in the holistic plane (and when such an attempt at coordination has existed, it has typically been a failure) or in the functional plane. Lastly, environmental concerns have not been of importance. However, at present, all these negative characteristics have begun to change substantially.

B. New Water, Energy and Food Policies and their Planning

The shortcomings that have been found in the traditional policies concerning the treatment of the interactions between the Nexus elements have started to be overcome with the application of planning strategies and instruments. Originally, planning was a simple policy of the construction of hydraulic works or energy infrastructure. These one-dimensional (or one-way) forms of planning barely featured any form of relationship with other Nexus elements. Furthermore, the hydraulic works have normally been linked to irrigation, and the construction of a large quantity of these was carried out with a lack of attention to their profitability (or attention to a certain economic and financial equilibrium). They were intended to supply cheap water to the irrigators, and were carried out without any evaluation of mistakes made and possibilities for improvement for future projects and infrastructure (at least in the majority of cases).

In recent decades, a shift in this field has started to take place. This involves a different planning approach to what was previously adopted: one that increasingly incorporates evaluation, disclosure and transparency, and that recognises interactions amongst the multiple factors linked to hydraulic works, irrigation systems or energy infrastructure. Even though planning forms related to all Nexus elements can be found, the most successful advances have been within the scope of water planning. In Spain, for example, the first river basin management plans have been conducted since 1926 as a result of legal authorisation, although the management plans, in a modern sense, did not appear until the end of the 20th century. Within the framework of the European Union (EU), these plans did not appear until well into the 21st century. One of the most distinguishing dimensions of these plans is the consideration of the legal norm which binds all the authorities (Embid, 1991).

Of the aforementioned characteristics, the coordinated development of planning with ministerial departments that are proficient in matters different to water and the coordination of sectoral policies (agricultural and energy) ought to be emphasised. This approach to water planning has also influenced the legislation of some countries in the region. Ecuador provides an excellent example of this, due to the importance assigned to the planning in the Basic Law of Water Resources and Uses (LORHUyA in Spanish) from 2014. Highlighting the connection between planning and regional and sectoral development is important, as is the linking of planning over all public administrations at different governmental levels. This trait of linkage distinguishes the planning defined in LORHUyA from other examples in the region.

A similar context can be inferred from countries such as Mexico and Brazil. In the case of Mexico, water planning traces back to 1975, even though this was non-binding planning, and does not include the characteristics mentioned. The National Waters Law gives the National Water Commission (CONAGUA in Spanish) the responsibility to integrate and formulate the National Water Programme. At present, the National Water Programme 2014-2018 is active. Generally speaking, water planning is dependent upon what the National Development Plan commands (the current version of this plan spans 2013-2018), which is the plan that establishes special programmes that must exist, one of these being the National Water Programme. Note that these two planning cases are subject to the length of the presidential term. In other words, when a new presidential term begins, another cycle of water planning commences.

In Brazil, Law 9.433 (from 1997) establishes a set of terms as a basis for the National Water Resources Policy, which today are common in the majority of water legislation:

- Water is a public commodity and limited natural resource, with economic value, with priority given to use for human consumption and for animals.
- Water resource management must always make possible the multipurpose use of water.
- The basin is a territorial unit for the implementation of the National Water Resources Policy and the actions of the National Water Resources Management System.
- Water resources management must be decentralised and rely on participation from public administration, the users and the communities.

Water planning is one of the instruments of the National Water Resources Policy in Brazil. On January 30, 2006, the National Water Resources Council enacted the National Water Resources Plan. This plan includes guidelines used to prepare and approve river basin plans. It indicates that the plans must be consistent with strategic planning for different sectors (power, sanitation, navigation and others). The plan is not legally binding, and is therefore not binding with regard to the actions of the various authorities with competence on the matter. The time frame of the plan extends to 2020 and is considered as flexible and adaptable for the various circumstances of the related sectors (De Siqueira, 2008).

Water planning coordinated with sectoral policies (energy and agriculture) and set up as a rational process for decision making that is periodically reviewed is an indispensable factor in adequately focussing on the interactions of the Nexus elements. In Spain, sectoral planning also exists in energy (National Energy Plan, 2012) and agriculture (National Irrigation Modernisation Plan, 2002, updated in 2008), but these plans are set apart from hydrological plans, as they are non-binding and the implementation of their decisions is dependent firstly on the willingness of the actors that must take action in each case, and secondly on the political views and the consignment of the budgetary appropriations for the implementation of infrastructure or the different actions that are foreseen in them.

This is evidence of the dominance of the water element within the Nexus. As water planning is intended to address the different water uses, it has the capacity to cover the “voids” exhibited in other plans. Also, since the sectoral perspectives of the corresponding authorities that participate in the process are considered in the formulation of water planning, their essential character and ability to contribute to the required coordination between the Nexus elements is ensured.

Water planning with these characteristics is still not widespread.[9] Exceptions can be found in the legislation from Brazil, Ecuador and Mexico, and the Water Resources Law of Peru (2009) can be added to these, more specifically the National Water Resources Plan approved by Supreme Decree Nº 013-2015-MINAGRI (2015). It should also be specified that the important issues are the regulatory provisions (which in modern planning only appear in Ecuadorian law), the practical execution of planning with suitable content, and ultimately, its effective implementation.

In addition to water planning, another dominant Nexus component is energy planning. Experiences in this form of planning in the region are numerous and varied. Most countries rely on recent comprehensive plans, considering time horizons of at least 30 years (see Box 1). Because of their strategic nature, many of these plans (or parts of them) are not publicised, and only executive summaries or documents intended for dissemination are available, which do not necessarily reflect the real nature of the planning that is carried into practice or what is ultimately directed to investment.

The planning described in Box 1, at least in its theoretical framework, is of a comprehensive nature, contemplates the long-term and incorporates modern elements such as renewable energies, energy and water efficiency, energy security, environmental concerns and climate change. However, this planning cannot be considered to have derived from the Nexus approach, as the Nexus concept was barely nascent at the date of its formulation.

For example, and with very few exceptions, the interaction between water and energy is not addressed more than from the traditional hydropower perspective or inasmuch as can be included in the overall environmental concern. When considering energy efficiency, some consider the inclusion of household appliances used to heat water with solar energy. This clearly demonstrates that there is not even an early consideration of the Nexus in this sectoral planning, which is perhaps the most powerful and economically decisive of the Nexus elements.

If the development possibilities are largely attached to the availability of energy at a reasonable cost, this almost complete lack of evidence of a consideration of the Nexus elements in most modern energy planning in the region highlights one of the points to pay attention to. That is to say, it is possible to investigate and study the degree to which the regional energy planning formulated for the first half of the 21st century is sustainable and viable from the Nexus perspective.

The reference planning instruments for water and energy – beyond their existence, their public nature and level of implementation – prove to be reasonably clear. However, much greater uncertainty exists concerning the third Nexus element. Firstly, what is understood by the food Nexus element must be defined. If we understand that this third Nexus element refers to food, agriculture, land, or all of these at the same time, the planning will accordingly be very diverse. For example, Ringler, Bhaduri and Lawford (2014) suggest that the definition of the Nexus be broadened to include water, energy, land and food, as they recognise the difficulty in decoupling food production from the context of the where this production is provided.[10] Consequently, planning the use of water and the land can take on very diverse forms depending on whether some or all of these points are considered (social planning, economic planning, land management planning, environmental planning, etc.).

[9] According to Miralles-Wilhelm (2014), "these days, the water, food and energy sectors are planning without much integration. For example, water is allocated without accounting for energy limitations, energy generation is planned without much consideration into the sources or costs of water, and food production for the most part does not account for the energy and water requirements. Advocation is required so that the planning tools and institutional procedures evolve towards integrated planning approaches, with the end goal of utilising and managing the identified threats."

[10] The idea of the land has a greater scope than that of the soil. This is because in addition to including the pedological elements from which the soils are characterised, it also includes the elements of coverage of natural resources and how human interference has modified it.

Box 1: Experiences from Energy Planning in Brazil, Chile and Uruguay

Brazil represents a leading example of large-scale planning and development, which has allowed it to grow steadily in recent decades, until it has transformed into the leading economy of the region and one of the world's most important emerging countries. In 2007, Brazil published the National Energy Plan 2030, the first government study on integrated planning of energy resources for the formulation of a sustainable energy strategy of the supply required to meet the long-term changes in demand. The National Energy Efficiency Plan (2011) establishes a set of guidelines to achieve the energy efficiency goals.

The Chilean experience is relevant for the manner in which a crisis was transformed into an opportunity. The crisis in the electricity sector, as a product of the drought from 1999, together with the sudden interruption of the gas supply from Argentina in 2005, among other circumstances, left the country in a situation which demonstrated the need to diversify its energy matrix and plan to increase its energy security for the long-term, at a cost both reasonable and consistent with its level of development. As part of the policies to respond to this threat, the Chilean Agency for Energy Efficiency was created, and they have implemented various programmes in energy efficiency and planned diversification of energy sources in the long-term. Also, as government policy, different sectors were integrated using a systemic approach that includes not only technical and economic efficiency principles, but that also actively integrates considerations of security, sustainability and equity. In 2016, Chile starting to export liquefied natural gas to Argentina, given the inactivity of their regasification plants since 2009. The energy integration between both countries was expanded in 2016, with the entering into agreements for a supply of electric power from northern Chile, through a transmission line and new investments in natural gas and petroleum exploration.

Another change in the energy planning strategy can be seen in the case of Uruguay. The strong growth of energy demand, the lack of indigenous fossil resources and the limited room to incorporate additional hydropower generation have steered the government to propose policies on the development of non-traditional homegrown renewable energy sources such as solar, wind and biomass. The energy policy was established for the years 2005-2030, with short, medium and long-term objectives, and within its framework a system of promoting investments with tax exemptions was established, conditionally favouring renewable energy sources and public-private participation models.

One of the keys to the relative success that was well achieved in Uruguay, which has placed it as a frontrunner in receiving investments in renewable energies, is found in the existence of an energy policy based on consensus and that is participatory in the long-term. This is a prominent feature of this experience, starting from the formation of a multi-party energy committee in 2010, which ensured that the core aspects of this energy policy would be backed, even by the three opposition political parties. Within the framework of this participative drafting of energy policy, the Mesa Solar ("Solar Table" in English) was established as a multi-sectoral space, comprised of government entities, universities and companies, working towards the promotion and design of policy for this type of energy.

Source: Own development

The integrated planning of the three sectors, or from the Nexus approach, is framed within the broader planning process of development, which at the regional level has been defined as a political act, a theory, and a discipline for the creation of meaning (of ownership of the future) and for the multiscale, intersectoral and temporal governance (Prado, 2015). The following three dilemmas have been identified for planning development in the region:

- The intertemporal dilemma, which refers to the way to define the different time horizons (short, medium or long-term) of planning.
- The multiscale coordination, which concerns the forms of definition and the coordination mechanisms at separate territorial planning levels for development (local, subnational, river basin, national and global).
- The interaction between sectoral and integral, which relates to the forms of definition and coordination mechanisms of the specialised and sectoral planning approaches, with respect to each other and to the perspective of integration.

C. Further Relevant Issues

1. Connection with the Sustainable Development Goals

The arrival of a human rights policy in the last decade, which includes the three Nexus components, must be highlighted. Along these lines, the SDGs form part of the 2030 Agenda for Sustainable Development, which was adopted by the 70th Session of the United Nations General Assembly during the Sustainable Development Summit 2015. Some of the SDGs are directly related to the Nexus:

- Within the SDG 2 ("End hunger, achieve food security and improved nutrition and promote sustainable agriculture"), the goal to "double the agricultural productivity" by implementing "resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather events, drought, flooding and other disasters and that progressively improve land and soil quality" is formulated. Water is included in the references to droughts and floods. It proposes a target to achieve the "parallel elimination of all forms of agricultural export subsidies and all export measures with equivalent effect".
- Established within the SDG 6 ("ensure availability and sustainable management of water and sanitation for all") is the goal of achieving universal and equitable access to potable water at a price affordable to all, as well as to sanitation. It also considers the improvement of water quality, reducing contamination and halving the proportion of untreated wastewater. Similarly, it covers improving the efficiency of water resources utilisation, the implementation of integrated water management, the protection and restoration of aquatic ecosystems, the enhancement of international cooperation, and it mentions desalinisation within the objectives for supporting developing countries.
- Within the goals included in SDG 7 ("ensure access to affordable, reliable, sustainable and modern energy for all"), is the goal to ensure universal access to energy services that are affordable, reliable and modern. It also specifies the goal to "increase substantially" the share of renewable energy, double the global rate of improvement in energy efficiency, and promote investment in energy infrastructure and clean energy technology.

- Other SDGs that can be mentioned are: SDG 11, which aims for cities and communities to be inclusive, secure, resilient and sustainable; SDG 12, which concerns sustainable consumption and production patterns; SDG 13, which concerns measures to combat climate change and its impacts; SDG 15, which aims to protect, restore, and promote the sustainable use of land ecosystems; and SDG 17, which covers means of implementation.

Even though the approaches regarding water, agriculture and energy appear to be formally separated in the SDGs, they are in reality inseparable, as all are to be jointly achieved. This suggests that, the Nexus idea is implicitly present in the formulation of the SDGs, and thus a consistent approach is required by the states tasked with their attainment.

2. Efficiency and Financial Aspects

At the Bonn Conference, the "founding" element of the Nexus was explicit: the required increase in the use of its components as a means to enable the fulfilment of the forecast water, food and energy demands in the years 2030 and 2050. This is explicit in references to both water and energy (Martin-Nagle et al., 2012). It should be noted that the water productivity for agriculture depends on various factors such as the vegetation type, raw material cultivated, local and regional climate, land and water management practices, and the extent of land degradation. In the field of energy, the required increase in energy efficiency is considered. Regarding food, stress is placed on the need to avoid manufactured food losses, highlighting the improper use of energy and water to produce food that, due to these losses, will not be consumed. This increase in efficiency in use is consistent with the reference to the "green economy" and the focus on of the bioeconomy, and is expressed in the saying "create more with less", in accordance with also suggestive "greater harvest with much less water" (WEF, 2009).

To arrive at a true integration of the different Nexus components, a substantial financial investment is needed because "many of the old schemes have to be changed and much of the current infrastructure will have to be brought up-to-date or completely rebuilt" (Martin-Nagle, 2012). It is noted that these financing costs cannot be borne entirely by the public sector, and private investment will need to play a significant role.

