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Artículo

What do we Think About Water? Public Perception of the Current Situation of Water Resources in Costa Rica: an Indicator of Water Understanding and Management.

O que pensamos da água? Percepção da população sobre a situação atual dos recursos hídricos na Costa Rica: um indicador sobre conhecimento e gestão da água.

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Abstract: The objective of this research was to determine the level of knowledge and perception of the Costa Rican population about water for human consumption, general concepts, the impact of human activities, the occurrence of extreme events and water management and governance. In 2016, a quantitative-descriptive study of population perception was carried out through a semi-structured survey in which 800 people were consulted, through calls to landlines. It was found that the Costa Ricans: a) perceived that water is a public good and that there is greater availability of water than there is in reality, b) 22 % indicated having supply problems, infrastructure and/or water quality, c) are aware of the contamination of water bodies and willing to pay more for the treatment of wastewater, d) perceived a negative impact due to floods and landslides and, e) 55 % agreed that water for consumption comes from wells and springs, but only 12 % and

36 % had a general notion of what an aquifer and groundwater is, respectively. It is concluded that education programs should include general concepts on groundwater, water management and governance and that the willingness to pay more for wastewater treatment should be taken into consideration by the institutions for the improvement of environmental sanitation.

Keywords: Water, Water Resources, Public Perception, Public Policy, Costa Rica.

Resumen: El objetivo de la presente investigación fue determinar el nivel del conocimiento y la percepción de la población costarricense acerca del agua, para consumo humano, conceptos generales, el impacto de las actividades humanas, la ocurrencia de los eventos extremos, gestión y gobernanza del agua. En el 2016, se realizó un estudio cuantitativo-descriptivo de percepción de población por medio de una encuesta semiestructurada dirigida a 800 personas, a través de llamadas a teléfonos fijos. Se encontró que los costarricenses: a) percibieron que el agua es un bien público y que existe mayor disponibilidad de la que en realidad hay, b) 22 % indicó tener problemas de abastecimiento, infraestructura y/o calidad del agua, c) son conscientes de la contaminación de los cuerpos de agua y, d) percibieron afectación por inundaciones y deslizamientos y, e) 55 % coincidió en que el agua para consumo proviene de pozos y nacientes, pero solo el 12 % y el 36 % tuvo una noción general de lo que es un acuífero y el agua subterránea, respectivamente. Se concluye que los programas de educación deben incluir conceptos generales sobre agua subterránea, gestión y gobernanza del agua y que la anuencia a pagar más por el tratamiento de las aguas residuales debe tomarse en consideración por las instituciones para la mejora del saneamiento ambiental.

Palabras clave: agua, recurso hídrico, percepción social, políticas públicas, Costa Rica.

Resumo: O objetivo desta pesquisa foi determinar o nível de conhecimento e percepção da população da Costa Rica sobre a água, como: o consumo humano, os conceitos gerais, o impacto das atividades humanas, a ocorrência de eventos extremos, a gestão e o manejo. Em 2016, foi realizado um estudo quantitativo-descritivo da percepção da população por meio de uma pesquisa semiestruturada voltada para 800 pessoas, mediante chamadas para telefones fixos. Verificou-se que os costarriquenhos: a) perceberam que a água é um bem público e que há uma maior disponibilidade do que realmente existe; b) 22% indicaram ter problemas com abastecimento, infraestrutura e / ou qualidade da água; c) estão cientes da contaminação dos corpos de água e, d) perceberam o prejuízo devido a inundações e deslizamentos de terra e, e) 55% concordaram que a água para consumo provém de poços e nascentes, mas apenas 12% e 36% tinham uma noção geral do que são um aquífero e águas subterrâneas, respectivamente. Conclui-se que os programas de educação devem incluir conceitos gerais sobre águas subterrâneas, gestão e manejo da água, e que a disposição de pagar mais pelo tratamento de águas residuais deve ser levada em consideração pelas instituições para a melhoria do saneamento ambiental.

Palavras-chaves: água, recurso hídrico, percepção social, políticas públicas, Costa Rica.

Introduction

Perceptions are formed by erecting social constructions of a given reality. These perceptions correspond to a system of values, ideas, and practices that guide the establishment of a material and social order and allow coding and classifying the world and individual and group action (Moscovici, 1979). They become an effective way to generate dialogue between popular knowledge and scientific research (Santos, 2005), whose purpose is the understanding of the values and practices that society incorporates into the principles of ecological rationality (Leff, 2002).

That said, it is understood that society's perception of the water resource will have a significant influence on the management and decisions made regarding its protection since it allows visualising expectations, satisfactions or aspects to be improved by of actors involved

(Benez et al., 2010). For this reason, it is of great relevance, at the country level, to understand social perceptions about water, its use and its management. In addition, the approach to the integral management of the water resource must be developed in an interdisciplinary manner since, in this way, general concepts are integrated from the knowledge and experiences of different scientific and cultural fields, to understand and solve problems related to the water (Martínez Valdés & Villalejo García, 2018).

The fragility of the hydrological cycle places the human being in need to assess each element, stage, and action around the water. Global policies show growing concern and attention in this regard. An example of this is the establishment of the **United Nations Water** (UN-Water), which is an interagency platform, formally established in 2003 by the United Nations (UN). The first UN report on the Development of Water Resources in the world: Water for all, Water for life (United Nations, 2003), integrated water issues in the political agendas of the UN countries. This report indicates that we are facing not only a global water crisis but also a water resource management crisis due to the inability to use appropriate methods for its use. This situation lasts until today; for this reason, studies like this generate relevant information for decision making.

To achieve sustainable national development, knowledge related to water, as well as its protection and use, should be treated as a priority and as a principal component to the various aspects contemplated by development. This issue has already been raised by the United Nations Organization in one of its Sustainable Development Goals (SDG6) (Comisión Económica para América Latina y el Caribe, 2018). In Costa Rica, the 2013-2030 Water Agenda (Ministerio del Ambiente, Energía y Telecomunicaciones, Dirección de Agua, SENARA and AyA, 2013) and the Costa Rican National Drinking Water Policy 2017-2030 (Instituto Costarricense de Acueductos y Alcantarillados, 2016) also stated water protection and use as a priority.

Taking into account the importance of the water resource in the national agenda and the necessity of having information to introduce improvements in the educational programs in the country, researchers from various disciplines of the Universidad Nacional (UNA), Costa Rica, gathered within the framework of the Interdisciplinary Research and Water Management Program (PRIGA), in coordination with the Institute of Social Studies in Population (IDESPO), to carry out a survey called "Public Perception of the Current Situation of the Water Resources in Costa Rica".

