Received: 23 January 2023 | Revised: 20 August 2023 | Accepted: 1 September 2023

DOI: 10.1002/sd.2753

RESEARCH ARTICLE

Sustainable Development

WILEY

Untangling the vicious cycle around water and poverty

Marcos García-López[1] | Gabriela Cuadrado-Quesada[2] | Borja Montano[1]

[1]University Institute of Water and Environmental Sciences, University of Alicante, San Vicente del Raspeig, Spain

[2]Water Governance Department, IHE Delft Institute for Water Education, Delft, The Netherlands

Correspondence
Marcos García-López, University Institute of Water and Environmental Sciences, University of Alicante, San Vicente del Raspeig Road Without Number, San Vicente del Raspeig 03690, Spain.
Email: marcos.garcialopez@ua.es

Funding information
University of Alicante, Grant/Award Number: UAFPU2019-16

Abstract

Despite the recent improvements, there is still a problem of access to WASH services. This problem access is linked to poverty and inequality, which in turn cause difficulties in accessing water, thus creating a vicious cycle. This article analyses this vicious cycle using data from international organisations related to these issues. These data show how the lack of water access leads to limitations for households, which are deprived of employment or/and education due to the difficulty in obtaining water. This opportunity cost is the main mechanism through which the feedback between lack of access to water and economic poverty occurs. Not being able to obtain employment or/and education makes it impossible to get out of a precarious situation, which prevents the wider society to benefit from any economic gain, which in turn slows down the achievement of the goal of guaranteeing access to water for all. The responsibility lies with national and international institutions, which should not only focus on obtaining the necessary financial resources for infrastructure improvements, but also on having adequate governance to ensure water sustainability and equity.

KEYWORDS
economic poverty, human capital, inequality, WASH services access, water-economy vicious cycle

There is still a significant lack of WASH services access in the world, which has a major impact on society as a whole. Economic poverty and lack of access to these services feedback on each other, leading to a Water-Economy vicious cycle with education as a key element that impedes progress in both sectors. Lack of access to water, which has a strong inequality component as low-income earners suffer most from this problem, prevents people from obtaining an education or employment, which in turn limits escaping poverty and the adequate provision of water services. These problems extend to society, with a severe lack of access to basic services and a reduced accumulation of human capital, which is essential for solving such problems.

1 | INTRODUCTION

In 2010, the United Nations General Assembly (UNGA, 2010), by Resolution 64/292, recognised 'the right to safe and clean drinking water and sanitation as a human right that is essential for the full enjoyment of life and all human rights'. Even though the right to water and the right to sanitation were first recognised together, later on they were split as governments were giving more attention to the realisation of the right to water than to the right to sanitation. Therefore, in 2015 the UNGA explicitly recognised the 'human right to sanitation' as a distinct right of the right to water. After the formal recognition of the human right to water and sanitation in 2010 the United Nations

Human Rights Council (UNHRC, 2010) mandated that all countries around the world should work towards: 'appropriate tools and mechanisms, which may encompass legislation, comprehensive plans and strategies for the sector, including financial ones, to achieve progressively the full realisation of human rights obligations related to access to safe drinking water and sanitation'.

However, and despite improvements in recent times, almost 1 billion people suffer from water access problems and almost 2 billion lack decent water-related sanitation services (Adams et al., 2016; Hargrove, 2020). This progress has been uneven across countries and regions, so it must be assumed that progress does not occur in the same way everywhere and needs to be delved into on a case-by-case basis (Fuller et al., 2016). This is an essential problem that must be addressed to ensure the fulfilment of human rights for the entire population, so that the different regions can develop and the Sustainable Development Goals can be met. Adequate and equitable access to water is linked to several international commitments including the Sustainable Development Goals, making it a central societal issue. As Requejo-Castro et al. (2020) found, there are various connections between the different Sustainable Development Goals, which implies that progress in meeting one goal can have an impact on others. Access to water is especially important when talking about goal 1, which is about eradicating all forms of poverty, about goal 3, related to health and well-being, and, above all, when talking about goal 6, involving adequate access to water and sanitation for all. Access to water is also relevant to goal 8, which seeks to promote economic growth with decent employment, and goal 10, about reducing inequality. But, in addition, water resources management is important in terms of environmental sustainability through goals 11, 12, 13, 14 and 15, which deal with the sustainability of cities, production and consumption, the fight against climate change and the well-being of life, both marine and terrestrial. In other words, access to water and its proper governance and management is fundamental for the social, economic and environmental sustainability of society.