This impact on the financial aspects related to the Nexus also appears in other documents, such as what occurs regarding the linking of infrastructure, whose sustainability in the context of climate change depends on the existence of tariffs. Therefore, the investment costs in resilience (referring to the capacity of a system to withstand and recover from disasters and disruptions) will need to be reflected by the regulators in the tariffs to ensure that they would be viable and to account for the need to incorporate such risks into their appropriate regulatory frameworks. This is connected to the financial viability: the capacity of projects to be subject to loans from financial system institutions. This capacity will depend on "identifying, evaluating and quantifying the risks associated with climate extremes in the individual projects" (WEC, 2015).

This has consequences on the inclusion of the insurance system in the discussion (for example, regulating climate risk), foreseeing obligations by the insured party to minimise risks regarding catastrophes (WEC, 2015). Or taking selected climatic variables into consideration (such as the levels of rainfall reached at a given time) at the time to agree and pay the compensations specified in the insurance contract, and being able to change policies and compensation sums according to the

agreed factors. All of this will avoid the uncertainty associated with losses due to climate extremes.

An example is the loan agreement entered into by Uruguay and the World Bank in 2014, as a consequence of the drought in 2012, which mandated the substitution of hydroelectric power (which was impossible to produce in the required quantity due to the reduction in water being turbined) by more expensive energy from fossil fuels, which led to a budget deficit. To assist in the reduction of this financial exposure, the government entered into a loan agreement, which combined the risks owing to drought and an increase in the energy price, thus reducing the budget uncertainties to a greater extent (WEF, 2016).

This situation is an important consequence of the Nexus, because it shows the practical application of many of the interactions and entails a means of tackling them against the background of the environmental implications that underlie their reality. The need to build energy infrastructure where resilience is insured is emphasised. This action represents an additional cost that must be taken into consideration in project design and financial modelling, which allows one to conclude that "given the already huge amount of investment needed …, resilience is a prerequisite to unlock funds from public and private investors" (WEC, 2015).[11]

This means that an exact delimitation of what can be understood as resilience in energy projects must be obtained, which requires the collaboration between all participants in the energy market. They "have to understand the impact of extreme weather events on energy infrastructures. This means that energy companies and project sponsors, banks, insurance companies, long-term investors, governments and regulators have to work together. Better coordination will enable innovation, technology standards, suitable financing and instruments for risk transfer, and a regulatory framework for providing the necessary guidance in the regulation of the resilience and of the market. The energy industry and the financial sector should work with the regulators and with governments to adapt regulations in order to improve the viability of investments in energy assets from a greater variety of long-term investors." (WEF, 2016).

It is clear that the state should lead the process, and they should prevent the decision-making process from being captured by lobbying groups or by special interests of the financial and energy stakeholders. This process is handled by considering the sector as a system over the extent of its energy chains, within a framework of high economic and climate uncertainty as well as high social vulnerability. For the purposes of collaboration in these types of projects, a new concept called "intelligent climate investments" is introduced (WEF, 2016). These investments could have the potential of "finding ways to adapt established risk assessment analytics, models and reporting frameworks … that could unleash larger flows of capital towards climate-friendlier investments."

This economic and financial discourse has also elicited critical responses, such as those from Leese and Meisch (2015), who consider that the concept of the Nexus has been constructed under the hypothesis of security, and that a "precondition of the economic process" takes precedence, and the relation to "security needs and interests of certain companies" stands out. At the same time, aspects found in this approach are useful, given that "parts of the global population could eventually benefit from such a holistic concept." However, conceptualising the Nexus as securitisation process "allows us to understand why water, energy and food have now been framed under the urgent paradigm of security, instead of earlier discourses of distributional justice. One must, however, dare to ask what is really at stake in

[11] According to WEF (2016), financing the resilience of energy infrastructures comes at a cost, since the climate resilience must be included from the start of a project, or later on. To increase the susceptibility of a project loan and reduce costs, the financial models should include the risks pertaining to extreme weather events and the adaptation to climate change from the start of the project planning.

terms of the water, energy and food-security Nexus. Is it survival of mankind or is it the preservation of current economic setups?" (Leese and Meisch, 2015).

3. Security

The search for "security", which takes place in a society characterised by risk and uncertainty, also underlies the Nexus structure (cf. Beck, 1998). In a broader sense, the Nexus is placed below the focus on human security, highlighting the dimensions of water, energy and food security. In the WEF Annual Meeting in 2008, which took place even before the Bonn Conference, water security holds a privileged position in the origin of the Nexus construction (WEF, 2011). In other words, the understanding of the Nexus can assist in the attainment of water security.[12] This highlights the need to have a definite idea of what is represented by the term "security" (water, energy, food):

- Food security is the state in which "all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO, 1996).
- Water security was not directly defined in the Millennium Development Goals, but its subject matter could be inferred as "access to potable water and sanitation", defined in the following decade as the human right to water and sanitation, which represents a basic vision of such security.[13] In a broader sense, Peña (2016) defines water security for the conditions specific to the region as having: i) water availability that is adequate for human supplies, subsistence uses, ecosystem protection, and production; ii) the capacity to access and benefit from this water in a sustainable manner, and to consistently manage the interactions between different sectors, and iii) an acceptable level of water-related risk for the population, environment and the economy.
- Energy security is understood as "access to clean, reliable and affordable energy services for cooking and heating, lighting, communications and productive uses" (AGECC, 2010), and also as the "physical uninterrupted availability of energy at an affordable price, while respecting the environmental demands" (Peña, 2016).

Peña (2016) identifies four priority areas in the region in which water security represents a critical element for socioeconomic development: i) the population's access to an adequate level of potable water and sanitation; ii) the availability of water to ensure a sustainable and productive development, and to reduce the associated conflict; iii) the conservation of water bodies in a condition compatible with safeguarding public health and protecting the environment; and iv) the reduction of risks associated with excess water, especially in urban areas and areas that are susceptible to the effects of hurricanes.

In the reports submitted to the WEF, the potential world risks are evaluated from economic, environmental, geopolitical, social and technological points of view. Matters concerning water have always been featured prominently in these reports. In this manner, WEF (2016) considers the five greatest risks in the next ten years: i) water crises; ii) policy failures in the mitigation and adaptation to climate change; iii) extreme weather events; iv) food crises; and v) deep social instability. The energy risk is the only one of the Nexus components (and its environmental

[12] From the perspective of Hoff (2011), there are opportunities to improve the water, energy and food security through a Nexus approach. For these purposes, actionable tools can be employed such as the use of wastes as a resource, stimulating development through economic incentives, coherence between governmental and institutional policies, and obtaining benefits from productive ecosystems.

[13] WEF (2009) considers water security as the web that connects all the major challenges (food, energy, climate change and economic development).

sub-component) that is missing in order to include all of them in the classification. Specific to the region, the greatest risks identified are governance failures and the deep social instability, and hence direct references to the Nexus components do not appear (WEF, 2016).

The role of climate change must also be highlighted. Climate change projections indicate that for South America, the key risk will be the availability of water in semiarid regions and regions dependent on glacier melt. In Central America, the key risk will be floods and landslides caused by extreme precipitation (IPCC, 2014). Furthermore, an increase in extreme weather events affecting energy infrastructure is observed: insured losses (due to insurance policies) have increased by 40%, and more extreme events are expected in the future. This should lead to increased economic efforts towards protecting energy infrastructure assets, with the resulting need to move to private investment (WEC, 2015). The principal measure suggested is to increase the resilience of the energy infrastructure.

II. SELECTED ASPECTS OF THE NEXUS IN LATIN AMERICA AND THE CARIBBEAN

A. Difficulties in Implementing the Nexus Approach

1. Lack of Key Information

Defining the relevant interactions or priorities for the elaboration of recommendations regarding the Nexus approach in Latin America and the Caribbean requires a large amount of information that is both disaggregated and pertinent to the issues. This information must relate to sources of the water resource, uses and users of water, energy and land, production, water distribution, energy and food, contamination, consumption levels, efficiency, etc. Generally speaking, information on these topics that is available today is scarce, dispersed, unreliable, and is either non-comparable or completely inexistent.

The scarce reliable and disaggregated information available provides the first means to analyse the feasibility of applying a Nexus approach in the region. A key limitation is that the management of the water, energy and food sectors, which was until now carried out in an independent and isolated manner, has generally developed with insufficient information available. In recent times, as a result of the growing pressure on particular natural resources, their finite nature, the spread of conflict, and problems in the governance of these resources, interest in collecting better data has increased. Yet the data are always sensitive and lacking, often difficult to attain or estimate, and expensive to produce. When we are faced with the need to define and identify Nexus interactions at the regional level, information is required that is more comprehensive and of better quality than what is currently available.

The scarcity, inadequacy or inaccuracies of the information is one of the key limitations to identifying the most important Nexus interactions in Latin America and the Caribbean. It is enough to note, for example, the little available information on fundamental topics such as water resources used at the national level, where there was no data for the year 2010 in 14 of the 25 countries surveyed (56%) (CEPAL, 2015). It is worth emphasising that these national level data normally consider global estimations or approximations, and are not real results from actual measurements at the level of the uses or of the water bodies. Many water uses occur without formal titles of ownership or use, and without respecting the limitations or conditions established by these titles, and this is coupled with a lack of or no monitoring, auditing or control by the water authority (Embid and Martín, 2015). There are also no fundamental data available for the implementation of the Nexus approach, such as differences between consumptive uses and water extractions or disaggregated climate data, land and seasonal uses. There are no data with the required details, the databases are inadequate, or the available information cannot be verified.

The effective application of the Nexus approach in Latin America and the Caribbean therefore requires, as a first and essential step, strengthening the monitoring programmes and data generation, as well as consolidating and standardising the existing databases. This will allow a better understanding of the conditions of the different Nexus components, to conduct comparisons between sectors, river basins or countries, and to evaluate the impacts that different uses have on the water resources, associated ecosystems, and on water, energy and food security.

2. Weak Governance

The poor planning capacity goes together with what is also a very poor management, auditing and control capacity from the water authorities and the sectoral uses (irrigation, potable water and sanitation services, etc.). This well-known shortcoming in the region may be due to multiple causes, among which the following should be mentioned: the weaknesses of the states, the ineffectiveness of regulatory frameworks, the lack of institutional capacities and adequate material and human resources, the fragmentation of decision-making power and the lack of citizen engagement (Martín and Justo, 2015).

Within the context of weak governance, the private sectoral interests can be a major obstacle in the implementation of the Nexus approach which seeks different, and sometimes opposing objectives to the financial profitability of the powerful sectors. Without planning, there is no possibility to effectively implement the Nexus, to which the particular complexity derived from the specific difficulties and limitations of the involvement of the three different sectors must be added.

The sectors have a complex and diverse history in the region, and a common point for them is the ongoing discussions in each country on the level and degree of involvement of the State, society and the market in these sectors. All the sectors also endure an increasing impact of external factors that are dependent on the international context, and they are therefore difficult to plan for. Some noteworthy external factors are price trends, capital movement, the level of investment, and the application of international agreements on free trade or investment protection.

In this controversial sectoral evolution of planning and development, or underdevelopment, of strategic and extremely sensitive sectors, the scope for national action is diminished as globalisation increases. This creates the current need for a planning approach that is no longer sectoral or only national, but rather intersectoral and at different levels or scales. This planning approach is difficult in itself, and is non-existent in many countries within the region. This challenge can be described as almost insurmountable.

A significant impairment to complex planning activities using a Nexus approach is its multi-scale nature. This means that there is a need to simultaneously consider multiple planning scales (definitely local and national, but also regional or river basin), territorial plans with the involvement of various governments (state, local or administrative regions), and in some cases, other countries. With a view to implementing the Nexus approach, it appears to be essential to replace and revise the existing state of the art sectoral planning methods.

Because the structures, compositions and dynamics of the sectors are different, we must not only consider the regional, national and local levels. Regarding water, it is obvious that the river basin as a territorial unit is considered when dealing with the resource, but it is the local level (or another relevant level of aggregation or horizontal integration) at which the potable water and sanitation services are based, with a low relative repercussion on the international context. Energy can be considered at the river basin level when considering hydroelectricity. But the possibilities of energy planning will be defined by the design of its integrated and interconnected system, and by the possibilities of the country and the region in a much closer connection with the international market and regional geopolitics. This also will occur with food, determined by the national production capacity, but also by the purchasing power, increasingly dependent on availability and price evolution at the international level.

The energy matrix poses a marked complexity at the regional and national level. The same applies to the water matrix, and to food production and its linkages with nutrition. Every Nexus component has evolved unevenly and operates under a completely different logic to the others. From this point of view, it appears to be extremely difficult to place items on an equal footing when they are subject to diverse behavioural factors, many of which even exceed the national scope (i.e. the natural planning space), such as global energy and food prices. For example, the mere volatility of oil prices (Arroyo and Cossío, 2015) or food prices can render obsolete some planning that must face significant levels of uncertainty from its inception.

As a result, planning using a Nexus approach is significantly more complex than simply observing the relationship between the three components. Technical aspects exist that are relevant to the issue, but their actual implementation possibilities depend primarily on policy definitions and economic policy based on development models, the role of the state, and the income distribution.[14]

3. Regional Diversity

Latin America and the Caribbean contain a wide range of climates and geographical regions, and are characterised by abundant and diversified natural resources in the three fields of Nexus, but these resources are very unevenly distributed at both the regional level and within the countries.

Looking for example at energy, the importance of hydropower generation is clear in South America, as it represents more than 70% of the energy production in Colombia, Brazil, Peru, Uruguay and Paraguay (IAE, 2013). This is also true for Costa Rica, who managed to produce all their electricity through hydropower generation for several months in 2015 and 2016. These examples cannot be compared to the Caribbean or Mesoamerica, where thermoelectric or geothermal generation is significant, but hydropower generation is either non-existent, or is only existent to a small extent. In the same vein, the abundant water availability in the first-mentioned countries contrasts to the desalination potential in the Caribbean and Mesoamerica. Without accounting for Mexico, the Andean region produces approximately 65% of the oil and 34% of the natural gas in Latin America (Altomonte et al., 2013). There is a contrasting situation between countries such as Mexico and Venezuela, which are major regional exporters, and countries such as Chile, Paraguay and Uruguay, which are purely oil importers. Common regional features do exist, but there are at least three conditions that make it extremely difficult to develop a classification that is consistent with the countries and their implementation of the Nexus approach:

- The lack and low quality of information of the fundamental aspects involved.
- The heterogeneity of the countries in terms of populations, levels of development, availabilities of various resources, geography, quality of governance, the state's capacity and size, negotiating power, level of poverty, etc.
- The multiplicity of variables and issues involved in the Nexus.

These circumstances make it difficult to identify the primary connections; however, this becomes easier to identify when addressing the problem with a regional subdivision. At least five subregions can be identified in Latin American and the Caribbean, which could present common characteristics for the implementation of particular Nexus dimensions, though obviously not for others.