The objective of this research was to determine the level of knowledge and perception of the Costa Rican population about water for human consumption, the impact of human activities, the integrated management of the water resources, the occurrence of extreme events, its origins and the cognitive appropriation of basic concepts. This information will allow the implementation of measures aimed at improving education and awareness programs in society, which is fundamental as a basis for

empowerment and social participation in water resources management and protection processes in our country. It is to be expected that the greater the knowledge of citizens related to water resources, their importance in human supply and their protection, the greater their interest may be in participating, directly or indirectly, in water resource management processes, improvement of services and sanitation.

Reference frame

Currently, surface and groundwater resources, fundamental to Costa Rica's socioeconomic development, are being threatened in quantity and quality (Estado del Ambiente, 2017). Despite being a country with abundant water resources, with some 113 billion m3 al año (Estado del Ambiente, 2017), it also has a heterogeneous, spatio-temporal distribution of rainfall, so the availability of water varies widely (Política Nacional de Agua Potable de Costa Rica, 2016). This is how some regions of the country experience up to five months of the dry season, e.g. the Northern Chorotega Region, where there is a considerable decrease in the availability of water for human consumption, agricultural activities and other productive activities (Instituto Costarricense de Acueductos y Alcantarillados, 2016).

The contribution of wastewater from homes and industries with inadequate systems for the disposal or treatment of sewage, as well as the transport of agrochemicals from agricultural areas, among others, have altered the quality of surface water in most basins in Costa Rica, decreasing the amount of water available for consumption. Since 2007, a continuous monitoring program, implemented by the Environmental Analysis Laboratory of the UNA, evaluates the concentrations of heavy metals in surface water at 64 sites in the Virilla River sub-basin; 34 of these sites have shown moderate to high levels of pollution, especially in urban areas (Programa Estado de la Nación en Desarrollo Sostenible, 2016).

In Costa Rica, the importance of groundwater resources is undeniable. Based on information from SINIGIRH (2018), of the total water extracted by the Instituto Costarricense de Acueductos y Alcantarillados (AyA) for human supply, about 60% was groundwater, that is, from wells and springs, while for the Empresa de Servicios Públicos de Heredia, it was about 90%. The aquifers Barva, Colima Superior and Colima Inferior, the most important reservoirs in the Greater Metropolitan Area, provide drinking water to 65 % of the inhabitants of this region (Organización Panamericana de la Salud, 2003). Aquifers can be described as geological units capable of storing, transmitting and providing enough groundwater to supply a specific demand, either through wells or springs (Poehls and Smith, 2009).

Despite the great importance of this resource, there is a risk of leaching pollutants from septic tanks, agricultural lands and industrial zones, including nitrates and other agrochemicals, in several areas of the country (Estado del Ambiente, 2017; Fonseca-Sánchez et al., 2019; Madrigal-Solís et al., 2014); such is the case of the Barva aquifer, where an increase in

nitrates has been found in sectors with larger agriculture and urban areas (Madrigal-Solís et al., 2017; Madrigal-Solís et al., 2019; Reynolds et al., 2006). Among the potential sources of pollution, the widespread use of septic tanks as a sanitation system is one of the most concerning. By 2016, 76.4% of the population used septic tanks and only 21.4% had sanitary sewerage coverage (AyA, MINAE, and Ministerio de Salud, 2016), which poses a threat to groundwater quality throughout the country.

The leading institution for the protection and management of water resources in the country is the Ministry of Environment and Energy (MINAE), with AyA in charge of ensuring drinking water and sewerage coverage at the national level. Fortunately, the country has 92.5% of all the housing supplied through an aqueduct (Instituto Nacional de Estadística y Censos, 2012); most of the population has good quality water. However, monitoring of water quality in the Huetar Atlantic and Central Pacific regions conducted in water for human consumption determined the presence of at least one parameter not following the Costa Rican Drinking Water Quality Regulation in 97% of the systems analysed. Therefore, the challenges in terms of population supply include improving the efficiency of the institutions in charge of water management, increasing the coverage and supply of drinking water, especially in rural areas and, enhancing the infrastructure to ensure the sustainability of the service in quantity during extreme events (Instituto Costarricense de Acueductos y Alcantarillados, 2016).

Extreme events are infrequent episodes, events or events in a particular territory according to their statistical distribution. The most common events include the circulation of large hurricanes, the development of gigantic floods, prolonged droughts and the worsening of water stress, the sudden appearance of tornadoes, large hail storms, heat or cold waves, intense frosts, eruptions, earthquakes and tsunamis (Renom, 2009). Events that, for the most part, are intimately related to climatic or meteorological variability.

Knowing beforehand that climatologically Costa Rica shows two well-defined seasons, the rainy and dry season, the location in the intertropical convergence zone has resulted in hydrological irregularities due to the effect of the El Niño Southern Oscillation (ENSO), Niño and Niña phases. This phenomenon, associated with old and new anthropogenic and natural conditions or, due to global warming, has caused much more extreme events, where the availability of water resources has become the main trigger for social uncertainty, high economic costs due to damage to infrastructure and in the productive sector, and even the appearance or recurrence of pests resulting from ecosystem deregulation (Imbach et al., 2017; Ministerio de Ambiente, Energía y Telecomunicaciones and Instituto Meteorológico Nacional, n.d.).

With the current situation regarding the use, quality, extreme events and management of water resources in the country, the management of water resources at local and national levels is one of the basic actions to satisfy the primary needs of living beings and guarantee their availability in terms of quantity as well as quality for present and future generations.

Therefore, knowing the perceptions of the Costa Rican population about water resources allows identifying information gaps, erroneous ideas rooted in the population and point towards corrective measures with reliable information in the educational field, public opinion in general and in decision-makers.

Methodology

A quantitative-descriptive study of population perception was conducted through a semi-structured survey, carried out by residential telephones nationwide. This study was performed during August 2016, with a sample of 800 people from Costa Rica or foreigners with two or more years of residing in the country, adults and residents in private homes that had residential telephones. The sample was calculated based on general data of the country regarding the total number of women and men and stratified by sex and age. A maximum error of 3.5 percentage points was obtained with 95% confidence. The survey, designed with an interdisciplinary approach, considered aspects related to water resources, both in terms of population perception/opinion (not comparable with national data or statistics) and in terms of general knowledge of water resources (subject to comparison with data at the national level). These themes were addressed through the application of a questionnaire of 50 questions, distributed in five modules:

MODULE I. General perception of water resources.

MODULE II. Water for human consumption.

MODULE III. Effect of human activities on water resources (extreme events) and climate change.

MODULE IV. Effect of human activities on water resources (water supply, quantity and quality).

MODULE V. Water resource management (sanitation and governance).

Study population

Of the 800 people surveyed, 52.1% were women, and 47.9% were men. All age groups are represented with more than 17% participation in the survey; however, the age group with the highest participation among the surveyed population is 55 years and older (25.1%), followed by the 25-34 age group (22%).