This makes it necessary to analyse the determinants of access to water and the origins of the lack of access and inequality that occur in practice. This is a field that has been extensively studied, finding that the main determinants of access to water are income, level of education, household characteristics, and socio-demographic and geographic characteristics, especially between rural and urban residence (Adams, 2018; Adams et al., 2016; Adil et al., 2021; Antunes & Martins, 2020; Chaudhuri & Roy, 2017; Dungumaro, 2007; Luh et al., 2013; Pullan et al., 2014; Sintondji et al., 2017). The existence of determinants that explain access to water indicates that they also cause lack of access and, consequently, inequality. The main sources of such inequality are income and place of residence. Income distribution implies different levels of acquisitive power and lower incomes may be unable to afford the service. Place of residence affects inequality, as in certain urban areas, due to the presence of economies of scale, the cost of providing the service is lower and access is easier (Chaudhuri & Roy, 2017; Hutton & Andrés, 2018; Luh et al., 2013; Pullan et al., 2014; Yang et al., 2013).

Given the current situation of problems of access to water coexisting with inequality and poverty? with a tendency to put economic interests first, it is necessary to analyse the international situation regarding the link between the lack of access to water and the level of economic development. This link is key to explaining the situation of countries in terms of access to water and therefore needs to be properly analysed with the aim of ending inequalities and fulfilling access that was declared a human right in 2010. Thus, in this article we use information from international organisations, such as the Joint Monitoring Programme for Water Supply and Sanitation (JMP), the Food and Agriculture Organisation of the United Nations (FAO) and the World Bank, to analyse the situation by country and show how the lack of access to water greatly limits economic progress and overcoming poverty and inequality, which, in turn, prevents the existence of good water governance. What we expect to find is the presence of a powerful vicious cycle that mainly affects the poorest sector of the population. The objective of this article is to determine the mechanism by which the lack of access to water affects all levels of society, generating a great economic backwardness and slowing down the provision of basic services. Considering the well-known link between water and health (Bartram, 1999), lack of access to water leads to problems in all aspects of a society. The expected cycle starts with not having access to water, which implies an investment of time and/or money by a member of the household, especially women as shown by Sullivan (2002) as this loss of time is a key factor in water poverty. Those suffering water poverty are not able to get an education or a job and/or losing important financial resources for them. Therefore, the poorest part of the population, lacking access to water, becomes even poorer and unable to get good access to water by their own means, which leaves them trapped in this cycle where water poverty and economic poverty feed-back on each other and affect the overall situation of society. The research begins with a review of the literature focusing on water access and inequality, followed by the presentation of the data and the methodology, the results and discussion generated and, finally, the conclusions.

2 | WATER ACCESS AND INEQUALITY

As stated in the introduction, it is essential to analyse the determinants of access to water in order to adequately address the current problem. One of the main determinants of access to water consists of household income (Adams et al., 2016; Adil et al., 2021). This variable is closely related to poverty and employment in a country and is a clear sign of inequality in access to water, because this cannot be considered universal if depends on income. The other determinants are to some extent related to income. Educational level, for example, has a certain correlation with income, so it is a very important factor. The rest of the household characteristics, especially household structure, socioeconomic status, or the gender of the household head, also show relevance in explaining access to water and other services such as sanitation (Adams, 2018; Adil et al., 2021; Antunes & Martins, 2020; Dungumaro, 2007; Sintondji et al., 2017). Finally, sociodemographic and geographic aspects have also been studied. In this regard, the relevance of residing in urban or rural areas stands out (Chaudhuri & Roy, 2017; Luh et al., 2013; Pullan et al., 2014).

In the same way that there are determinants that explain access to water, there are inequalities derived from the different characteristics of water users (Malakar et al., 2018). These inequalities are not only in whether one has access to water or not, but within having access there are also differences depending on aspects such as the cost of the service, the quality and quantity of water available or the ease of access. Location is one of the main causes of these inequalities, since it conditions access to water. The main difference arises from residing in urban or rural areas, but within each of the areas new inequalities may arise based on other criteria (Chaudhuri & Roy, 2017; Luh et al., 2013; Pullan et al., 2014).