[14] The Nexus can be associated with an institutional economics approach, whereas conventional studies on energy, water or land are based on a neoclassical approach (Mirzabaev et al., 2015). The neoclassical perspective pursues the maximisation of benefits or the minimisation of costs, typically in one sector in particular, whereas the institutional economics approach seeks to optimise the system performance as a whole.

- The Andean region (Venezuela, Colombia, Peru, Bolivia and Ecuador).
- The Southern Cone (Argentina, Chile, Paraguay and Uruguay).
- The Amazon region (Brazil, Guyana and Suriname, and also regions of Colombia and Peru which are located in the Amazon).
- Mesoamerica (Belize, Guatemala, Honduras, Costa Rica, Mexico, Nicaragua, Panama and El Salvador).
- The Caribbean.

The pronounced heterogeneity, together with the limited information available, suggests that a higher degree of alignment in identifying the priority interactions can only be achieved by refining the analyses to a national or local level. This means that more factors and sophisticated data are included in the definitions of these interconnections, which vary significantly, including within regions as extensive as Brazil, Mexico, Peru or Argentina. However, this heterogeneity in the availability of energy sources or the importance of transboundary water resources also means that the optimal efficiency from a Nexus perspective can only be achieved through a process of planning or integration at the regional scale, both for energy and for international river basins. This leads us to the conclusion that multi-scale planning is required (or at least multi-scale coordination), which in turn increases the complexity of implementation.[15]

4. Insufficient Knowledge of the Local Nexus Dynamics

The Nexus can be seen in specific local situations in which conflicts emerge that demonstrate the trade-offs typically associated with competition between alternative water uses. The local level is also the scale at which beneficial links between alternative uses can be identified. Therefore, knowledge of the possible Nexus dynamics at the local level is key to the effective implementation of this approach in addressing trade-offs and in the promotion of synergies.

The poor knowledge and low systematisation of the possible dynamics at the local level is a factor that inhibits the implementation of the Nexus approach. In order to address this, the development of a systematic classification of potential interrelations emerges as a core element in the effective implementation of the approach. Meza et al. (2015) presents an example of this methodology by identifying the priority interactions (mining, aquifer overexploitation, urban expansion, hydropower and agriculture) for four regions in Chile (Antofagasta, Copiapó, Maipo and Maule) with distinct problems, analysing both current problems (cf. Figure 2) and those under climate change conditions.

[15] An example from South America is integration of the field of energy, which marked its first milestone with the Treaty of Montevideo (1980), which established the Latin American Integration Association and created a legal framework for several partial agreements concerning energy integration, norms concerning the interconnection and supply of electrical energy, gas interconnection, and commercialisation, development and transportation of crude oil, liquefied gas and other liquid hydrocarbons.

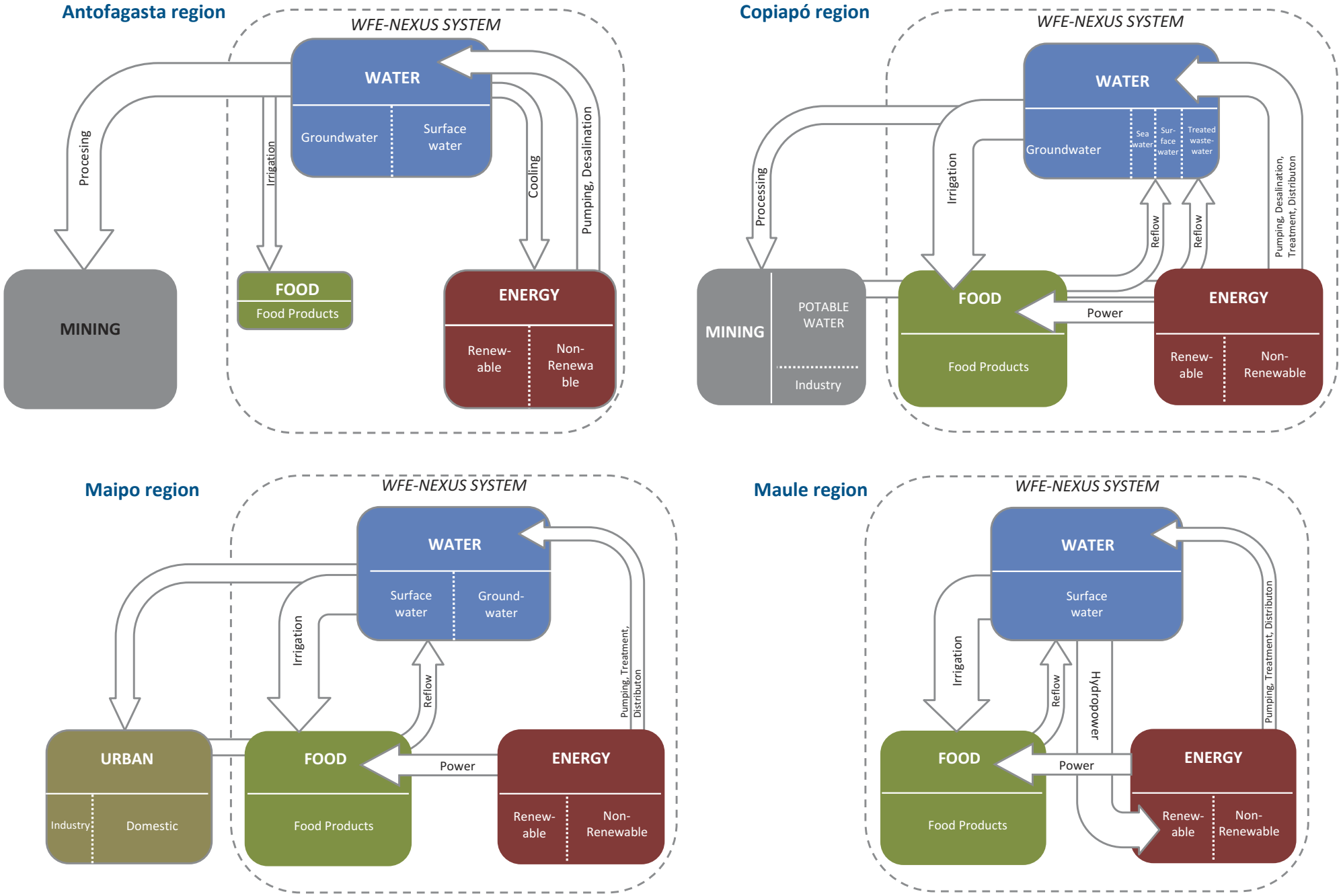

Figure 2: Nexus interaction diagrams for four regions in Chile

Source: Francisco Meza; Sebastián Vicuña; Jorge Gironás; David Poblete; Francisco Suárez & Melanie Oertel (2015) "Water-food-energy nexus in Chile: the challenges due to global change in different regional contexts", Water International, volume 40, numbers 5-6.

B. Nexus in the Region

Very few studies of the Nexus in Latin American and Caribbean countries have focussed on explaining their regulatory framework as either a tool or an obstacle to the integration of policies and regulations which, in the majority of instances, appear to be highly disconnected or fragmented. One should not lose sight of the fact that the legislation, despite being vital, only represents one of the links in the chain (which consists of policy, planning, legislation, administration and management)[16], that musts synchronise with the other links in order to achieve the synergies that the implementation of the Nexus approach can attain in the development and use of the various natural resources involved.

One of the items to keep in mind is human rights, which are very important in the region, yet have been omitted thus far from studies conducted as an integral part of the Nexus equation. However, human rights are a cross-cutting line that should join the public intervention to the productive sector and simultaneously should play a useful role in defining the interactions introduced by the Nexus. This diverse role would be comparable to one that would also have the right to investment protection and, in the narrower national plane, the definition of priorities contained in the water laws for the allocation of water rights. Human rights, investment protection treaties and priority lists should achieve a system of coordination and continuity, even though there can often be vectors that act in an opposing direction.

1. The Human Rights Legal Framework

A characteristic of the 21st century in Latin America and the Caribbean, with regard to the initial recognition of the Nexus during the previous century, is the sharp increase in policy concerning the declaration, recognition, specification and guarantee of human rights. The high position that these human rights present in the region, combined with their relative level of nonfulfilment, place this system and the objectives linked to it at the forefront of any policy design. In this way, this priority definition derives from the same regional and constitutional legal system that is none other than the fulfilment of the human rights, especially economic, social and cultural rights, linked with the management of the three Nexus elements. This must be considered as a priority element in the design of public policy that, with a Nexus approach, promotes sustainable economic development consistent with the SDGs.

This homogenous regional legal framework recognises the right to water, food (International Covenant on Economic, Social and Cultural Rights) and basic public services (American Convention on Human Rights and the San Salvador Protocol) as rights at the top of the hierarchy, and with this, defines a framework of priorities for the implementation of the Nexus.

Within the Nexus context, it is important to recognise the role of human rights as modulating or limiting particular sectoral policies that are driven purely by considerations of productivity (fundamentally for collecting money) that could overlook the implicit requirements of the Nexus. It is not a question of producing enough energy to meet the predicted worldwide increases in demand according to certain temporal projections, but as asserted in the 2030 Agenda and the SDGs, and as a guiding premise of the various policies, energy must be provided in a basic way and at an affordable price to the different people to whom it is a prerequisite for carrying out a dignified life. The same can be said for food or for the provision of drinking water and sanitation services. These priorities, defined by human rights treaties, in turn coincide with the majority of the regional water laws that grant

[16] This chain could also be ordered as policy, legislation, planning, administration and management. In this definition, the planning would be a consequence of legislation, and it would contain legal framework which addresses the elaboration and its effects.

the common use of water an absolute priority over special uses.[17] Among the defined special uses, domestic water supply appears to be treated as a priority ahead of the other uses.

At times, this international legal framework clashes and must be integrated with another very important framework for the development of the Nexus: the foreign investment protection right (Bohoslavsky, 2010).[18] This right has determined and still strongly determines the projects linked to the development of any of the Nexus elements. The relationship between these two international legal systems has already demonstrated tensions in the region, which make it impossible to ignore their future consideration (Bohoslavsky and Justo, 2011).

This priority objective is a national and international normative prescription that draws from various complementary institutions and from concurrent validity (common use, public service, domestic supply as a priority use and the human right to water) to define with complete clarity that the priority in water use, and therefore in the implementation of the Nexus approach, is the fulfilment of the right to water for the people. Furthermore, this priority has been the proposed means and approach for how to manage and prevent the growing conflict for water use in the region (Martín and Justo, 2015) and to address what are foreseen as the primary regional risks: governance failures and political and social instability (WEF, 2016).

Some constitutions have recently begun to proclaim these rights. Within the regional scope, this is evident in the constitutions of Uruguay (2004), Ecuador (2008), Bolivia (2009) and Mexico (constitutional reform of February 2012), that all proclaim the human right to water in this sense. The human right to food is found in the Bolivian and Ecuadorian constitutions. The right to electricity is found solely in the constitution of Bolivia, which also includes the right to access gas for household use. This makes Bolivia the only country in the region whose constitution includes the three rights.

2. The Priority Ranking for Water Use

The gathering of information on the order of priorities established for the granting of rights within the water legislation of countries in the region allows not only for the evaluation of the state of the art (which uses are considered as priorities with respect to others), its evolution and the mechanisms for its definition, but also evaluation of the constraints and possibilities for the future coordination of the Nexus, from the legal-political and institutional point of view.

The priority schemes are typically established for allocating rights according to uses, but some laws also include priority rankings for the provision of rights that are already granted, in the case of shortages or scarcity. The priority systems can be fixed (the order of preference is objectively set in stone in the law), flexible (in every instance, the order is established on a discretionary basis by the administrative authority) or semi-flexible (the order is set by law, yet can be changed when justified). However, the practical application of granting rights with the priority

[17] The classification of common, domestic and primary or general water uses as opposed to special private or exclusive uses has been adopted by the vast majority of water legislation in the region. The difference consists in that the former uses are those whose principal and immediate objective are meeting physical needs that are vital for life and can be carried out by manual means by all capable people. They are defined as free of charge, comprehensive and unrestricted, and by their nature do not lead to a reduction or noticeable damage to the flows. In contrast, the special uses are those that are aimed at producing an increase in the scope of work and the economic power of humankind. They are costly, distinct, and require the prior granting of a permit or concession for population supply, irrigation, industry, mining, energy, etc. However, it must be kept in mind that the content, definition and the means for both common and special uses may vary substantially according to each legislation.

[18] These treaties can disregard, in their practical application, some human rights: "It is therefore critical that the states rely on an established body of domestic laws to protect land rights, water use, the environment and labour rights. The agreements … should establish periodic checks of the water rights and the allocation of water to investors, in order to ensure that they do not impair the citizens' access to water. Additionally, these agreements should not undermine the government's capacity to enact new internal regulations in the protection of public interest (including pollution controls…)" (Saulino, 2011b).

system has not been much less peaceful, and experience shows that it can be undermined[19] and/or circumvented by the authorities themselves (Erice, 2013).

From the analysis of the legal priorities for the granting of rights in water legislation from countries in the region, the following features emerge:

- In general, three types of water legislation can be identified: i) those that consider a priority regime for water use; ii) those that do not specify a priority regime, but refer its definition to other authorities (planner, discretional power to the water authority, river basin organisation, etc.); iii) those without water legislation, where a definition of priorities is therefore inexistent. Planning is essentially defining priorities and allocating resources accordingly.
- Legislations that establish priorities and identify in first place common and domestic use as well as human consumption. Agricultural, farming and irrigation uses are identified in second place. No law that establishes priorities positions electricity generation above these aforementioned uses. From a regulatory perspective, and between the Nexus elements, the priority in water use is: firstly, the fulfilment of the human right to water and food (which typically includes agricultural practices for subsistence); secondly, agricultural activity and/or irrigation; and in third place, electricity generation.
- Use of water for energy production is lagging considerably when compared with the composition of the regional energy matrix and the importance that hydropower generation has for the region. In some legislations, such as that of Mexico, water for energy use appears noticeably low in the established order, and the difference between water for energy generation that is intended for the public service (sixth place) or private services (ninth place) should be highlighted.
- Caribbean and Central American countries, with the exception of Nicaragua, Honduras and Costa Rica, do not have water laws (Guatemala and Haiti), or their laws do not include a predefined priority ranking (Cuba, El Salvador, Panama and Puerto Rico).
- At least three problems of interpretation arise regarding the legal orders of priorities and the Nexus matter in question: i) whether hydroelectric or energetic uses can or cannot be included among industrial uses; ii) whether water use for the irrigation of crops used as biofuels can be considered as an agricultural use, and if it should start being considered as a use for energy production; and iii) whether power generation comprises only that of hydroelectricity, or if it includes water utilisation in any other form of power generation.
- The question also persists on the suitability of establishing these priorities,[20] its flexibility or exception, as well as on their full justification at present. It appears clear that aside from some laws (Mexico, Nicaragua, Paraguay and Ecuador), the majority of laws do not consider environ-

[19] There are instances in the region where attempts were made to grant water rights under budgetary laws, leaving legislation and institutions aside, through ad hoc exemptions, even in areas with shortages and over-allocation of resources: "this attests to the need for legal, technical-administrative and financial independence of the water management agencies and of the stability of their staff. In addition, it clearly confirms the need to have rules of the highest ranking and inviolability of the allocation processes" (Solanes and Getches, 1998).