With regard to the education of the population surveyed, most of the people surveyed had only secondary education (34.9%) and university education (34.1%), followed by lower percentages associated with primary education and para-university education, respectively and, finally, those who indicated that they did not have any degree of education (0.75%) (Table 1).

Table 1
Demographic characteristics of the persons interviewed (N=800). Own elaboration.

Sex	Percentage
Men	47,9
Women	52,1
Total	**100**
Age (years)	**Percentage**
From 18 to 24	17,4
From 25 to 34	22,0
From 35 to 44	18,0
From 45 to 54	17,5
From 55 and over	25,1
Total	**100**
Educational level	**Percentage**
None	0,75
Primary	20,1
Secundary	34,9
Para-university	10,4
University	34,1
Total	**100**

Source: own research

Results and discussion

Module I. General perception of water resources

In this study, 98 % of the respondents considered that water belongs to every person, which is possibly a reflection of the population's deep-rooted perception of universal rights to water and the fact that accessibility to water is postulated as an inalienable human right (United Nations, 2010). In spite of this, when people were asked if they would be willing to share the water of their community with another neighbouring community, the percentage drops to 93 %, evidencing that, faced with the reality of a possible scarcity of water, some people were less willing to facilitate the equitable distribution of water, although a high percentage maintains the position of sharing. This behaviour has been observed in several countries, where, as scarcity or inequality in water distribution increases, social conflicts over unsatisfied demand increase (Fornaguera, 2015; Reyes, 2017; Urteaga et al., 2016).

Another question referred to the perception of water-related problems in the communities. Almost 80 % of the surveyed population considered that they do not have water problems, while 21.6 % of people indicated that their main problems are water supply or scarcity, limited infrastructure, mismanagement of the resource, pollution and lack of water in the dry season. When asked about possible solutions

to the problems, they referred to improved infrastructure and water management, as well as communication improvement and efficient use of the resource as the main solutions. However, very few surveyees considered taking care of water sources as a solution. This indicates that the majority of people considered that the water limitation derives from an administrative and infrastructure issues when actually, the background of environmental sustainability and preventive care is much more relevant in the long term (Foster and Chilton, 2018).

The inquiry also evidenced that 12 % of the surveyees still consider that water in Costa Rica is an inexhaustible resource; therefore, their awareness of the rational use of the resource could be lower. Fortunately, 88 % consider the resource to be exhaustible and are more conscious of its vulnerability. It should also be noted that the largest proportion of people who considered water to be an inexhaustible resource were the oldest (>55 years), which is possibly a reflection of the concepts taught in the education system in the past.

Another question regarded the availability of the world's water for human consumption. According to the U.S. Geological Survey estimates, less than 1 % of the world's water is available for human consumption (USGS, https://water.usgs.gov/edu/earthwherewater.html). According to the results of this research, only 10% of the respondents correctly indicated this answer. The majority of Costa Ricans surveyed (37.5 %) perceived that more than 50 % of the planet's water is available, which is a large overestimate and, again, reflects the perception that there is much more water than actually exists.

It is interesting to note that although the respondents indicated that there is more water in existence than there really is, they also have the perception that it is important to protect water (93.8 %) and that every person is responsible for water management (64 %).

Module II. Water for human consumption

About water for human consumption, 86.3 % of the surveyees indicated that they knew which entity supplies them with water at home. The majority (53.4 %) indicated that the Aqueducts and Sewerage Institute (AyA) is their provider, while 19.3 % indicated that their water comes from a municipal (local government) aqueduct, and 17.4 %, specified that the Administrative Associations of the Community Aqueduct and Sewer Systems (ASADAS) are in charge of providing this resource. Only 6.8 % stressed that it corresponds to the Public Services Company of Heredia (ESPH), and 3.2 % considered that other entities are responsible. When contrasting these data with the national reality (≈ 47 % corresponds to the AyA, 14 % to the municipalities, 30 % to the ASADAS, 4.7 % to the ESPH and 4.3 % to other administrators; Mora et al., 2016), an underestimation of the importance of the ASADAS as water providers, was observed.

Fifty-five per cent of surveyed Costa Ricans agreed that water for consumption comes from wells and springs; however, this perception

is lower than the 60 % and 90 % reported by the AyA and ESPH, respectively (SINIGHIR, 2018). Another 22 % of the surveyees indicated that their water came from other sources (river, dam, pipe and tank), and it should be noted that 23 % do not know the source of the water they consume. This last point is of special relevance, as it indicates the lack of interest of an important group of the surveyed population in knowing the origin of the water they consume. This lack of knowledge has other repercussions, as it deprives this population of the capacity to watch over the protection of their supply sources or the quality of the water they use. neighbouring42 % of the people surveyed highlighted that water has been deteriorating in recent years, however, according to the survey, few people chlorinate (7.3 %), boil (14.4 %) or filter (13.7 %) the water they consume.

Most of the population surveyed (85.5%) also do not know how much water is consumed in their homes per month. Only 32 % said they knew this information, and indicated that their consumption ranged between 11 and 20 m^3, which is close to the national reality because a family of four people approximately consumes 15 m^3/month. It should be noted that most people recognised the problem of water supply and yet are not very aware of the amount of water spent in their homes. This situation makes it more difficult to determine the effectiveness of water-saving measures applied in households.

Regarding the price paid for the water service, 80 % of the respondents said they consider that they pay an appropriate price and more than half (58 %) indicated their willingness to pay more for the service (Figure 1). It is noteworthy that there are still many houses which do not have a water meter, so it is difficult to calculate the consumption and, at the same time, it is not possible to know if the charge is appropriate in each house.

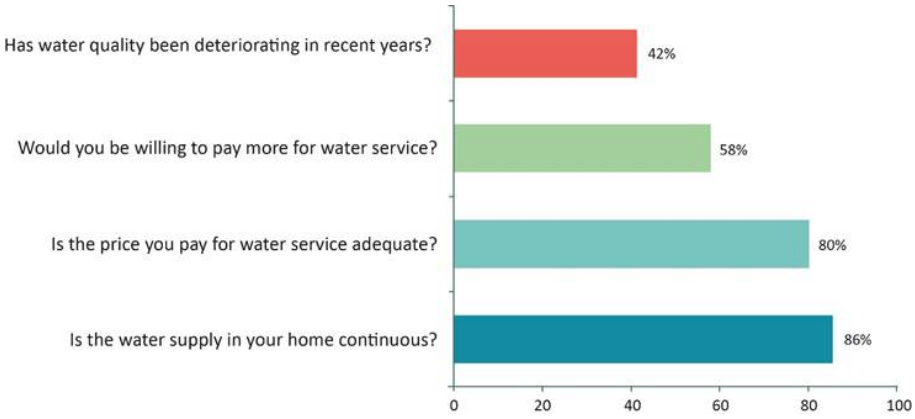

Figure 1
Percentage of affirmative responses on price, service, supply and quality of water (N=800). Source: own research.