In other words, different drivers of inequality can occur simultaneously, so that the situation can become very complicated, therefore, governance matters to ensure equitable and sustainable access to water. For the purpose of this article, we understand water governance as 'the practices of coordination and decision making between different actors around contested water distributions' (Zwarteveen et al., 2017: 3). Three words deserve especial attention in this definition. The first one is: practices. It emphasises the interest in what people do. In this way, the term entails an invitation to take the everyday activities—which include creativity, improvisation, tinkering and messiness. The second term that stands out of is: contested. This term serves to acknowledge that most decisions about water involve choices that are political in the sense that they favour some people over other. The third term is distributions, which draw attention to the above-mentioned political choices: choices about where and to whom water goes and about which infrastructure/investments deserve public funds (Zwarteveen et al., 2017).

Inequality caused by income is also very important, as there are several cases where, within the same city or region, individuals with financial resources have good access to water while poor individuals do not enjoy it (Yang et al., 2013, Hutton & Andres, 2018). However, since water supply is necessary, poor users are forced to invest time, and even financial resources, in getting the water they need. This is a cost of time and money for individuals who already have scarce resources (Seyoum & Graham, 2016; Soares et al., 2002). The remaining determinants can also lead to inequality, but they are much less studied than financial or geographic aspects. Moreover, inequalities may be different between access to water and access to sanitation, as for example in the case of Saudi Arabia, where inequality in access to water was lower than that present in terms of connection to sewerage (Gazzeh & Abubakar, 2018). Therefore, inequality in access to water is not a secondary problem, but combating it is part of the core of the issue as it is a very important limit to development that mainly affects the poorest individuals in society (Cetrulo et al., 2020).

We are therefore talking about a complex issue involving various factors that interact with each other. Thus, governance and management are essential if we are to address existing problems and guarantee access to water and sanitation services. It should be borne in mind that there is no single way to do this, the practices that can be carried out to meet these objectives can be very varied but, in any case, these measures must consider the particularity of each case for governance to be adequate (Zwarteveen et al., 2017). Governing water is very complicated, since in addition to technical issues such as resource availability, available technology or geographical or economic aspects, there are different levels of authority at which policies can be implemented (Gupta & Pahl-Wostl, 2013). In this sense, the current trend is to bring governance to different levels. This includes a global scale, but also the possibility of bringing it to the point closest to the water resources, so finding the balance is a complex issue (Gupta & Pahl-Wostl, 2013). A regulatory framework is needed that establishes general criteria while allowing some flexibility at the levels of management closest to the resources (Gupta & Pahl-Wostl, 2013). This regulation must also be broad enough to not leave loopholes and be compatible with sustainable development and the use of varied tools (Cuadrado-Quesada et al., 2018). Of course, developing such regulation is a very complicated matter, but the benefits that can arise from it are very high (von Benda-Beckmann, 2002). Good regulation that establishes general criteria and allows flexibility in management is compatible with ensuring food security for citizens and fighting climate change, aspects for which actions are needed at different levels of governance (Ostrom, 2010). Regulations can be non-applicable or become outdated, so they must co-evolve with community practices to keep up to date in a way that is acceptable to users (Cuadrado-Quesada & Joy, 2021). Laws that are not capable of taking the reality and practices into account are inadequate laws and, given that practices vary from place to place, comprehensive laws must consider the characteristics of each case in order to have the support of users (Cuadrado-Quesada & Joy, 2021; Dellapenna & Gupta, 2008). In summary, achieving good governance is complicated, but it is essential for adequate development in which the needs of the entire population are met (Cuadrado-Quesada et al., 2018).

There is currently a tendency to allocate water to the most profitable uses, which can lead to supply problems in the search for maximum financial profit (Joy et al., 2014). When economic criteria such as profitability or efficiency are imposed over social or justice criteria we find cases of water (in)justice in which a small segment of the population has a large amount of water while the bulk of citizens have poor access to it (Joy et al., 2014). This is a governance problem that arises from the objective of maximising profits as a tool to develop (Maroufpoor et al., 2021). One of the most important exponents of this issue is the virtual water trading, which is considered an efficient and potentially profitable method of resource allocation (Kumar & Singh, 2005). However, the main criterion explaining international trade in agricultural products is not the amount of water available, but the amount of land to cultivate, resulting in countries with water scarcity but land abundance exporting products with a high-water cost (Kumar & Singh, 2005). This, in turn, generates inequality in the distribution of resources, as a large amount of water is used for the production of export products while there are problems of access to water among citizens. In other words, virtual water transfers are not equitable and do not depend on available water resources or social development (Seekell et al., 2011).