[20] According to Solanes and Jouravlev (2005), "the only functional priorities for the purpose of the granting of water rights at the request of the party should be uses for drinking water and sanitation services, provided that they always establish safeguards so that this does not interfere with the generation of clear signals about the levels of water scarcity, and not lead to an inefficient use of water during such a scarcity. This is without causing detriment to the preservation of flows for ecological reasons."

mental flows within the priority rankings for the granting of rights,[21] though they might be included in another section of its content, such as budget usage or in another manner.

- Lastly, consideration of the emergence of new uses that can affect traditional dynamics is also important, such as the demands of the tourism sector. In Costa Rica for example, conflicts over water use have already appeared between rural communities and tourism companies, because the use in this sector is intensive both in the facilities and their maintenance, and for the watering of golf courses. When considering tourism in the coastal areas, desalination presents an alternative for the reduction of potential conflicts with communities.

In the water legislation, the priority regimes established for water use appear in a relatively clear form. However, in reality and especially in practice, the issue turns out to be significantly more complicated, and considers interferences and inconsistencies between the regulatory frameworks of the Nexus elements and their application. In effect, the centrality and apparent clarity of the water legislation begins to fade when faced with the letter of the law and, in practice, with energy legislation or with the so-called electrical regulatory frameworks in particular and, in general, with environmental legislation and administrative contracting, and potentially with international investment law, of growing importance for the Nexus.

Despite the legal provisions that prioritise other water uses, other circumstances that usually determine and sometimes distort the application of the aforementioned priority orders need to be added. In practice, use for hydroelectricity can be seen as preferred relative to other uses (especially agricultural) for:

- The acquisition, weakness or absence of monitoring and control systems.
- The asymmetries with regard to economic weight, power of influence and negotiation.
- The actual location of use, that in the case of hydropower will often be upstream, providing strategic advantages.
- The hydropower uses are concentrated and relatively recent, and its laws are in many cases clearly established, recorded and protected. In contrast, laws for agricultural uses are scattered, with little organisation and are sometimes only of a customary nature.

As an example, in a situation of weak governance, the problems that the powerful hydropower sector can place on the implementation of a Nexus approach that affects its interests cannot be ignored. If the true aim is the implementation of a Nexus approach and not the exclusive benefit of one sector, the asymmetry of information and negotiating power with other involved sectors, especially the agricultural sector, must be appropriately measured and balanced by a competent authority.

The dominance that hydropower use acquires, in practice, ahead of the remaining uses has been a subject of analysis for the countries of Mesoamerica (Panama, Nicaragua, Guatemala, El Salvador, Costa Rica and Honduras) (Espinoza Rodríguez, 2016). Similar occurrences can be observed in Brazil, Chile (Bauer, 2009) and Peru. The latest primacy that the legal instruments for the development of energy projects end up having over water legislation can also be observed in Argentina. Adding to this primacy is the complexity of a federal system that grants the majority of the energy planning and regulation functions to the Federal State, while

[21] In Costa Rica for example, although the environmental flows are not considered in Water Law, the governing body, given the rise in concessions for private hydropower generation, decided to not allow that sources would dry out, and proceeded to define a methodology for the application of ecological flows. They established that in some cases at least 10% of the low (i.e. dry season) flow must remain in the water source.

both water management and the majority of the water and environmental powers are kept at the provincial level, and these circumstances set an obstacle to the implementation of the Nexus approach (Martín, 2010).

The strengthening of this primacy of hydropower use indicates that, despite water representing the predominant Nexus element, the use of water for energy purposes has been dominated by a constant energy demand that is only restrained by price, a hypothesis that is also supported by the consideration of the production of biofuels. This hypothesis implies that, as argued from the scope of the fourth element (climate change) that integrates the Nexus in its expanded version, the energy production and consumption patterns must be revised. From this perspective, the energy production requirement, or otherwise put, its continuation at a reasonably low price, appears to be the item that is applying pressure to the other Nexus components (water, food and climate).

In other cases, this occurs because the realisation of water use for energy purposes is implemented through administrative contracts at the highest level, with legislative measures that include, in some cases, the conclusion of international treaties. The construction and development of large infrastructures that involve two or more Nexus elements (hydroelectric facilities, dams, desalination plants, aqueducts, water transfers, transmission lines, nuclear plants, wind farms, mining concessions, etc.) typically involve concessions for works, services or public domain, and environmental permits, and in some cases even international treaties[22] (eg. for energy integration or the use of transboundary rivers). In cases that involve international treaties, the legislative power essentially intervenes using a special law which, given that it occupies the same legal level, means there this no obligation to observe either the preceding general legislation or the priorities defined by it (Martín, 2010).

The conclusion is that, although a defined legal framework exists for the different Nexus elements, many important decisions, such as the definition of priorities in terms of the use of water and energy sources, are taken at the highest involved level of government, using legislative power, and are therefore in many cases not subject to the previous regulatory framework for water or energy, but only to the conceptual framework. For this reason, the Nexus approach needs to promote, foster and involve the setting of priorities as a matter of state policies, and also integrated and multi-temporal planning at the medium and long-term, with a broad consensus of the political forces that act to guarantee its longevity. A planning approach that incorporates these characteristics will generate greater possibilities for the successful implementation of a Nexus approach. The mere promotion of legislative reforms or non-binding planning at the sectoral level is indispensable, but not enough to prompt the required transformations.

[22] There are many examples of this in the region, such as the treaties related to the hydroelectric dams Yacyretá (Argentina and Paraguay) and Itaipu (Brazil and Paraguay), or the most recent "Agreement for the Supply of Electricity to the Republic of Peru and Exportation of Surpluses to the Federal Republic of Brazil".

III. PRIORITY RELATIONSHIPS BETWEEN THE NEXUS ELEMENTS IN THE REGION

This chapter specifies the relationships between the Nexus elements that can be established in a general form. In particular, the identification of the interconnections that can be considered as priorities or as crucial for the implementation of the Nexus approach in Latin America and the Caribbean are analysed in more detail. This definition is based on the following criteria: i) consideration of water as the dominant Nexus element; ii) the impact of the other Nexus elements; iii) emphasis on the sectors of economic significance, with the potential for development and increasing conflict; and iv) the fulfilment and upholding of human rights, particularly economic, social and cultural rights.[23] When an interconnection is prioritised or takes on a high importance, it means that it concerns a crucial activity for the region (or some of countries in the region), and it presents an opportunity to improve the performance of this activity using a Nexus approach.

A. The Interactions between Water and Energy

The use of water for energy production is a traditional concept that refers, above all, to hydroelectric energy. Water use for these means represents the key element of the water-energy Nexus, evidenced by the fact that 15% of global water capture is for this purpose (IRENA, 2015).[24] This is a significant amount that must be qualified, because it is significantly lower in desert or arid areas where water is scarce, but to the contrary, is significantly higher where there is an abundance of water, as is generally the case in many countries in the region where there is both a prevalence of existing hydroelectricity and a great unused potential for utilising hydropower still remains.

In any case, a number of problematic issues concerning hydropower must be pointed out, which shed light on certain characteristics of the water-energy Nexus, and are relevant to the region.

- Firstly, attention must be given to the extent to which it is unsuitable to consider hydropower as an example of renewable energy. Consideration as a renewable energy would imply a water use that is non-consumptive, with limited environmental impact, and little impact on other users of the resource. It is known that significant losses are generated (normally due to evaporation) in the infrastructure that store water for the generation process, and the magnitude of these losses depends on the temperature at the reservoir locations. Also, when considering the massive production of electricity by large reservoirs, their construction involves the flooding of substantial land areas, which in itself has a clear environmental impact, aside from the inevitable sedimentation of the reservoirs that leads to, at a certain point in time, the end of their primary utility. Similarly, there can be a social impact when inhabited areas or sites that are religious or sacred for certain cultures are affected. A further issue is the degree of compatibility of this form of energy production with other water uses. Although it is based on the assumption that low consumptions of water resources are needed for the production of hydropower (not a completely exact assumption), it is evident that the turbine use

[23] These presumptions, with a focus on institutional strengthening and the guarantee of economic, social and cultural rights are consistent with the risk assessment in WEF (2016) where, unlike other regions that are largely threatened by natural disasters, water crises or abrupt changes in the energy prices, concerns in Latin America and the Caribbean are first and foremost due to failures in governance, secondly, the deep social instability caused by economic factors, and thirdly, these economic factors themselves.

[24] In accordance with their mandate, IRENA (2015) recommends a reduction in the use of water for hydropower production and a replacement of this for renewable energies (mainly deriving from wind or the sun): "in the way that renewable energies with a low-intensity water requirement are expanding, the accumulated positive impact on the water-energy Nexus is becoming increasingly significant … the electricity derived from wind energy in the United States prevented the use of more than 130 billion litres of water, equivalent to the annual water consumption of 320,000 homes".

operates at changing timescales (often dependent on the energy price at the moment of production[25]), which unequivocally affects water uses that take place downstream of the reservoir. The above described situations may not occur when the reservoir is built for the sole purpose of generating electricity, although they commonly lead to an inefficient use of water that is affected by the rhythm of the turbine use. In any case, this should not overlook what is still a low production of hydropower in the region when compared to its theoretical potential.

- When a multipurpose reservoir is designed in a technically correct manner, the compatibility between different uses can be defined before its construction, and this determines (i.e. enables or precludes) other uses that can be carried out from this reservoir. However, a compatible plan for the various uses of the reservoir water does not always exist at the time of developing the technical project, even though the reservoir is multipurpose. At times this plan is not specified, it is subject to the implementation possibilities of these various uses, with a certain discretional power for the administrator. The practice of building multipurpose reservoirs could become more common in the future, in contrast to the current situation, where reservoirs are generally single purpose.[26] In Ecuador, for example, the water policy introduced in 2007 stresses the construction of multipurpose reservoirs (in which hydropower generation is always one of the uses).
- Water availability is a key element of energy security in countries where hydropower (or energy produced by thermal or nuclear plants, for which water is needed for cooling) is dominant in the energy system. This means that the competent authorities must undertake water management appropriate to the energy uses derived from the water, especially when they configure an energy matrix for energy production dependent upon hydropower or the use of water for cooling processes.
- Droughts represent a weak point in the utilisation of water for energy production. Droughts reduce the water availability and, by extension, affect the electricity production. In Latin America and the Caribbean, a recent example of this is the drought in Brazil, where many millions of people were affected by power outages caused by the drought, as it was impossible to generate the usual energy output because of the water scarcity (Roehrkasten et al., 2016).[27] This highlights the need to implement water and energy planning processes in a correct and coordinated manner, to prevent, or at least reduce, the inevitable and critical consequences that are faced when depending upon only one energy source as the core element for guaranteeing energy security, and these circumstances are exacerbated in the context of climate change. This makes it worthwhile to rethink the energy matrices, paying greater attention to the potential for a greater harnessing of new and renewable energy sources.

[25] This occurs in electricity markets with multiple energy sources and where hydropower, due to its versatility, normally comes into the equation at the foreseeable moment at which electricity prices will be at their highest. This facilitates the profitability of the generation plants, but affects the uses that will take place downstream, which will often have to be configured as "precarious" when the holder of the production plant has the right to flexibility in the generation quantity. Everything depends on what is specified in their concession or authoritative title.

[26] Characteristics of hydroelectricity development in previous years has been the prevalence of small-scale run-of-river power generation and an emphasis on building dams with smaller storage capacity and with electricity generation as their sole purpose (unlike other times, when the focus on multiple uses was more widespread) (Altomonte et al., 2013).

[27] The same situation exists in Venezuela, where the drought has had a strong impact on hydropower generation in the country (WEC, 2015). In Brazil, hydroelectricity consumption dropped by 7% in 2013, and a further 6% in 2014, and the problems continued to exacerbate in 2015 and 2016. In December 2014, the largest dams in the country were only at 16% of their capacity, and restrictive measures on consumption had to be implemented. Energy was imported from Argentina, energy transfers from the north to the south of Brazil were authorised, and a policy for energy diversification was launched, with particular focus on wind energy.

- The use of irrigation canals for the production of hydroelectricity is a factor that can definitely be embedded in the Nexus, and one that is beginning to take on importance in the region. This impact is not significant in quantitative terms, but at the local level this form of production can be important by both reducing the expansion needs of distribution networks in countries with deficiencies in this regard, and by helping to decrease the irrigation systems costs for farmers. All of this demonstrates a very important link between water, energy and food.
- Climate events underlie all relationships between the Nexus elements. For example, it is impossible to generate wind energy when wind speeds are very high, such as for the hurricanes that occur at certain times of the year in parts of Central America (WEC, 2015). Similarly, strong flooding can force reservoirs to be emptied as a precautionary measure, which will not allow turbine use for the duration of this operation. In the same manner, an increase in temperatures can interfere with cooling processes in thermal or nuclear plants, which can lead to temporary suspension of their operation(s).[28] However, this is a phenomenon that is currently of little measurable importance in the region. In any case, the heating effect that the discharging of the waters used for cooling has on the body of water must be considered. This discharge can affect the water quality and temperature, and inhibit certain life forms in the ecosystems, something that must be considered given that environmental protection underpins Nexus considerations.

Hydropower generation is by far the principal energy source in the region, but it is distributed very heterogeneously among the countries. The Southern Cone generates 68% of its electricity from hydropower, while this fraction reaches 71% in the Andean Group countries. In Central America, Mexico generates 15% of its electricity from hydropower, while all other countries in this region generate a greater fraction from this source. The Caribbean countries are the exception, and because of the little available surface water, they do not depend on hydropower to a significant extent (Escobar, López and Clark, 2011). Furthermore, South America is placed third in the regions of the world that added the most hydroelectricity capacity in 2015 (IHA, 2016). Likewise, hydropower projects are ranked in second place (after mining and oil) in terms of socio-environmental disputes over the use of water resources (Martín and Justo, 2015).

This sector represents an opportunity for the application of a Nexus approach that combines the multipurpose nature of the reservoirs in a more efficient way (although those that have been built since 2000 have achieved this to a lesser extent than historically), and at the same time to optimise its economic, social and environmental impact. The regional hydropower potential must be reassessed using a Nexus approach that considers the three elements. The same applies to hydropower projects in the design, construction and development phases, taking into consideration the future scenarios of flow development, precipitation and water uses, since a greater installed capacity does not necessarily result in to greater generation.