Module III. Effect of human activities on water resources (extreme events) and climate change

During the survey, information was obtained on the percentage of the Costa Rican population that has lived (or perceived to have lived)

some extreme event. Sixty-three per cent of the surveyees stated they had witnessed the passage and inclement weather of tropical storms (which have indirectly and repeatedly affected Costa Rica because of its geographical position). Then, 33.1 % of the population highlighted the incidence of droughts, 27.6 % said they had experienced floods and 20.9 %, landslides. Surprisingly, 18.8 % claimed to have experienced the passage of hurricanes, even though the survey was conducted before the direct impact of Hurricane Otto, in late November 2016, a situation which showed that a sector of the Costa Rican population is not clear about what is considered a direct impact and perhaps confused with the indirect effects caused by the passage of other hurricanes in Central America (e.g. Hurricane Juana in 1988). Finally, 18.1 % said they had experienced the negative effects of flash floods and 17.8 %, tornadoes.

Even though these meteorological events have always existed, the increase in their frequency and intensity generates great concern in the population. By comparing the quantitative data of this research with a survey carried out by IDESPO in 2009 (IDESPO, 2011) it can be interpreted that, in just seven years, the population has perceived an increase in the occurrence of all types of extreme events (Figure 2).

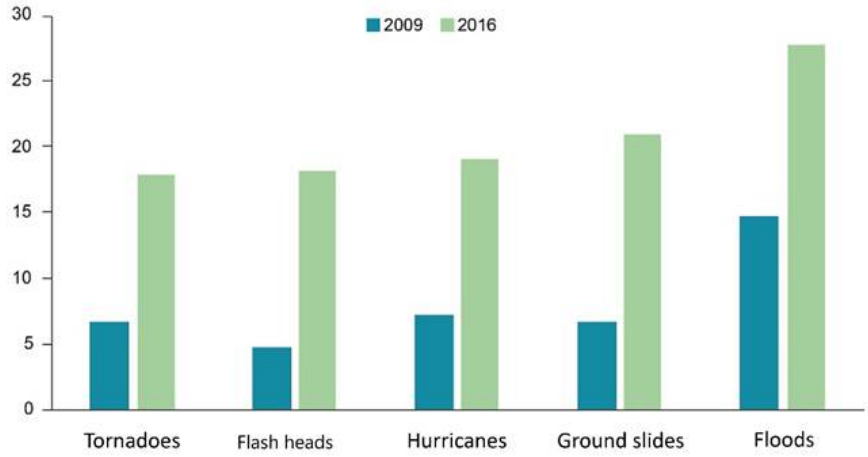

Figure 2
Percentage of people who reported having lived through extreme events, 2009 and 2016 (N=800). Own source of the research and IDESPO (2011).

Concerning flooding, people in the 2016 survey, were asked about their perception of the causes/ origins of this phenomenon. As a result, 91 % reported that floods have been intimately associated with the accumulation of solid waste in sewers and rivers, while 66 % associated it with the pernicious effects of deforestation, 65.4 % with the obsolete storm sewer infrastructure, 54.3 % with the construction of houses on the riverbanks, 38.4 % with sedimentation that accumulates in rivers and 30 % with urban areas growth. The above indicates that the population clearly associates anthropogenic disturbances with increased risk and vulnerability during times of affectation of hydrometeorological phenomena. Moreover, important measures such as the Law for Integrated Waste Management (Legislative Assembly of the Republic of

Costa Rica, 2010), adequate integrated watershed management or land-use planning, are not always implemented.

Costa Rica has the vulnerability of historically threatened ecosystems whose recovery is fundamental for the implementation of adaptation strategies, resilience and water security in rural and urban territories. Given the latter, it was asked whether our respondents had been aware of the infrastructure construction project for the transfer of water from the Caribbean slope to Guanacaste (Pacific slope). Only 38.6 % of those polled indicated that they were conscious of this governmental commitment, which is a project that arose as a strategy to mitigate water stress in the dry tropics, as well as taking advantage of the excess water in the Caribbean, both predicted for global warming scenarios (National Meteorological Institute and Regional Committee of Hydraulic Resources, 2008).

Additionally, 91% of those interviewed said they knew what climate change is and that 99% agreed that Costa Rica had been affected by this phenomenon. However, Costa Ricans did not prioritise these effects as causes of increased floodings over the past years. This contradiction shows us the multi causality of events, and the challenges that it implies for the adoption of better environmental education on issues of risk management in extreme events, climate variability, climate change and the difference between both concepts, to generate proposals for adaptation and resilience.

Module IV. Effect of human activities on water resources (water supply, quantity and quality)

Of the total interviewed population, only 12 % demonstrated adequate, albeit basic, knowledge of what an aquifer is. The remaining 88 % provided answers far detached from the concept of an aquifer; among the most frequent: river, intersection of rivers, underground river; place or zone where water is stored; drinking water under the ground; where there are fish; surface water reserve; water under the ground; water near the surface; a well; a spring or even stagnant water. The results of this survey confirmed the enormous need to reinforce topics related to these underground resources, in primary and secondary education programs.

Among the people who thought they knew what an aquifer is (N=442/800 people), 58 % stated that human decontamination of an aquifer is possible, while 7 % did not know. Only 35 % stated that decontamination is not possible. This contrasts with the fact that, once polluted, the water of an aquifer is extremely difficult to decontaminate, due to its very low rates of movement through the pores and fractures of the aquifer, its inaccessibility, the fact that certain pollutants are persistent, or the fact that the costs are so high that restoration would be economically unviable (Foster and Chilton, 2018).

When asked if they knew what groundwater is, 63 % of the surveyees answered affirmatively. However, only 36 % had a correct general idea of what groundwater is: water that flows underground through an aquifer

(Poehls and Smith, 2009). Other people responded that groundwater is: piped water; wells; springs; drinking or pure water; stagnant water; sewage; dirty water; water that passes under the ground through tunnels, culverts, pipes, pipelines, drains, conduits, caves or caverns; underground rivers; underground lakes; what is under the sea or below the earth's crust.

Amongst those who believed they knew what groundwater is (N=500), only 46 % responded adequately that water reaches subsoil rocks or aquifers through water infiltration through the ground (Figure 3). Others indicated that the water was already there or arrived through aqueducts, amidst other responses; while one quarter indicated that they did not know the answer. Despite the lack of knowledge of the basic concepts surrounding groundwater, 97 % of the population who said they knew what groundwater is (N=485), was convinced that it is an important resource. Eighty-three per cent indicated that it is used for human consumption, 83 % responded that it is used for irrigation and 78 % said that it is used in industrial activities. On the other hand, 94 % indicated that human activities cause groundwater pollution. These results show that the Costa Rican population, on the one hand, recognises the importance of groundwater resources in the development of the country and, on the other, visualizes that they are threatened due to the activities of this development.

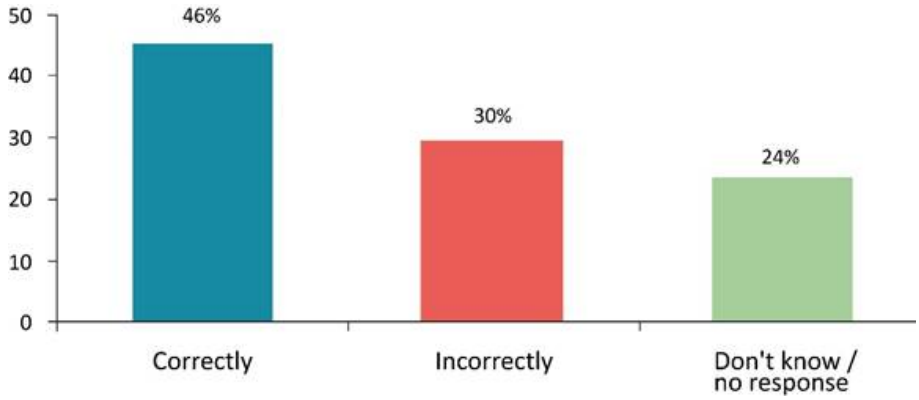

Figure 3
Percentage of people interviewed who responded correctly or incorrectly to the question about how an aquifer is recharged. Own source of the investigation.

Regarding surface waters in Costa Rica, between 97 % and 99 % of the population surveyed perceived that domestic wastewater, solid waste such as garbage, industrial waste and agricultural products (fertilizers and pesticides) are the sources of rivers, streams and lakes pollution; while 86 % perceived that animal waste represents sources of pollution for these water bodies. In addition, 99 % of people said that the presence of pesticides in water could cause mortality of fish and other organisms, health problems for aquatic organisms and health problems for human beings. This showed that the interviewed population is aware of the damage that human waste causes the country's surface water resources and, consequently, to the aquatic fauna and the health of the population.

In fact, there are several studies that support the population's appreciation of the severity of contamination of surface water bodies in Costa Rica, both by solid wastes, wastewater and other industrial and agricultural pollutants (Arias-Andrés et al., 2018; Contraloría General de la República, 2013; Echeverría-Sáenz et al., 2012; Echeverría-Sáenz et al., 2018; Fournier et al., 2018).

Module V. Water resource management (sanitation and governance)

Wastewater is defined as water that has been used, and its quality has been modified by the incorporation of pollutants (Poder Ejecutivo, 2007). Considering the use and final disposal of water in their homes, questions were asked regarding what surveyees consider to be wastewater.

As can be seen in Figure 4, except for rainwater collected in gutters, more than 79 % of people consider that water from showers, toilets and kitchen sinks to be wastewater. However, there is a percentage of the population that, despite considering the kitchen sink waters to be residual, did not perceive the same with the water used in the toilets, which is an incoherence or reflects lack of knowledge on the subject. With regard to rainwater, 59.1 % of the population considered it to be wastewater, which can become an obstacle for the promotion of rainwater reuse practices in certain applications for which its quality may be appropriate, as has been done in projects at the Central American level, executed mainly by NGOs, both for domestic and agricultural consumption (Global Water Partnership, 2016). The National University, through IDESPO and the Mesoamerican Center for Sustainable Development of the Dry Tropics (CEMEDE-UNA), has developed modules of Rainwater Harvesting Systems (SCALL, for its Spanish acronym) for human consumption and water harvesting reservoirs for agricultural uses in the Chorotega Region and the Caballo Island in the Gulf of Nicoya.

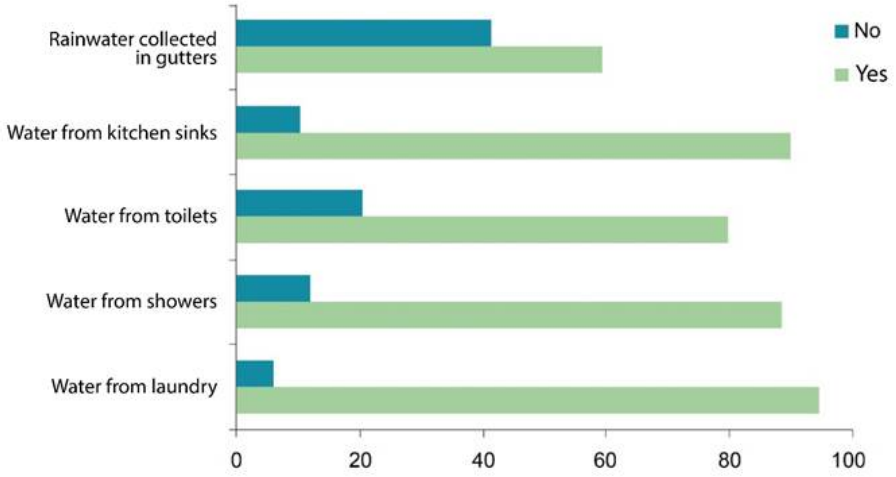

Figure 4
Percentage of interviewed population that considered different types of home-generated waters as wastewaters. Own source of the investigation.

Regarding final disposal, questions were asked about the destination of wastewater according to the classification by groups of soapy wastewater and sewage. As can be seen from Figure 5, the septic tank is still the main solution for the disposal of toilet water, despite the recent construction of sewerage systems for wastewater treatment by the AyA. Concerning soapy water, 35.6 % of those surveyed said they sent it to sewerage systems, information that surpasses the AyA data, since only 21.43% of the total number of homes in the country are connected to such systems (AyA, MINAE, Ministry of Health, 2016).

It is important to mention that, in the case of soapy water, some people recognised that they send their water to the curb (19.6%) and to the river (13.8%), which translates into direct water pollution problems. In fact, in Costa Rica, one of the most important sources of point pollution is the direct discharge of untreated industrial and domestic wastewater into rivers, especially in densely populated watersheds (State of the Nation and Sustainable Development Program, 2016). The General Comptroller of the Republic (2013) estimated that only 5% of the ordinary wastewater discharged into the country's water bodies, receives pre-treatment, which entails the deposit of an enormous load of pollutants in Costa Rica's rivers and streams.