Instead of static plans and designs, hydropower infrastructure must be planned within the ranges of uncertainty that are imposed by climate and precipitation trends for the region. In this respect, it is recommended that plans include provisions for specific operations depending on the climate and water demand, with adaptive infrastructure, and both pumped-storage constructions and small-scale hydropower systems should be considered as alternatives, to adapt to this climatic

[28] In France in 2003, the increase in temperatures, the resulting higher evaporation and the rise in water temperature in the rivers hindered the cooling in nuclear plants because of the lack of water in a suitable condition (Roehrkasten, Schaeuble and Helgenberger, 2016).

variability. These alternatives benefit from flexibility and diversification (Escobar, López and Clark, 2011).

Hydropower generation delivers reliability to the system, but it must be complemented by other forms of renewable energy, although intermittent, in order to reduce the risks deriving from an excessive and exclusive reliance on hydroelectricity as a source.[29] The modification and permanent or seasonal reduction of power generation due to drought or a reduction in flows provides an evidence that is exacerbated in some regions, countries or river basins, when the forecast future scenarios are taken into account (Vallejo, 2013; Flavin et al., 2014; Recalde, 2016). For example, a pessimistic scenario modelled for the Chixoy Hydroelectric Dam (Guatemala) and Cerrón Grande Dam (El Salvador) predicted reductions in electricity generation of greater than 20% by 2020, greater than 40% by 2050 and greater than 70% by the end of the century. Modelling using a less pessimistic scenario predicts an increase of between 4% and 6% by 2020, and later a reduction of 26% in Chixoy and 17% in Cerrón Grande by the year 2100 (CEPAL et al., 2015).

The El Niño phenomenon affects the region with droughts (the Caribbean, Colombia, north-eastern Brazil and Venezuela) and floods (Peru, southern Brazil, Paraguay, Uruguay, Ecuador, Bolivia and Argentina), strongly impacting the energy sector. For example, in Colombia and Venezuela, the impacts of this phenomenon led to water and energy rationing in several instances, with losses and higher production costs associated with the increase in thermoelectric generation to compensate for the shortfall in hydropower generation. This is in contrast with Peru and Ecuador, where the effects are predominantly due to the infrastructure. The Andean countries are particularly vulnerable to the phenomenon, as the El Niño can result in a reduction of 0.6% and 1.7% of their gross domestic products, for the normal and extraordinary event, respectively (CAF, 2016; Martín, 2016).

Among the analyses undertaken in the region that are based on a Nexus perspective, it is worth mentioning one from Bolivia that applied the methodological approach from the Food and Agricultural Organization of the United Nations (FAO) (Flammini et al., 2014). This analysis found, when considering the San Jacinto multipurpose hydropower project, that "it exerts increased pressure on food and soil, given that the crop productivity is lower than average. This may be because in the irrigation area, the quality of the vine is favoured more for subsequent processing of wine than for gross sales… On the other hand, even though the construction of the reservoir has limited the downstream movement of fish, the number and types of species have increased, in some cases without due control, resulting in some species that could be predators of other pre-existing species. The project, … as well as having created a benefit for the region, also has trade-offs. The most significant of these is the impact on the water quality in the reservoir due to agricultural discharges which contain pesticides" (Rojas and Heiland, 2015).

Hydrocarbon production and mining, being within the water-energy interaction and as users of both water and energy, can also be identified as a clear priority status because of the proven reserves and extreme dependence that many countries in the region have on these activities, among other reasons (Altomonte and Sánchez, 2016). This is true in the Andean countries (Chile, Bolivia, Peru and Ecuador) along with other countries such as Argentina, Brazil, Colombia, Mexico and Venezuela. The effects of hydrocarbon exploitation and mining are pertinent to the extent that they occupy the highest level in terms of socio-environmental conflict (Martín and Justo, 2015).

[29] This search for renewable energies should not be limited to the conventional energies (eg. wind and photovoltaic, which are being increasingly integrated into the region), but should include energies that are still in an experimental phase, such as wave and tidal power. For example, it is estimated that Chile possesses a potential for wave energy that is unmatched in the world (Hassan, 2009). Harnessing only 10% of this potential would double the installed capacity of Chile's Central Interconnected System.

The region has very substantial proven reserves of oil and natural gas, accounting for 20% and 4% of what exists in the world, respectively (Altomonte and Sánchez, 2016). An issue within this line of activities that should be addressed in greater detail from a Nexus perspective is the exploitation of unconventional hydrocarbons, with the additional risk of contaminating aquifers and affecting domestic water supply or irrigation water. Investigation and exploitation using the process of hydraulic fracturing (otherwise known as fracking) involves an energy, water and environmental impact much higher than from the methods employed for exploiting conventional resources.

It is important to note that the region possesses more than a quarter of the world's technically recoverable shale gas resources, which are mostly located in Argentina, Mexico and Brazil, and are currently in the process of being developed (Arroyo and Perdriel, 2015). The major risk in its development will be felt by the key Nexus element of water, while its vital role for the region is explained by: i) the potential energy self-sufficiency in countries which boast this resource; ii) the potential economic impacts of lower energy prices, lower volatility in energy prices, greater economic growth, lower levels of inequality, creation of job sources, etc.; and iii) the potential stronger integration of energy resources into a renewed geopolitical scenario in the region.

The same occurs when considering the required water and energy inputs for mining, an activity that can require an intensive use of both of these resources. For several countries in the region, mining represents both a great dependency and a potential for growth, for example with gold (Peru), copper and silver (Chile, Mexico and Peru) and iron (Brazil). Furthermore, mining is one of the fastest growing sectors in the region, and is currently a major destination for mining investment portfolios in the world (Altomonte and Sánchez, 2016).

Water consumption by the mining sector can reach up to 6% of the total water consumption in Argentina, Brazil, Chile, Colombia, Costa Rica, Mexico and Peru (Willaarts, Garrido and Llamas, 2014). Mining can affect both the quantity and quality of water. Impacts on quantity are more pronounced in areas of water resources scarcity. This occurs in semiarid areas such as central Mexico, northern Colombia and north-eastern Brazil, and in arid areas such as northern Chile, north-western Argentina, western Bolivia and southern Peru. When groundwater is non-renewable or exhibits a very low recharge rate, its exploitation can severely affect the water security for human populations, as has occurred in northern Chile, as well as in other locations (Willaarts, Garrido and Llamas, 2014). In areas where water resources are abundant, the major problem is to avoid contamination.

Likewise, mining can require intensive energy use, and this can compete with energy demands from other sectors, potentially causing significant impacts. In a number of cases, the high profitability of the mining industry allows the energy costs of desalination in arid or semiarid zones to be managed, thus closing the Nexus loop. As a result, the extractive sector often competes with other sectors (such as irrigated agriculture and urban development) for the scarce resources of water and energy.

B. The Interactions between Energy and Water

When considering the energy-water relationship, what first stands out is the most "traditional" technology of desalination of marine waters and brackish waters, pumping groundwater, and the modernisation of irrigation systems.[30] So that these processes can be carried out, the role of energy has always been identified as essential. Something that must be added to these processes is the complete urban water cycle, as a sign of the high consumption of energy required for the various processes in this cycle, from water treatment and distribution to harvesting and purification.

Although desalination is not seen as a priority in the region, it has started to constitute an increasingly attractive option, especially in locations without alternative supply options, such as in the Caribbean (Hoff, 2011), or to carry out high profit activities in arid areas, such as copper mining in Chile or for urban use in Mexico.

The major disadvantage of desalination consists in its high energy intensity. For example, out of the various primary water sources utilised in Spain, water from desalination plants requires the highest energy intensity (the energy consumption is 3.48 kWh/m^3), while the abstraction of groundwater or surface water only requires an energy consumption of approximately 0.50 kWh/m^3 (Ferro and Lentini, 2015). There are various methods for desalinating brackish water or marine water, and the salt concentration, the required quality standards, as well as the type of energy source available and its cost are all determining factors in selecting the most suitable method.

Therefore, desalination should only be considered as an appropriate option when there are no other supply sources, or when the environmental impact of developing these other sources and the energy costs for transporting the water are very high (Ferro and Lentini, 2015). In areas of extreme aridity, the aim is to establish combined energy and desalination plants that employ innovative processes of integrating thermal desalination with energy generation. In this process, the residual steam from the power plant is harnessed as a heat source for the desalination process, thus improving the efficiency of the system and resulting in cost savings.

Within the scope of this energy-water interconnection, drinking water and sanitation services are also highlighted, both in terms of expanding its coverage and, primarily, the improvement of its quality and the rise in treatment of urban wastewater and its reuse for agriculture, with operations that are electricity-intensive and often inefficient. A significant proportion of the energy consumption of these services is estimated to be localised in stages of transport, distribution and harvesting, particularly in the pumping of fluids in the supply of potable water. Conversely, when considering with sewage, the highest consumption of energy occurs in wastewater treatment; the treatment of sewage and sludge disposal consumes a significant amount of energy, although it can be used to generate electricity (Ferro and Lentini, 2015). Electricity costs for the service providers represent between 5% and 30% of the total operating costs, and it is estimated that the total energy expenditure could be reduced by between 5% and 15%. Studies at the national level have begun to adopt a Nexus approach to analyse the services for sewage, wastewater treatment and reuse of water, with Brazil providing an example of this (Stepping, 2016).

Similarly, the construction of long-distance water transfers is only possible when significant quantities of energy can be utilised for the transportation of the water,

[30] The "modernisation of irrigation systems" refers to the transformation of the irrigation techniques, that move beyond gravity-based irrigation systems (flooding) to localised irrigation or sprinkler irrigation. In theory, this leads to a saving in water use, but it does carry with it an increase in energy consumption. The savings in water consumption are usually not substantial: the results of the modernisation tend to be an increase in the number of crops and the expansion of the area under irrigation. Both factors can cause a reduction in the return flow and aquifer recharge, which can affect the water availability for other uses located downstream.

circumstances that are vital at some locations within the region (eg. Mexico City, Mexico; and São Paulo, Brazil). Also, the most important consideration is the water elevations, even though on some occasions these elevations can be compensated, either partially or wholly, with the resulting elevation drops in the transported water and the possibility to install hydroelectric plants in these sections of elevation drop.

This energy-water interaction is very important, given the constantly increasing energy consumption in the various processes outlined above. This is also linked to the growing appeal for desalination. Technological advances have allowed a substantial reduction in the cost of desalinated water, yet it still remains significantly more expensive than water collected by other means. The same trend, in terms of energy expenditure, can be said for the greater use of groundwater in agriculture, which is strongly linked to subsidised energy prices for this purpose in a number of countries.

In light of these high energy consumptions, one of the main lines of proposal revolves around a greater utilisation of renewable energies[31] and an improvement in energy efficiency (Ferro and Lentini, 2015). The Nexus perspective between energy and water emphasises the need to incorporate water scarcity into the decision-making process in the energy sector.

Lastly, the facets of agriculture that more clearly involve energy consumption are considered. The agrifood chain consumes approximately 30% of the world's consumed energy (FAO, 2011a). The central position that agriculture occupies in the region is evident: it uses approximately 70-80% of the consumed water and occupies 25% of the total surface area. At the same time, a considerable potential for expansion and possibilities to increase productivity exist, particularly through the implementation and modernisation of irrigation systems, which typically carries with it an increase in energy consumption. The modernisation and expansion of irrigation and the increasing use and dependence on groundwater are already key variables in some countries in the region, and in the future, could transform into critical Nexus variables in many of the others.

A more intense or more efficient use of water in agriculture is accompanied by an increase in energy consumption which must be considered in advance when adopting a Nexus approach. The modernisation of irrigation systems without an adequate consideration of its impacts on hydrology, the environment or energy, and in areas with a deficit, supply insecurity or volatility in energy prices, can make the producer more vulnerable, raise their costs and have consequential impacts on farming output, its profitability and the call for subsidies that is made to the public sector. These are factors that must be considered in the design of policy using a Nexus approach, for a sector that presents significant opportunities for its implementation and expansion.

The overexploitation of aquifers, for its part, brings with it a number of problems or inefficiencies that could be designed for or avoided, more swiftly, using a Nexus approach. This overexploitation, combined with low energy prices (often subsidised, with the aim of encouraging agricultural development), can not only lead to an unsustainable management of aquifers both in hydrological and environmental terms, with significant impacts on the quality and quantity of the resource, but also brings about energy inefficiency, and in some cases, social injustice.

The inefficiency stems from the higher energy consumption both globally and individually that is involved in pumping, which increases as the piezometric levels drop. Other factors to take into account are the injustice of who ends up being

[31] According to IRENA (2015), "With decreasing renewable energy technology costs, technology advances and increasing scale of deployment, renewable desalination is likely to become significantly more cost effective and to represent a key solution to mitigate growing development risks posed by resource constraints. The competitiveness of renewable desalination is further enhanced when volatile fossil fuel costs are taken into account."

disadvantaged in the process of deepening boreholes for pumping, and the increased costs of extraction or use of electricity subsidies designed by policies that do not typically divide between beneficiaries, and end up favouring the major stakeholders, including being detrimental to priority uses, such as to domestic water supply ahead of supply for agriculture or mining. The process of deepening boreholes often complicates domestic supply and human consumption, due to the decline in groundwater or quality levels, emphasising on one hand its high costs, and on the other hand, the absence or weakness of field controls that characterise the region. Examples of this situation can be found in Copiapó and Antofagasta (Chile), The Ica Valley (Peru), and Guanajuato, Sonora and Mexico City (Mexico).

In Mexico, for example, this interaction has received attention from a Nexus focus between water, energy and climate, and implementing an energy pricing policy has been proposed in order to discourage the pumping of water, in order to lessen the overexploitation of aquifers and to improve their sustainable usage (Scott and Shah, 2004). It was concluded that there is a need to strengthen policies that are founded on the Nexus, such as an increase in the agricultural electricity tariff, the removal of the low night tariff, the application of regulations that constrain the extraction of groundwater for energy uses, such as establishing tiered energy pricing subject to the drops in aquifer levels, or limiting new electrical connections used for groundwater extraction (Scott, 2011).

At the same time, these forms of proposals for overexploited aquifers should not disregard the fundamental fact that both energy and water have historically been (and still are) the means to enable small-scale irrigation or to deliver competitiveness to the agricultural sector, characterised by direct and indirect subsidies of various forms.

C. The Interactions between Water and Food

The relationship between water and food can be considered in the rural setting, which refers to agriculture, with or without irrigation, and also in the urban setting, where the main links are between providing services of drinking water and sanitation to the population, the provision of food to the cities, and waste management. In the rural setting, the connections are established through the use of water for two coinciding purposes in the means of food production: irrigation and aquaculture, with a much greater importance given to the former than the latter.