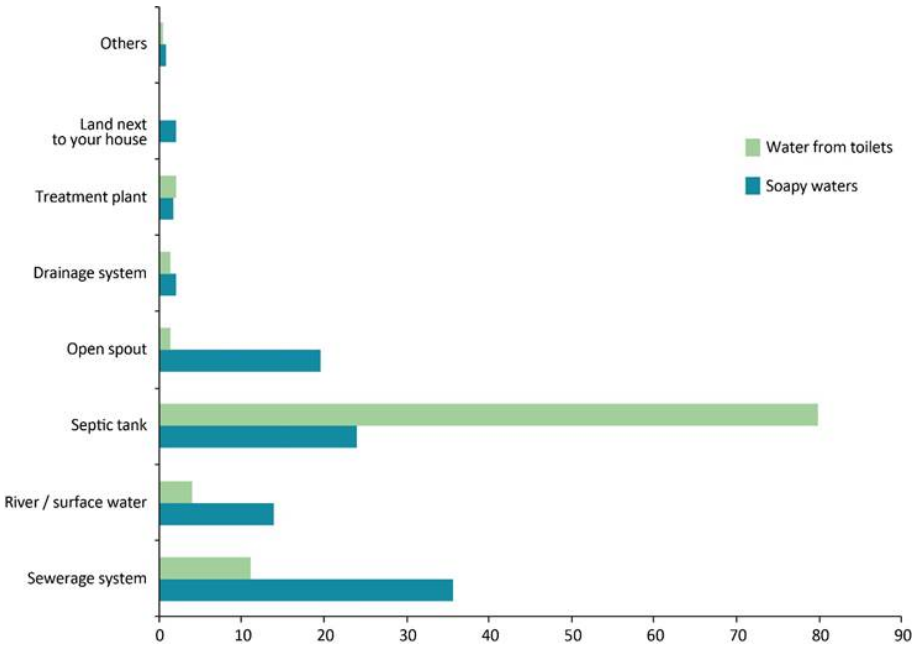

Figure 5
Percentage of respondents indicating which is the destination of their home´s wastewater. Own source of the research.

Concerning the concept of wastewater within the supply and consumption cycle, approximately half of the people (54.2 %) did not consider that the wastewater they generate could contaminate water for consumption in their community. Although the population is aware that human activities can generate water pollution as a global problem, they do not relate to the fact that the wastewater they generate can contaminate surface waters, and that this can be a problem if surface waters are used for consumption. This perception could be derived from the lack of knowledge of concepts of the hydrological cycle such as those discussed in the previous sections.

The absence of adequate wastewater management and disposal systems has direct consequences on public health. For example, the incorrect disposal of excreta increases the risk of disease, an effect that is very clearly perceived by the population. For this reason, it is to be expected that 94.2 % of people agreed to pay more for the adequate treatment of wastewater, which represents an opportunity to increase the collection of funds, through the water bill, for the financing of projects that improve environmental sanitation in our country.

Conclusions

In Costa Rica, there are weaknesses in infrastructure and management that prevent the supply of drinking water to the entire population and, besides, pollution threats to put the quality of surface and groundwater resources at risk. Due to this fact, it is essential to understand the society's perception of water resources, their use and management, in order to evaluate the approval or disagreement regarding institutional actions and

the need to strengthen education programs, which would achieve greater social impact in the decision-making process.

One of the most important conclusions of this research is the fact that 98 % of the interviewed Costa Rican population considered that water belongs to all people, but in the case of any eventuality, 7 % would not share their water with other communities. In addition, merely 10 % of the people surveyed answered correctly that only 1 % of the planet's water is available for human consumption. Part of the surveyed population (22 %) indicated that they have water problems in their community, for example, inconveniences associated with water supply, infrastructure and quality. According to 64 % of the sample, the responsibility for water resource management in Costa Rica belongs to all people. Also, Costa Ricans perceived greater affectation by floods and landslides between 2009 and 2016, and at the same time indicated that garbage in the streets and sidewalks are the cause of the floodings in the cities.

The majority of the surveyees indicated that the price they pay for the water service is adequate. Only 55 % of Costa Ricans surveyed agreed that water for consumption comes from wells and springs. Only 12 % and 36 % have a basic understanding of what an aquifer and groundwater are, respectively, even though the main source of drinking water in Costa Rica is of underground origin. The septic tank continues to be the main solution for the final disposal of sewage, as 79.4 % indicated using this type of treatment. Not so, for soapy waters, where only 24% are sent to septic tanks.

Approximately 60 % of the population surveyed expressed willingness to pay more for the water service, and 94 % would pay for adequate wastewater treatment. This is an opportunity for water managers to include an item to finance projects that improve the protection of water resources and sanitation of wastewater.

The results provide a baseline that contributes to the establishment of policies oriented towards the inclusion of the basic knowledge topics of the survey (hydrological cycle concepts) in primary and secondary education programs, as well as the implementation of strategies to improve the knowledge and awareness of adult citizens on basic issues of surface and groundwater, use, sanitation, management and protection of water resources. In addition, the results can be used as a basis to construct indicators to validate the degree of knowledge acquired by citizens if the above strategies are implemented.

References

Arias-Andrés, M. J.; Rämö, R.; Mena-Torres, F.; Ugalde, R.; Grandas, L.; Ruepert, C.; Castillo, L.E.; Van den Brink, P. y Gunnarsson, J. S. (2018). Lower tier toxicity risk assessment of agriculture pesticides detected on the Río Madre de Dios watershed, Costa Rica. *Environ Sci Pollut Res*, *25*(14), 13312-13321. doi https://doi.org/10.1007/s11356-016-7875-7

Asamblea Legislativa de la República de Costa Rica. (24 de junio del 2010). *Ley para la Gestión Integral de Residuos*. (Ley N° 8839). Retrieved

from https://www.pgrweb.go.cr/scij/Busqueda/Normativa/Normas/nrm_texto_completo.aspx?param1=NRTC&nValor1=1&nValor2=68300&nValor3=83024&strTipM=TC

AyA, MINAE y Misterio de Salud. (2016). *Política Nacional de Saneamiento de Aguas Residuales 2016- 2045*. San José, Costa Rica: AYA, MINAE y MS. Retrieved from https://www.aya.go.cr/Noticias/Documents/Politica%20Nacional%20de%20Saneamiento%20en%20Aguas%20Residuales%20marzo%202017.pdf

Benez, M.; Kauffer-Michel, E. y Álvarez-Gordillo, G. (2010). Percepciones ambientales de la calidad del agua superficial en la microcuenca del río Fogótico, Chiapas. *Frontera Norte*, *22*(43), 129-158. Retrieved from http://www.redalyc.org/pdf/136/13612035006.pdf

Comisión Económica para América Latina y el Caribe. (2018). *Agenda 2030 y los Objetivos de Desarrollo Sostenible: una oportunidad para América Latina y el Caribe*. Santiago, Chile: Naciones Unidas-CEPAL. Retrieved from https://repositorio.cepal.org/bitstream/handle/11362/40155/24/S1801141_es.pdf

Contraloría General de la República. (2013). Informe acerca de la eficacia del Estado para garantizar la calidad del agua en sus diferentes usos (Informe No. DFOE-AE-IF-01-2013). San José, Costa Rica. Retrieved from https://cgrfiles.cgr.go.cr/publico/jaguar/sad_docs/2013/DFOE-AE-IF-01-2013.pdf

Echeverría-Sáenz, S.; Mena, F.; Arias-Andrés, M.; Vargas, S.; Ruepert, C.; Van den Brink, P.J.; Castillo, L.E. y Gunnarsson, J.S. (2018). In situ toxicity and ecological risk assessment of agro-pesticide runoff in the Madre de Dios River in Costa Rica. *Environmental Science and Pollution Research*, *25*(14), 13270-13282. Retrieved from https://link.springer.com/article/10.1007%2Fs11356-016-7817-4

Echeverría-Sáenz, S.; Mena, F.; Pinnock, M.; Ruepert, C.; Solano, K.; De la Cruz, E.; Campos, B.; Sánchez- Ávila, J.; Lacorte, S. y Barata, C. (2012). Environmental hazards of pesticides from pineapple crop production in the Río Jiménez watershed (Caribbean Coast, Costa Rica). *Science of the Total Environment*, *440*, 106-114. Retrieved from http://pnp.cr/plataforma/sites/default/files/echeverria-saenz_2012_environmental_hazards_of_pesticides_from_pineapple_crop_production_in_the_rio_jimenez.pdf

Estado del ambiente. (2017). *Capítulo II: el estado del ambiente costarricense*. San José, Costa Rica. Retrieved from http://www.odd.ucr.ac.cr/sites/default/files/IAE2017/02-Capitulo-II-2018.pdf

Fornaguera, I. (2015). Conflictos por acceso al agua se desbordan en la Sala IV. *La Nación*. Retrieved from https://www.nacion.com/el-pais/servicios/conflictos-por-acceso-al-agua-se-desbordan-en-la-sala-iv/BE7N574TJNBGRIIYZDCX62VCQY/story/

Fonseca-Sánchez, A., Madrigal-Solís, H., Núñez-Solís, C., Calderón-Sánchez, H., Moraga-López, G. y Gómez-Cruz, A. (2019). Evaluación de la amenaza de contaminación al agua subterránea y áreas de protección a manantiales en las subcuencas Maravilla-Chiz y Quebrada Honda, Cartago, Costa Rica. *Uniciencia*, *33*(2), 76-97. Retrieved from https://www.revistas.una.ac.cr/index.php/uniciencia/article/view/11644

Foster, S. y Chilton, J. (2018). Chapter 4: Groundwater management: policy principles y planning practices. Villholth, K., Lopez-Gunn, E., Conti, K., Garrido, A., Van Der Gun, J. (Eds.), *Advances in Groundwater Governance* (1-621). London, CRC Press. Retrieved from http://bnfwv4fm4l13stiajd7sf413.wpengine.netdna-cdn.com/wp-content/uploads/sites/2/2019/01/advances-in-groundwater-governance.pdf

Fournier, M.L.; Echeverría-Sáenz, S.; Mena, F.; Arias-Andrés, M.; de la Cruz, E. y Ruepert, C. (2018). Risk assessment of agriculture impact on the Frío River watershed and Caño Negro Ramsar wetland, Costa Rica. *Environmental Science and Pollution Research*, 25(14), 13347-13359. Retrieved from https://link.springer.com/article/10.1007%2Fs11356-016-8353-y

Global Water Partnership. (2016). *Informe anual: Entre aguas*. GWP. Tegucigalpa, Honduras. Retrieved from https://www.gwp.org/globalassets/global/gwp-cam_files/ea_cosecha-aguas-lluvias_fin.pdf

IDESPO. (2011). Percepción de la población costarricense acerca de los desastres naturales. *Horizontes Ambientales*, (1), 1-53. Retrieved from http://unpan1.un.org/intradoc/groups/public/documents/icap/unpan048505.pdf

Imbach, P.; Beardsley, M.; Bouroncle, C.; Medellin, C.; Läderach, P.; Hidalgo, H.; Alfaro, E.; Van Etten, J.; Allan, R.; Hemming, D.; Stone, R.; Hannah, L. y Donatti C. (2017). Climate change, ecosystems and smallholder agriculture in Central America: an introduction to the special issue. *Climatic Change*, *141*(1), 1-12. Retrieved from https://link.springer.com/article/10.1007/s10584-017-1920-5

Instituto Costarricense de Acueductos y Alcantarillados. (2016). *Política Nacional de Agua Potable de Costa Rica, 2017 - 2030*. San José, Costa Rica: Comisión Interinstitucional. Retrieved from https://www.aya.go.cr/Noticias/Documents/AyA%20Pol%C3%ADtica%20Nacional%20de%20Agua%20Potable%20de%20Costa%20Rica%202017-2030.pdf

Instituto Meteorológico Nacional y Comité Regional de Recursos Hidráulicos. (2008). *Informe nacional: Clima, variabilidad y cambio climático en Costa Rica*. MINAET, GEF, CRRH, IMN y PNUD. San José, Costa Rica. Retrieved from http://cglobal.imn.ac.cr/documentos/publicaciones/CambioClimatico/climaVariabilidadCambioClimaticoCR.pdf

Instituto Nacional de Estadística y Censos. (2012). *X Censo Nacional de Población y VI de Vivienda 2011: resultados generales*. San José, Costa Rica: INEC. Retrieved from https://www.cipacdh.org/pdf/Resultados_Generales_Censo_2011.pdf

Leff, E. (1998). *Saber ambiental: sustentabilidad, racionalidad, complejidad, poder*. Siglo XXI Editores, México, D.F. Retrieved from https://bibliodarq.files.wordpress.com/2014/12/leff-e-saber-ambiental-sustentabilidad-racionalidad-complejidad-poder.pdf

Madrigal-Solís, H.; Fonseca-Sánchez, A.; Núñez-Solís, C. y Gómez-Cruz, A. (2014). Amenaza de contaminación del agua subterránea en el sector norte del acuífero Barva, Heredia, Costa Rica. *Tecnología y Ciencias del Agua*, 5(6), 109-118. Retrieved from http://www.redalyc.org/articulo.oa?id=353539530007

Madrigal-Solís, H.; Fonseca-Sánchez, A. y Reynolds-Vargas, J. (2017). Caracterización hidrogeoquímica de los acuíferos volcánicos Barva y Colima en el Valle Central de Costa Rica. *Tecnología y Ciencias del Agua*, 8(1), 115-132. Retrieved from http://www.scielo.org.mx/pdf/tca/v8n1/2007-2422-tca-8-01-00115.pdf

Madrigal-Solís, H.; Fonseca-Sánchez, A.; Calderón-Sánchez, H.; Gómez-Cruz, A. & Núñez-Solís, C. (2019). Design of a monitoring network as a participative management tool: physical and chemical quality of groundwater in three sub-basins in the Central Valley of Costa Rica. Revista*Uniciencia*, *33*(1), 43-60. Doi: http://dx.doi.org/10.15359/ru.33-1.4