Even when irrigation is efficient, substantial losses typically occur in the transportation of water to the plot of land when the irrigation canals are not covered, which is usually the case in the region. In countries where legislation is based on a hierarchy of water uses, this is a use of water that holds a privileged position (for irrigation, but the same does not occur for aquaculture), and is normally only surpassed by domestic supply. A first conclusion from this situation is the need to subject the expansion of the “agricultural frontier” to rigorous controls, because of the ramifications it has, not only on water consumption, but also on energy consumption.

This explains why the majority of reforms in developed countries are focussed on reducing water use in agriculture, to allow this “extra” water to be dedicated to other uses that may generate a greater added value. These policies aim, through reducing the water dedicated to agriculture, to enable the relaunch of particular industrial water uses without affecting food production. The countries that strive for these policies are usually self-sufficient in food production, have a surplus, or

owing to their economic capacity, have the potential to acquire such food in the international markets or to develop policies (such as the modernisation of irrigation systems) to save water and continue at the same level of food production.

These policies often lead to conflict between the representative organised structures for farmers (federations, associations, etc.) and for other uses, and even with governments. It is partly for this reason that a proper implementation of the Nexus approach could bring with it a reduction in socio-environmental disputes between the different water users, both between owners and also for informal users, who are of great importance in the region. This is mainly because the application of the Nexus approach in policy-making should allow the identification, in advance, of impacts and problems between its various components, and therefore allow them to be corrected from their origins.

In developing countries, policies for more intensive use of irrigated areas are common, as an ambition to achieve food security or food sovereignty. One such example of this is the Law of the Decade of Irrigation 2015-2025 in Bolivia (2015). Its objective consists of attaining one million hectares under irrigation within these ten years, "with the purpose of promoting agricultural production through investments from the central state level and from autonomous territorial bodies that target irrigation development."

The development of these types of measures requires an availability of water of both sufficient quantity and quality as well as the financial means needed to undertake the investments. It also later requires, as something that is often overlooked, having suitable organisational structures (both within the organisation of the irrigators and in the administrative framework of the levels of government) for the effective management and productivity of this increase in irrigated agricultural area. Among other required conditions is the need to have administrations with the appropriate technical levels to undertake, with legal certainty, the allocation (through concessions or other systems) of the required water flow rates to serve the new irrigated areas, and to proceed with a registry of pubic waters that accurately reflects the legal status of water allocation and use, something that is very difficult to track down, and often compromises the success of public policies.

To avoid some of the risks associated with irrigation, emphasis is sometimes placed on the greater capacity to increase food production using "green water", which is water from precipitation and that is in the soil, and should be linked to rainfed crops, as opposed to "blue water", which is water artificially transported by various pipelines and channels, and that is used for irrigated crops. The argument is that in places where there is insufficient available water, food security can only be improved by increasing the productivity of the existing water resources and by limiting population growth (Falkenmark and Rockström, 2011).

Similarly, the water-food relationship can be improved with an increase in urban wastewater treatment that reaches a level of quality which allows it to be used for irrigation. This can be feasible in the vicinity of large inhabited areas, which enable the costs of facilities for the treatment and reclamation of wastewater to be covered. Also, the capture of rainfall, termed "rainwater harvesting", has a role in this relationship.

Finally, what is known as "virtual water" must be considered in the water-food interaction. This refers to the water that is transported (embedded) in the food that a country imports (or exports). This approach can be used to justify the public policies, depending on the position of the country (area, river basin or region) as an exporter or importer of virtual water for certain foods. The balances that

can be determined in relation to virtual water, together with the water situation (generally a surplus or deficit), can be used to provide advice on escalating particular policies on the production of some food type or, to the contrary, to proceed to import the food, allowing for the required consideration of the economic and social conditions in every case.

The big question raised through the concept of virtual water trade is whether it proposes water savings. Hoekstra and Chapagain (2008) estimate that the global water savings made possible by agricultural trading is 352 billion cubic metres per year. Given the global trends of increasing consumption and decreasing availability of water resources, the usefulness of these approaches is evident, especially for countries with water scarcity, so that water and agricultural policies can be guided by these approaches. It is worth adding that the region of Latin America and the Caribbean is a net exporter of virtual water, and the cases of Argentina and Brazil stand out significantly in this regard (Willaarts, Garrido and Llamas, 2014). From the Nexus perspective, stopping the production of particular foods which have large water footprints and substituting this with consumption of the same product from an imported source can enable water to be released for other uses, such as energy production or environmental conservation.

With an extraordinary relative potential of water resources, energy resources, and food production capacity, the region has a substantial food debt with its own population in the majority of the countries (Martínez and Palma, 2016). The potential implementation of a Nexus approach cannot ignore that it is none of food, water resources, energy sources or agricultural development that are lacking in the region, but rather a minimal amount of equity in the sustainable development models and the distribution of its benefits, as is theorised in some of the Nexus approaches (Biggs et al., 2015).

This paradox cautions about the need to complement and connect the concern for the Nexus and the water, food and energy security with the immediate scope of minimal levels of equity and the fulfilment of human rights linked to the Nexus elements, especially the rights to food and water. If the situation is considered in terms of security, addressing this paradox in the region is a key role in providing global food security (Bellfield, 2015). Though it seems that the system is incapable of guaranteeing minimal acceptable levels of security in all three Nexus fields.

What should also be mentioned is the urban water cycle (or Urban Nexus), which includes the transport from the intake point (normally situated outside the urban area, and sometimes even outside of the respective municipal jurisdiction), the treatment to make the water potable, the transport of the treated water to the various supply points, wastewater collection, the piping and channelling of wastewater to the respective wastewater treatment plants, purification, sludge treatment, and ideally, the reclamation of urban wastewater to allow its reuse with safe quality levels for the various uses for which it will be allocated, including in agriculture.

Drinking water and sanitation services gain a particular importance in the region, as an area of interconnection. This occurs for various reasons: i) 80% of the population is urban, and this is projected to increase exponentially; ii) the urban sprawl taking place is barely planned; iii) the existence of various megacities as critical sites for urban supplies and with growing energy costs; iv) the vulnerability, spatial segregation and lack of sustainability; and v) the low coverage and poor quality of public services, especially the services of sanitation and urban wastewater treatment (CEPAL, 2014).

This phenomenon, which characterises the region as having one of the highest percentages worldwide of the population living in urban centres, poses a cross-sectional problem, because it involves the three Nexus elements, with specific interactions within the general urban context of developing countries (Babette, 2016), and particularly in the megacities in Latin America. The interconnections are essential in the production and management of the three Nexus elements, but also in the transportation and food consumption, and in the production, treatment and disposal of waste (solids and liquids) that takes place principally in urban contexts.

This dependency and reciprocal influence of the city on the land that produces goods and services, food, water and energy has led to the reconsideration of the scale of spatial planning, which is traditionally centred on the urban aspects of this planning. The priority interconnections of the Urban Nexus should be included within the major challenges faced in the cities: scarcity and poor quality of public services, environmental pollution and degradation, transport, waste, poverty, social division and insecurity.

D. The Interactions between Water, Energy and Food

The best demonstration of the relationships between the Nexus elements[32] may be seen in the production of biomass, where plant products are considered as an energy source. This is a development that has largely increased in recent years, notably within the region (Saulino, 2011a; Hoff, 2011).

The positive aspects of a new energy source classified as "renewable" should, nevertheless, clarify whether it takes into account that this plant yield used for energy generation may result in a decrease in food production, due to the corresponding reduction in the agricultural land allocated for this purpose and also by taking away a portion of the water from its connection to irrigated agriculture.[33] Similarly, and when considering forestry residues, the ecological function of forests may be affected. Another consequence may be an increase in food prices, although the cause and effect relationship between (global) biomass production and agricultural prices is not unanimously accepted (Martín Mateo, 2008).

These risks can be prevented with adequate government intervention, which can operate at various levels. The first level is that of the approval of energy production facilities using biomass. Another is intervention that can be developed for agricultural or forestry areas that are intended to be used for these purposes. Typically, both of these forms of intervention are needed.[34]

A preventative approach was formulated in the Bonn Conference, in the sense that "the developing countries that are considering the use of bioenergy have to consider all the factors and consequences, such as the suitability of the land, water availability, competitiveness, socioeconomic costs and benefits, food security, economic growth and poverty reduction" (Hoff, 2011).

Another important element to consider is that one third of the food that is produced is wasted, which is also at the origin of the Nexus considerations (Martin-Nagle et al., 2012). At the global level, this food waste represents for 15% of the total energy demand. Even more significant is the impact of these losses on

[32] There is an FAO methodology to measure the impacts of water and energy decisions on food (see page 34) (Flammini et al., 2014).

[33] According to the European Commission (2011), "Intensive agriculture intended to produce more food and biomass might increase demand for freshwater for irrigation purposes, putting more pressure on water reserves. Water-wise solutions should be developed rapidly, so as to make irrigation more efficient, reduce water consumption and manage and preserve aquifers sustainably."

[34] In Spain, for example, electrical facilities for this energy production are subject to approval. In addition, there is an existing procedure, primarily for an environmental purpose, for forestry areas allocated to biomass production. The procedure for agricultural areas is principally based on the perspective of water, since the concessions must refer specifically to the irrigation and crop areas to which the water is allocated.

water consumption, as it is estimated to account for between 20% and 30% of the total use of this resource (Hoff, 2011). This is an important point that should be considered in policy making and when planning food production and management (food preservation through refrigeration, safer transportation, educating small farmers and their families, etc.) to avoid or reduce this negative outcome.

Lastly, with regard to the interactions between agriculture and climate change, it should be added that agricultural activity accounts for between 10% and 12% of the generation of global greenhouse gases (IRTA, 2016). In the same way, electric power generation and heat contributes 27% to the overall emissions of these gases (Martin-Nagle et al., 2012).

Environmental considerations in the Nexus are highly important: approaches that are purely sectoral (from the point of view of energy or of food production) and are solely based on productivity carry the risk of leading to the highest utilisation of water, with the consequent degradation of the resource that could ultimately impair this energy and food production, whose maximisation was indeed the cause of the degradation of the water resource.

The region is a net exporter of raw materials and food, while still having a high potential for development. Brazil and Argentina, in particular, are among the largest producers of first generation biofuels, as are other countries such as Colombia, Paraguay and Peru, albeit to a lesser degree. However, countries that are moving in other directions must also be taken into account. In Bolivia for example, the Framework Legislation of Mother Earth and Integrated Development for Living Well from 2012 prohibits "the production of agrofuels and the commercialisation of agricultural products for biofuel production, as long as it is the priority of Bolivia to ensure its sovereignty with food security".

In the cases of Brazil and Argentina, there has been a large increase in the production and consumption of these biofuels, with a connection existing between the levels of production and consumption and the oil price. The result of this activity is a large increase in water demand, which is more pronounced in Argentina than in Brazil, given that the sugar cane is not irrigated in Brazil, whereas it is in Tucumán (the region in Argentina where most production occurs). However, in both cases, an increase in water pollution has been observed due to the use of fertilisers and pesticides used for cultivating plants and, similarly, there is an increase in water pollution deriving from the same biofuel production process. (Saulino, 2011a).

Out of the interactions between food and energy, the production of biofuels is of particular relevance to the region (Mirzabaev et al., 2015). From this point of view, the Nexus approach suggests the need to review the circumstances that have led some countries to venture into the production of biofuels (Saulino, 2011a; Scott, Kurian and Wescoat, 2015).

It is also important to highlight that, as a region that is a net exporter of food and agricultural raw materials, large quantities of biomass wastes are generated, both in the field and in processing, which have enormous potential as inputs in the production of biomaterials and bioenergy. The central concept of a bioeconomy approach is that of the biorefinery (see Jungmeir, 2014), which presents an alternative for the full range of different biomass uses, creating new value chains and reducing, or even eliminating, waste disposal into the environment. In particular, the concept of a waste biorefinery has been developed (Bhaskar at al., 2016; Mohan et al., 2016). Argentina, one of the major agricultural exporters of the region, is already moving towards this approach, and it is foreseeable that other countries will follow this trend.

E. The Identification of Priority Interactions

Bearing in mind the limitations on making general definitions that stem from the immense regional diversity, the areas of the identified priority interactions (see Box 2) are listed in Table 1. Generally speaking, Table 1 displays the level of importance that agriculture and food, modernisation of irrigation and overexploitation of aquifers, biofuels, hydrocarbons, hydropower generation, mining, and the Urban Nexus, represented by drinking water and sanitation services, have in each subregion (see page 24) and for some countries in particular, from the point of view of the implementation of the Nexus approach.

Box 2: Priority Nexus Interconnections in Latin America and the Caribbean

Water-Energy: hydropower, hydrocarbons and mining

Most forms of energy production require water, but hydropower is that which is of highest importance in the region, given that it is the main energy source and the one that represents the highest future growth in the majority of countries in South America and Central America. Large-scale hydropower projects exhibit multiple interconnections, and the overreliance on this source when considering climate change and variability simultaneously threatens water, energy and food security in countries such as Colombia, Venezuela, and of some Caribbean countries.

Hydrocarbon exploitation and mining require varying amounts of water and energy, which can severely affect the environment and the quality of water resources. This interconnection is of high importance in almost the entire region, but especially so in the Andean countries, Brazil, Mexico, Venezuela and some Central American countries. This relationship can take on a particular intensity when hydraulic fracking techniques are adopted.

In terms of quantity, the use of water for energy production does not compare to what is used in agriculture (aside from arid or semiarid regions), yet it is what creates the greatest social conflict due to the displacement of populations as well as the associated consequences and the effect on the quality of water sources.

Energy-water: water abstraction, use and desalination

The greatest energy expenditure in the region related to water occurs in the steps of groundwater abstraction, its transportation and its use, especially when used for irrigation. In this interconnection, special consideration should be given to the level of subsidy for extraction, the overexploitation of aquifers, and the inefficiencies of the irrigation systems and pumping equipment. The growing importance and reliance on groundwater is common to the entire region, especially in Central America and Mexico, where up to 65% of water used is from groundwater, as well as in the desert or semi-desert areas of Argentina, Brazil, Chile, Bolivia, Mexico and Peru, for example. The increasing overexploitation of aquifers brings forward interactions between the three Nexus fields, which impact the water quantity and quality, remove lands for production and increase energy costs for water abstraction, with bigger negative impacts often being felt by the weaker users. At present, energy consumption in water purification and desalination are not significant, and these processes are limited to specific places for activities that are highly profitable (mainly in Chile, Mexico, Peru and some Caribbean countries).

Water-food: agriculture

The importance of agriculture must be understood in relation to regional particularities, where its large-scale practise and expansion (with the majority of produce

exported) has a direct relationship on deforestation, monoculture, an increased risk of diffuse pollution, sedimentation, erosion and floods, displacement of local populations, and impacts family farming and subsistence, which is of particular importance for food in the region. It is of crucial importance for the region in terms of water consumption, contribution to gross domestic product and provision of work, with almost all countries in the region affected by it.

Water-energy-food: biofuels and the modernisation of irrigation systems

A special relationship between the three Nexus elements occurs with the production of biofuels, since they typically consume water for energy production, and this can affect food production because of the removal of land and water for this purpose. Agriculture grown for energy production or biofuels does not only share the impacts of large-scale agriculture, but can also influence both the availability and price of foods. The development of biofuels is of particular significance in Argentina, Brazil and Paraguay, and to a lesser degree in Peru, Colombia and Central American countries such as Costa Rica. Similarly, the relationship between the three Nexus elements can be seen in the agricultural sector when the modernisation of irrigation systems is involved (which involves higher energy use, greater water consumption and can increase food production). It can also be seen with the establishment of policies designed to encourage electricity production, with discounted tariffs, contributing to the overexploitation of aquifers because water extraction increases.

Source: Own development

Interconnection areas	Andean Region	Amazon Region	Southern Cone	Mesoamerica	The Caribbean
Agriculture, modernisation of irrigation systems and overexploitation of aquifers	High	Medium	Medium	High	Medium
Biofuels	Medium (Peru, Colombia)	High (Brazil)	High (Argentina, Paraguay)	Medium	Medium
Hydrocarbons	High (Ecuador, Venezuela, Peru)	High (Brazil)	High (Argentina) (Low in Paraguay and Uruguay)	Low (High in Mexico)	Low
Hydropower generation	High (Colombia, Venezuela)	High (Brazil)	High (Argentina, Paraguay, Peru, Uruguay)	High (Costa Rica, Guatemala, Panama, Honduras)	Low
Mining	High (Bolivia, Chile, Peru, Colombia, Venezuela)	High (Brazil)	High (Argentina)	High (Mexico)	Low to medium
Urban Nexus (drinking water and sanitation services in cities)	High (Bolivia, Colombia, Peru)	High (Brazil)	High (Argentina)	High (Mexico)	High (Haiti, Nicaragua)

Table 1: Importance of the interconnection areas according to subregion (source: own development)

IV. CONCLUSIONS AND RECOMMENDATIONS

A. General Conclusions

The little consideration given to the Nexus in the region.

Until now, the countries in the region have not incorporated a Nexus approach in the design of their policies, in planning, in the regulation of public services or in the management of natural resources. At the same time, the characteristics of the region highlight the importance that this approach can bring to the sustainable development of these countries, for the following reasons:

- The relative abundance of natural resources, with a great potential for development in the three Nexus areas, even though their exploitation is based on development models whose conditions of sustainability and equity must be adjusted.
- This situation juxtaposes the limited capacity for the formulation and implementation of public policies in line with the Nexus approach, as well as the weakness, or even nonexistence, of intersectoral coordination systems.
- High levels of inequality, poverty and dissatisfaction in the guaranteeing and the fulfilment of human rights.

A general definition of the priorities and interactions between the Nexus components. Water must be seen as the dominant element in the Nexus consideration

The Nexus approach should not consider all of its elements to be on equal footing. For the variety and essentiality of its function, water should be the decisive element in the established relationships, in the policies formulated, and finally, in the sense of policy and planning changes that can be designated by water as an element.

The Nexus approach involves, contrary to what has occurred until now, the consideration of all elements in their multiple interactions, with the purpose of defining priorities, preventing adverse or negative effects and taking advantage of synergies, bearing in mind the underlying theme of environmental care and protection. Out of the activities that involve two or more Nexus elements, the following should be considered concerning the importance to the region:

- Agriculture in relation to food, and within this: i) the modernisation of irrigation systems as a strategy to increase food production, which can also reduce the quantity of water in the production process, but which requires large amounts of energy for the transportation of water and for localised irrigation with sprinkler systems; ii) utilising irrigation channels to generate energy that is used locally or as part of the agricultural efforts; and iii) the overexploitation of aquifers, which entails extensive energy requirements in abstracting water and possible harm to the groundwater quality.
- Hydropower generation, which requires a sufficient quantity of available water and can affect agricultural production because it manipulates water flows to meet energy demand, which is often out of phase with the seasonal requirements for other uses.

- Hydrocarbon operations and mining provides tax revenues to the state and is a source of jobs for the community. However, these operations require large volumes of water and, at the same time, can affect the quality of the water resource, leading to multiple problems in urban water supplies, agriculture and other uses.
- Biofuel production diversifies the energy matrix and can be a source of substantial revenue for the state (through taxation) and for farmers. However, it affects water consumption, intensifies competition for land and can affect food production, reducing the amount produced or increasing food prices, as well as affecting the ecological functions of the forests if adequate precautionary measures are not adopted.
- Under the concept of biorefineries, the use of agricultural, agro-industrial and food wastes can enable the full range of different biomass uses, creating new value chains and reducing or eliminating waste disposal into the environment.
- Consideration of all interconnections within the urban contexts that characterise the region, in particular those related to the expansion, improvement of the quality and efficiency of the services of drinking water supply and, importantly, the services for sanitation and treatment of wastewater.

The search for a suitable territorial space for the formulation of regional, subregional and national priorities.

The identified priority interconnections must be formulated in a generic and imprecise manner, given that the territorial scope is as broad as the entire region of Latin America and the Caribbean, and it would be difficult to attain the required level of precision to be operative. This leads to the conclusion that particular focus should be given to the subregions and river basins, including those that are transnational, as an optimal spatial domain for their particular definition. Thus, in the defined context of a subregion or river basin, one can begin to identify priority or critical interactions and interdependencies with more clarity, such as the diversification of the energy matrix, the portfolio of available water sources and the production of biofuels (cf. CAF, 2013). Operationalising the priority interconnections, or improving their coordination, would require attention to be paid at the following levels: national, subnational, local or municipal, the river basin, the interconnected or integrated system, and in some cases, up to the regional, transboundary or even international level.

The fulfilment of economic, social and cultural rights as a priority at the regional and national level.

The existence of a territory that is rich in natural resources, an exporter of virtual water, food and energy, as is the region of Latin America and the Caribbean, and that maintains a cohesive system of human rights that grants the highest international, and in some cases, constitutional hierarchy to the rights to food and in particular water, means that the implementation priorities of the Nexus should be easily identifiable. As the primary objective of intersectoral policy, the Nexus approach should be dedicated to the complete satisfaction of the economic, social and cultural rights associated with the Nexus elements. This is because there cannot be a development, an increase in synergies or efficiency, or sustainability, that does not have the immediate fulfilment of the minimum life necessities as a

primary and immediate objective, which entails the progressive implementation of the content of these rights. This connects directly to the idea of water, food and energy security.

The definition of priorities. The role of the law and of water planning.

The majority of laws in the region place human consumption and domestic supply in first position in the order of priorities, with agricultural use in second place, while energy and industry occupy the third, fourth or fifth places. But the relative position of water for irrigation and for energy uses may change according to the needs and particular conditions of each country and the conditions specific to each river basin. In particular, the production of biofuels warrants a serious consideration in all countries of whether, from the perspective of water uses, it is considered as an agricultural or energy use, since the position of both these uses in the hierarchical order is very distinct, and until now (and aside from some exceptions), agricultural uses have the ascendancy.

River basin water planning would be the preferred instrument for specifying the relationship between these uses, and there should also be a clear decision regarding the environmental or ecological uses (set as uses, or preferably as restrictions on the use of available resources), especially for hydropower generation. Aside from some exceptions, water planning in the region is, in the majority of cases, a theoretical approach, mostly devoid of practical implementation and, above all, when this implementation exists, there is a lack of respect for its decisions. Planning should be adaptive depending on the various circumstances that may occur, and should never be inflexible or rigid. A common problem is the lack of criteria, standards and thresholds (economic, environmental and social guidelines and indicators) to approve or reject plans.

The strengthening of governance and the required emphasis on planning.

The countries of the region exhibit serious deficiencies in their governance systems, including the legal configuration for the planning of the various Nexus components. This is clearly linked to the ideological system that recently weakened the functionality of planning and, generally speaking, the transformative potential of state or public action (CEPAL, 1995).

Among the specific Nexus considerations, planning is the cornerstone which has the aim of enabling the interconnections between its components, with the resulting enhancement of its potential and the possibility to minimise its conflicts. Coordinated planning of the three components can represent a new impetus to strengthen, integrate and give greater consistency to the sectoral processes of territorial, water (see Box 3), energy and environmental planning, with regard to the different geographic levels (regional, integrated electric system, national, local and river basin) of each one of them.

The informed participation by citizens and relevant public and private stakeholders must be one of the characteristic features of the planning, both in its formulation and in its execution, monitoring, evaluation and review. For this to happen, instruments (consultations, public information, websites, etc.) and participatory bodies should be created that take into consideration the unique, ethnic and gendered characteristics of those participating. In any case, the norms should make it clear that participation is not deciding, but rather taking part the process of decision-making, which can influence these decisions if the participation actions are undertaken at an appropriate time, which means not at a time when the planning process is essentially finalised, with the major decisions already made.

On this basis, it is important to keep in mind that without suitable and neutral institutions, planning does not occur, or is only the will of some. Planning activities that are centred on water should begin, as a first priority, by strengthening the institutional capacities (legal powers, financing and task force) of the water management agencies. In addition, the neutrality of the evaluator and planner should be ensured. Otherwise, the planning process will be geared towards what has greater political reward and financial yield. Therefore, it is paramount to separate the construction, development and sectoral roles from those that manage the resource and approve plans and projects.

Box 3: Key Elements for Planning Processes

Planning involves finding a balance between the economic entities' security rights over water, which is important for the promotion of investments and controls on private activities throughout (and after) the process. Also, if planning lacks flexibility, proceeding with rigid plans, especially in a global economy and under changing conditions, can lead to costly errors. Planning entails the answering of various questions: which resources are subject to state control, how are quality and quantity managed, what extent of power do public authorities have over water, what is the role of water planning, how does water planning integrate with regional planning and planning in other sectors, and what process should be used to facilitate a continuous and dynamic review of plans?

Planning demands the integration of quality and quantity in the management of the resource, just as it demands the same for surface water and groundwater, and between the water supply and demand. It also involves the supervision of the different forms of use, including the cancellation of permits when there are inefficient uses. It also includes an identification and matching of uses and abstractions, as a means of preserving sources, minimum flows and ecological requirements.

Water rights should be adjustable, in accordance with the planning objectives. While the state cannot perform the function of eradicating these rights, it can adjust them within certain limits, thus conforming them to environmental constraints or to the better use of the resource. In some systems, water use permits are not permanent, but rather of a periodic duration, something that allows their adjustment, after a reasonable time for depreciation of investments.

Planning entails a preparation of emergency plans in the face of extreme natural events and man-made disasters. This includes a classification of users and an establishment of priorities based on public interest. Some systems forecast their project analyses and evaluation of uses based on environmental, economic and social impacts, as well as audits, system rehabilitation, conservation, moratorium on the granting of new permits, and eventually, the elimination of certain uses.

Other important elements are the creation of special management areas and protected natural areas, the setting and safeguarding of ecological or minimum flows, and the coordinated management of competing demands. Some systems require plans to be formulated before the approval of any substantial modification to water bodies and their peripheries.

Administrative fragmentation works against planning. This fragmentation can arise between distinct water uses, between the different manifestations of water in the hydrological cycle, and between planning entities and everyday management. Without integration of the administrative powers, planning often ends up serving little useful purpose. Therefore, many systems ensure that their plans are

approved as law, and the need to link the plans to the system of granting permits is emphasised.

There are key elements for planning processes. While they will not ensure its success, it does not make sense to plan without them. They are: i) definition of the economic, environmental and social objectives; ii) determination of indicators for evaluating the connection of the objectives with each plan, and also of the performance thresholds, which must be met for plan approval; iii) know how much water there is, who uses it, and where and how it is used, which requires management institutions, water rights, registries, and systems for the adjudication and resolution of conflicts; and iv) knowledge of water economies and their services, in order to take maximum advantage of economies of scale and scope, as well as to attain equity through efficiency.

Source: Solanes (2008)

Diversification of the pattern of development in the framework of Nexus planning.

The region is characterised by intense patterns of development in the exploitation of their natural resources, which are resources that are often non-renewable, as occurs for example with oil or other mineral products, whose exploitation can require an intensive water use. This follows a model of one-dimensional development that is not diversified, and is therefore often unsustainable when considered from the point of view of the environment and also of social inequality. This also brings with it a vulnerability, a risk exposure that translates into insecurity, political instability and dependency. This arrangement must be changed, leading to a progressive diversification of these patterns of development (CEPAL, 2016) in the framework of planning of the three Nexus components that is multi-scalar, intersectoral and temporal. This change should lead to arrangements for water use, power generation and food production that are more sustainable, resilient, equitable and efficient. At the same time, the Nexus approach can represent an opportunity to confront climate change in an effective manner, while altering unsustainable development patterns.

The diversification of the project portfolio and investments in water, energy and agriculture.

Diversifying the project portfolio and public and private investments related to the three Nexus elements should lead to public policy making in the following ways:

- Ensuring the protection and inviolability of water sources, especially those dedicated to human consumption and urban supply, with the early identification of alternative sources for critical situations.
- Planning, designing and building infrastructure under the Nexus approach and within the ranges of uncertainty imposed by the trends owing to climate change for the river basin considered. The infrastructure should be resilient and adaptable, so that it contributes to the strengthening of water, energy and food security, simultaneously.
- Incentivising proper treatment of wastewater so that it can later be dedicated to other uses, preferably that of agriculture.
- Diversifying energy generation sources to avoid exclusive reliance on only one form and promoting energy complementation, in the face of uncertainties and weather and climate variations.

- Supporting the establishment of facilities that generate renewable energies, exclusively in local and rural areas, and as support for irrigation systems and drinking water services (including the desalination of brackish marine waters).
- Promoting an improvement in energy and water efficiency from various perspectives (eg. irrigation, wastewater treatment plants, drinking water supply systems and building construction standards).
- Promoting agricultural production methods that reduce monoculture and deforestation, and provide for family farming.

In doing this, a substantial contribution will be made to the security, not only that of sufficient provision, but also of sustainable provision, reducing vulnerability and improving social stability and environmental sustainability, which is the conceptual basis of the Nexus.

The achievement of public policies with broad political consensus in the medium and long term.