Martínez Valdés, Y. y Villalejo García, V. M. (2018). La gestión integrada de los recursos hídricos: una necesidad de estos tiempos. *Ingeniería Hidráulica y Ambiental*, *39*(1), 58-72. Retrieved from http://scielo.sld.cu/pdf/riha/v39n1/riha05118.pdf

Ministerio de Ambiente, Energía y Telecomunicaciones (MINAET) e Instituto Meteorológico Nacional (IMN). (s.f.). *Sobre algunos fenómenos meteorológicos en Costa Rica*. Retrieved from https://www.imn.ac.cr/documents/10179/20909/Compendio+sobre+fen%C3%B3menos+meteorol%C3%B3gicos

Ministerio de Ambiente y Energía, Ministerio de Salud (2007). Reglamento de vertido y reuso de aguas residuales. Decreto 33601, La Gaceta 55, Alcance 8. Retrieved from: http://www.regenciaquimica.ucr.ac.cr/sites/default/files/33601-s-minae.pdf

Ministerio del Ambiente, Energía y Telecomunicaciones; Dirección de Agua; SENARA y AyA. (2013). *Agenda del Agua, Costa Rica: 2013-2030*. Retrieved from https://www.gwp.org/globalassets/global/gwp-cam_files/documento_de_posicionamiento_agenda_del_agua_nov_20121.pdf

Mora-Alvarado, D.; Mata-Solano, A. y Portuguez, C. F. (2016). *Informe nacional: Agua para consumo humano y saneamiento y su relación con los indicadores básicos de salud en Costa Rica: objetivos de Desarrollo del Milenio y la Agenda para el 2030*. Instituto Costarricense de Acueductos y Alcantarillados. Laboratorio Nacional de Aguas. San José, Costa Rica. Retrieved from https://www.aya.go.cr/centroDocumetacion/catalogoGeneral/Informe%20de%20calidad%20del%20agua%202015.pdf

Moscovici, S. (1979). *El psicoanálisis, su imagen y su público*. Buenos Aires, Argentina: Editorial Huemul. Retrieved from http://www.bibliopsi.org/docs/carreras/obligatorias/CFG/social/robertazzi/Moscovici%20-%20El%20psicoanalisis,%20su%20imagen%20y%20su%20publico..pdf

Naciones Unidas. (2003). *Informe: Agua para todos: agua para la vida*. UNESCO y WWAP. Paris, Francia. Retrieved from http://unesdoc.unesco.org/images/0012/001295/129556s.pdf

Naciones Unidas. (2010). *Informe: El derecho humano al agua y al saneamiento*. Asamblea General de las Naciones Unidas. Retrieved from https://www.un.org/spanish/waterforlifedecade/human_right_to_water.shtml

Organización Panamericana de la Salud. (2003). *Calidad del agua potable en Costa Rica: situación actual y perspectivas*. San José, Costa Rica: OPS. Retrieved from https://www.bvs.sa.cr/php/situacion/agua.pdf

Poder Ejecutivo. (19 de marzo del 2007). *Reglamento de vertido y reúso de aguas residuales*. (Decreto 33601-MINAE-S). La Gaceta N°55. Retrieved

from https://aresep.go.cr/normativa/868-reglamento-de-vertido-y-reuso-de-aguas-residuales-22-3-2007

Programa Estado de la Nación en Desarrollo Sostenible. (2016). *Capítulo 4: Armonía con la naturaleza*. Vigésimosegundo Informe del Estado de la Nación. San José, Costa Rica. Retrieved from: https://file:///C:/Users/UNA/Downloads/Armon%C3%ADa%20con%20la%20naturaleza_Cap%C3%ADtulo%204.pdf(HMS1)

Poehls, D. J. y Smith, G. (2009). *Encyclopedic Dictionary of Hydrogeology*. Massachusetts, EEUU: Elsevier Inc. Retrieved from https://books.google.co.cr/books?hl=es&lr=&id=Rtjtazovs9AC&oi=fnd&pg=PP1&dq=Encyclopedic+Dictionary+of+Hydrogeology.+Academic+Press,+Elsevier+Inc.+Massachusetts,+EEUU.&ots=WhVZkYF9KU&sig=Tj6VximFxh5lHGh31Dju19ZWBs0#v=onepage&q=Encyclopedic%20Dictionary%20of%20Hydrogeology.%20Academic%20Press%2C%20Elsevier%20Inc.%20Massachusetts%2C%20EEUU.&f=false

Renom Molina, M. (2009). *Temperaturas extremas en Uruguay*. Análisis de la variación temporal de baja frecuencia y su relación con la circulación de gran escala (Tesis Doctoral). Universidad de Buenos Aires, Argentina. Retrieved from http://meteo.fisica.edu.uy/archivos/PaperMadeleine/Tesis.pdf

Reyes, J. (2017). La crisis del agua, detonante de conflicto social. *Contralínea.com.mx*, 1-15. Retrieved from https://www.printfriendly.com/p/g/HvvXtP

Reynolds-Vargas, J.; Fraile-Merino, J. e Hirata, R. (2006). Trends in Nitrate Concentrations and Determination of its Origin Using Stable Isotopes (18O and 15N) in Groundwater of the Western Central Valley, Costa Rica. *Ambio: A J. of the Human Environment*, *35*(5), 229-236. Retrieved from https://bioone.org/journals/ambio-a-journal-of-the-human-environment/volume-35/issue-5/05-R-046R1.1/Trends-in-Nitrate-Concentrations-and-Determination-of-its-Origin-Using/10.1579/05-R-046R1.1.short

Santos, B. de S. (2005). *El milenio huérfano. Ensayos para una nueva cultura política*. Madrid, España: Editorial Trotta. Retrieved from https://www .google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=2ahUKEwjP9PjIx9_jAhWmuVkKHb8EDQwQFjAAegQIABAB&url=https%3A%2F%2Festudogeral.sib.uc.pt%2Fbitstream%2F10316%2F44228%2F1%2FEl%2520Milenio%2520Hu%25C3%25A9rfano.pdf&usg=AOvVaw3HVucEzB5wS-Y2mY5unena

SINIGIRH. (2018). Estadísticas e Indicadores del Agua. Sistema datos indicadores para GIRH Mayo 2017 (Hoja de cálculo 2.6.2.e1.a.). Sistema Nacional de Información para la Gestión Integrada del Recurso Hídrico. Retrieved from: http://www.da.go.cr/indicadores-de-la-gestion-del%20%20-recurso-hidrico/

Urteaga Crovetto, P.; Guevara Gil, A. y Verona Badajoz, A. (2016). El Estado frente a los conflictos por el agua (235 p). Lima, Perú: Pontificia Universidad Católica del Perú. Retrieved from https://www.academia.edu/33860312/Terceras_Jornadas_de_Derecho_de_Aguas_El_Estado_frente_a_los_Conflictos_por_el_Agua