The Nexus approach should promote and involve the planning and setting of priorities as a matter of state policy and the planning of its three components in the medium and long term with a broad consensus of all political forces, guaranteeing both its immediate feasibility and its longevity. State policies and a planning process that create avenues for the participation of citizens and relevant actors in the public and private sectors will have greater possibilities to successfully implement the Nexus approach than only having the promotion of legislative reforms by the government, the construction of isolated infrastructure or the planning at the sectoral level, which are all essential, but not enough. Legislative reforms, investments and planning must be the logical and consistent result of such stable and long-term policies.

The need to possess adequate information concerning the functioning of the water, energy and agriculture sectors.

Part of the state policies that should be set up must consist of providing the necessary means for collecting and generating accurate, consistent and updated information about the situation and the actual operations of the water, energy and agriculture sectors and food production, as well as about the difficulties that each of them have in their involvements with the others. This is because it is impossible to develop detailed and useful water, energy and agricultural plans used for decision making, both by public institutions and by the private sector, if core issues for the adoption of sectoral policies are unknown or not known in sufficient detail, and this is more pronounced when adopting a Nexus approach.

The promotion of quality research in the Nexus sectors that is adapted to the regional requirements, and is reflected in high-level teaching.

So that the appropriate information is made available, the promotion of research policy in subject matter related to the Nexus is also required, which must develop in the universities, in cooperation with the relevant stakeholders of the sectors. These universities should incorporate the research outcomes and data that stems from having the best possible information in the Nexus sectors into educational programmes of the degrees most directly related to the Nexus. Education policy and also policy related to cultural promotion or teacher outreach will be

an indispensable feedback element in the gradual development of the Nexus approach in the water, energy and agricultural sectors, and will also be very useful in the professional training needed so that public administrations can properly develop their competencies.

B. Institutional and Organisational Proposals

The implementation of information acquirement systems and production of information that is fundamental for the Nexus approach.

It is necessary to produce quality information on the use, availability, behaviour and evolution of the Nexus elements. These data should be consistent and comparable across the different planning scales, and be placed at the disposal of relevant actors and the general public.

Capacity-building programmes.

Trade-offs to be addressed and synergies to be promoted under the Nexus approach are somewhat catered to the local and territorial area (Meza et al., 2015). Therefore, it is important to promote research on the Nexus subject in these areas. Better knowledge of the local dynamics of the Nexus not only contributes to the identification of areas of action and priority information requirements, but also helps in identifying the capacities that must be created or strengthened for the effective application of the approach.

A modern water legislation with content that reflects the Nexus priorities.

State policy, once formulated, must be reflected in legislation. The majority of countries in the region have a water law in place, although this is not always a modern law that considers the Nexus requirements. In any case, it is considered appropriate to have a water law that reflects and coordinates the requirements derived from an effective Nexus policy: river basin planning, adaptation measures to climate change, environmental issues as an underlying element, water conservation, and the priority position of human consumption and domestic supply ahead of other uses. Similarly, it is necessary to have an appropriate and guaranteed procedure for the granting of water rights, a water register that reflects and guides the existing legal reality (typically concessional), and mechanisms for conflict resolution that ensure transparency and impartiality.

Energy legislation that promotes the implementation and use of renewable energies and energy efficiency, without resulting in the overexploitation of water resources.

The key role of hydropower generation in the majority of the region stems from the abundance of water resources. It is the responsibility of public authorities to take action to reduce the disadvantages presented by hydropower generation. This basic premise must not neglect the need to promote other renewable energies (thermo solar, wind and tidal) to diversify the energy matrix. These energy sources can even be useful at the local level for small communities. Promotion and development renewable energy use can be achieved through an appropriate pricing policy, but its application in the realm of overexploited aquifers must be avoided or adjusted. The use of biomass for energy production must be subject to administrative control for the protection of water and to not adversely affect food production.

Agricultural legislation that supports the establishment and modernisation of irrigation systems.

Agricultural legislation should push the establishment of irrigation systems and, in the case of already existing systems, their modernisation. This is aimed at increasing food production, striving for its diversity and improving the living conditions of rural communities. The legislation covering modernisation should control the potential expansion of the agricultural frontier with the water volumes saved through the modernisation projects, and the policy should be subject to administrative authorisation procedures. It is advisable that the projects of transformation and modernisation primarily use energy from renewable sources for localised and sprinkler irrigation.

Planning must be the common element of the three legislations.

The realisation of a Nexus policy requires administrative planning. Only in planning can the interconnections be portrayed and combined with future projections, which is the essential prerequisite for the realisation of a Nexus approach. The administrative powers must drive the planning preparation procedures, in which all administrative sectors related to the Nexus must participate, even when dealing with planning that is for only one sector. The competent public authority must facilitate public participation in the formulation of planning.

Planning in each sector must be developed with the consideration of information coming from the other two sectors.

Planning in each sector must be developed with the consideration of information coming from the other sectors, and should be approved by an entity in which representatives of the regulators, governing bodies or other authorities from each sector are present. The entities responsible for sectoral planning must give consideration to the points of view of the other sectors. The most appropriate approach would be if the major planning instrument in each sector was approved by the government (which enables judicial control of planning decisions) or, where appropriate, by the parliament.

Water planning and transboundary river basins. Actions of the bodies referred to in the treaties.

When dealing with transboundary river basins, it is necessary that the relevant treaties provide for the execution of planning that, although initially referring only to water, does not ignore the interconnections established with the other Nexus elements. For that purpose, what was set out in the Directive of the European Parliament and of the Council in 2000 can be taken as a reference, which is “establishing a framework for Community action in the field of water policy”, with regard to planning for river basins within the EU or for transboundary river basins that share a border with other countries.[35] Similarly, it is recommended that within the legislation that regulates the actions of entities established by the treaties concerning transboundary or cross-jurisdictional rivers, criteria are incorporated that consider the impacts on the separate Nexus components in the decisions that are adopted.

[35] The Agreement on Cooperation for the Protection and Sustainable Use of the Waters of the Spanish-Portuguese Hydrographic Basins (1998), better known as the Albufeira Agreement, can be an excellent example of how to consider the planning and management of transboundary river basins.

Coordination between the different regulators and governing bodies.

The existence of three economic sectors normally involves the action of various regulators or governing ministries that develop the corresponding control functions and administrative interventions. When this occurs, formal coordination mechanisms are highly desirable, aside from the informal mechanisms that these entities can implement themselves (regular meetings, workshops, memoranda of understanding, etc.). One way to achieve this is through ministries that coordinate the work of other ministries or secretariats (provided that they have jurisdiction over all the Nexus sectors). However, it must be remembered that in many instances, this approach has not worked well in practice, both due to the lack of clarity concerning the jurisdiction of these entities and because the sectoral entities continued to possess more powers and resources. Another recommendable method can be, for example, delegated committees (or other denominations) that are composed of the relevant ministers and chaired by the President (or Vice President) of the Government, or round tables, in which there is participation of all public sectors and private stakeholders. At the same time, for the great administrative complication that this would represent and the rare existence of such concrete implementation at the global level, it is not recommended to include all the entities tasked with the three sectors in the same ministry or regulator.

Human rights must be included in the legislation applicable to the three Nexus components.

The relevant human rights (right to water and sanitation, right to energy, right to food) should be included in the corresponding legislation. This inclusion can be facilitated by the incorporation of these rights in the respective constitution. Regardless of this, it is not the declarations in the legal standards that are vital, but rather putting effective mechanisms in place, with proper control of the public or private bodies that may violate these rights.

Investment protection treaties must take into account their consequences on the human rights protected at the domestic level.

Most countries in the region have signed investment protection treaties that affect foreign investment made in the different Nexus sectors. There have been noticeable harmful consequences on human rights and on the state's ability to implement public policy, which have followed the application of some of its clauses. It is therefore necessary that in new additions to the treaties or in the amendments of existing treaties, the human rights approach and the consequences that specific policy decisions could have on them are considered, with thought given to the most appropriate methods for conflict resolution between public authorities and foreign investors.

The Nexus in the policies developed by the local or subnational public entities.

Decisions important to the Nexus are not only adopted by the central institutions (government and parliament), but also by the local and subnational public entities. Therefore, it is recommended to ensure that, through policy reforms, all public entities (also the municipalities or governments at the regional or subnational level, not only the central administration) consider the impacts on the Nexus components, of the decisions that they adopt in their respective competences and, similarly, that the central or federal government institutions evaluate the consequences for the local and subnational entities of their decisions on matters related to these components.

The Nexus and the integration and regional cooperation approaches

The existence of various mechanisms for integration and regional cooperation mechanisms in Latin America and the Caribbean (such as the Southern Common Market, the Amazon Cooperation Treaty Organisation and the Andean Community of Nations) leads to the recommendation that the Nexus approach is to be considered in their activities and within their competences. This same is proposed for the entities established by international treaties concerning the use of transboundary waters (the Treaty of the River Plate Basin, the Guarani Aquifer Agreement, etc.).

C. Sectoral Proposals

In the field of water:

- Introduce (or improve) effective control systems for the extraction of surface water and groundwater to avoid conflicts arising from the over-allocation of water rights, impacts of ecological flows and over-exploitation of aquifers. Among these, there is a need to have administrative approval and progressive implementation of water meters (flowmeters) for measuring the extracted quantities. This must be complemented by a system of administrative sanctions (or criminal penalties for the more serious infringements).
- Incentivise the desalination of brackish water, which is cheaper and technologically easier than the desalination of marine waters.
- Recover energy, nutrients and methane in wastewater treatment processes.
- Where one does not exist, incorporate policy on ecological flows that is related primarily to energy uses, but also to other water uses.
- Consider the impacts of the sectoral taxation policies on the Nexus components (policies that seemingly only affect one of the Nexus components, eg. taxes on energy or irrigation development programmes).

In the field of energy:

- Increase the production and consumption of renewable energies (solar, wind and wave), especially in rural communities, as well as fostering energy complementation between sources to cope with climate and weather uncertainties.
- Link renewable energies with the installation of desalination projects and locally produced renewable energies with the pumping of groundwater.
- Utilise the infrastructure of irrigation systems for hydropower generation.
- Develop the capacities for energy production from biomass, using wastes from the agricultural, forestry, fishing and agro-industrial sectors.

In the field of agriculture and food:

- Reduce produced food waste through improvements in food transport and storage, as well as by using low-intensity thermal energy in the drying of food.

- Reduce, eliminate or apply conditions to subsidies for water used in irrigation (including for pumping), especially for extractions in overexploited aquifers, with consideration given to the type, form and beneficiaries of the exploitation.
- Promote innovation in the development of models for the collection and the management of biomass using agricultural and food waste, to be used in the sustainable production of bioenergy and bioproducts.

In other sectors:

- Criteria on the awarding of public contracts that are related to the potential impact on the Nexus components should be incorporated into the regulatory legal system of public contracts.[36]
- Incorporate the criteria for considering the effects on the Nexus components and their interactions with the different projects, policies and plans into the evaluation of public projects and the environmental impact assessment, including the strategic environmental assessment.
- Consider the relationship between the Nexus components in research policies and scientific or technical innovation and incorporate the Nexus and its associated issues into education policies.
- Consider the use of payments for (the protection of) environmental or ecosystem services to facilitate the achievement of water, energy and food security.
- Through tools and instruments that have a Nexus approach, strengthen the processes of management and mediation of socioenvironmental conflicts associated with investment projects.

D. Public Policy Instruments Highly Important to the Region

Among the public policy instruments mentioned in the general conclusions and institutional, organisational and sectoral proposals, there are three that stand out in the implementation of the Nexus approach in Latin America and the Caribbean: i) planning; ii) economic instruments; and iii) policies aimed at the effectiveness of human rights (see Box 4).

[36] For example, the efficient and rational use of water and energy as a criterion in the awarding of public contracts, as is the case in the Public Sector Contracts Law in Spain, which is implemented in EU legislation. The precept lists the evaluation criteria for the offers. To start with, criteria that are "directly linked to the subject of the contract" must be evaluated, and among these, "environmental characteristics or details linked to the fulfilment of social requirements" emerge. For contracts whose implementation could have a significant environmental impact, it is stated that in their adjudication, environmental conditions will be assessed that are "measurable, such as the lowest environmental impact, the saving and efficient use of water, energy and materials, the environmental costs of the life cycle, the procedures and methods of ecological production, waste generation and management or the use of recycled or reused materials or of eco-friendly materials."

Box 4: Public Policy Instruments Highly Important to the Region

Planning and information

Planning is the main instrument for the implementation of the Nexus approach. The interactions can only be properly captured with planning, which also includes a future projection that is the precondition for carrying out the Nexus approach. The administrative powers must drive the planning preparation procedures, in which all administrative sectors related to the Nexus must participate, even when dealing with sectoral planning, and with due public participation. Planning in each sector must be developed with the consideration of information coming from the other two sectors, and should be approved by an entity in which representatives of the regulators, governing bodies or other authorities from each sector are present. This cross-sectoral, multiscale and temporal planning must be referenced to the geographical area that is optimal for its formulation, without losing sight of the coordination with the other areas. The planning presupposes that there will be enough information available to formulate the plans. The implementation of a Nexus approach requires new, reliable, accurate, up-to-date and disaggregated information at a much greater level than what is available in the region (including in the subregions).

Economic instruments and taxation

To a large extent, the effectiveness of this planning will depend on the ability to channel both public and private investment towards the Nexus. For this reason, the economic instruments are of utmost importance. These cover the spectrum of fiscal and tax policy, subsidies and direct investment. The review of the energy tariff policy and of energy subsidies is an indispensable tool for this type of intervention. Schemes for the promotion and advancement of investments in renewable energies are a good example of how to apply these instruments to properly manage investments in the direction outlined in the planning. Another example relates to the electricity subsidy for pumping groundwater from overexploited aquifers, and making desalination licences conditional to the exclusive use of new renewable sources (see page 38). They also include taxation on water, rewarding efficiency and providing economic benefits for the reallocation to uses that deliver a greater utility when considered from a Nexus approach and not exclusively from a sectoral focus. Added to this is agricultural policy, including land management, tax exemptions and import and export tariffs, with a strong impact not only on the level of efficiency of water, land and energy use, but also on the domestic food prices.

Intersectoral public policies aimed at the effectiveness of human rights

The third pertinent instrument relates to the formulation of public policies aimed at the fulfilment of economic, social and cultural rights, as a primary objective of the intersectoral policies in the implementation of the Nexus approach. This includes the construction of infrastructure that, for this purpose, should be conceived using a Nexus approach from the outset, as well as referring to tariff or subsidy policies, and to the social programmes and plans that have food and nutrition as their objective. This is because a development, an increase in synergy or efficiency, or sustainability cannot occur when they do not have the immediate fulfilment of the minimal vital needs as a primary and immediate objective, something that involves the progressive implementation of the content of these rights of constitutional and supra-constitutional hierarchy, but is to a large extent unfulfilled. This connects directly with the idea of water, food and energy security.

Source: Own development

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