In order to solve current problems, having good indicators that allow us to determine what the situation is in a given place and how

to design water policies is essential to adequately address existing problems (Flores Baquero & Pérez Foguet, 2016; Luh et al., 2013). Thus, knowing details about the differences in access to water related to the existing inequality both in terms of economy and access to water would allow improving governance with the aim of achieving sustainable development goals (Cole et al., 2018; Yu et al., 2014). The socioeconomic characteristics of households and the cost of service are essential factors linked to service affordability (Dungumaro, 2007; Ezbakhe et al., 2019; Sebri, 2015) of which very little information is available for international analysis (Schiel et al., 2021). In addition, there is inadequate information on the cost of production in terms of water, so precise analyses about virtual water trade are very limited. The key is to have a complete measure of the overall service situation, which can be observed through water availability, physical access, quality, safety, affordability and acceptability (Giné-Garriga & Pérez-Foguet, 2019). These criteria can be measured through various indicators, but it is complicated to have them available in an international perspective. This problem appears even in local contexts, since the places where access to water suffers the most are places with scarce financial resources, so that having good information in that context is complicated (Jiménez & Pérez-Foguet, 2010). Added to this is the fact that different policies are carried out in each place, so the measurement performed must be able to assess this issue (Flores et al., 2013).

3 | DATA AND METHODOLOGY

In order to carry out the proposed analysis, information was collected from various international institutions (JMP, FAO and World Bank) that deal in some way with the issue of access to and consumption of water. Based on this information, a specific methodology has been followed in order to present our analysis.

3.1 | Data

The data used in this article come from three international institutions, each providing information on specific issues. The data on access to water comes from the Joint Monitoring Programme for Water Supply and Sanitation (JMP), an initiative of the United Nations (UN) and United Nations International Children's Emergency Fund (UNICEF). These data measure not only access to water itself or to water-related sanitation services, but also issues related to the quality of access to these services. We will use, in particular, the proportion of the population that has access to water, how much of this water is supplied through pipes and the proportion of the population that has access to basic sanitation. These data are presented in two different ways. The first is to show the information by country, while the second will show the data by income level, so that inequality can be included in the analysis. It should be noted that sometimes the data on access to water or sanitation show the values '<1' or '>99', which have been changed to 0.5 and 99.5, respectively, so that calculations and maps can be made with them. Information on food trade and food supply to the population comes from the Food and Agriculture Organisation of the United Nations (FAO). All information on water consumption, agriculture and the Human Development Index (HDI) comes from AQUASTAT, FAO's database on water-related issues. Finally, data on income, gross domestic product (GDP) and human capital are obtained from the World Bank database. In total, 27 variables are available, descriptions of which are shown in Table A1. The variables on access to water and sanitation are from 2020, while the rest of the available data are from 2018 due to availability constraints. The variables selection has largely depended on the information available in the databases of the mentioned institutions. The aim has been to collect variables that are relevant to explain access to water. This requires, first, having variables to measure access to water and, second, knowing information about the determinants of access to water, which, as seen in the literature review, revolve around income and area of residence (Adams, 2018; Adams et al., 2016; Adil et al., 2021; Antunes & Martins, 2020; Chaudhuri & Roy, 2017; Dungumaro, 2007; Luh et al., 2013; Pullan et al., 2014; Sintondji et al., 2017). Unfortunately, there is no disposable income variable for all countries, so GDP is also used. In addition, given the relationship between a country's income or GDP and its economic structure, details on the agricultural sector and the Human Capital Index (HCI) have been included as indicators of economic backwardness (in addition to the development backwardness through the Human Development Index), which would be related to lower income. It is worth detailing the HCI, which is included in this analysis as an education indicator. This index calculated by the World Bank contains three components (World Bank, 2018): (1) survival rate of children under 5, since children who do not survive are not able to obtain education; (2) schooling, both by the number of years attended school and the quality of that schooling, measured through the scores obtained by students in international standardised tests; (3) health, a factor related to the possibility of obtaining education, measured through the survival rate of people aged 15–60 and the growth of children under 5, which is an indicator of quality of life during childhood. This indicator is thus a measure of how productive children born today will be as members of the labour force in the future, as it combines health indicators with education indicators. From an economy with a relatively high weight of the agricultural sector, a surplus foreign trade in terms of food products would be expected, so the trade balance of this type of products is included, as well as the food supply of the population. In order to explain access to water, the availability of resources is also relevant, justifying the inclusion of variables on the amount of available resources and water stress, among others. Finally, of course, in addition to including water access variables distinguishing between urban and rural areas, the population residing in each area, as well as population density, are also considered.

3.2 | Methodology

Based on the different sources of information and variables available, three main techniques of analysis will be followed. First, basic descriptive statistics will be shown for all the variables of interest, something of great importance if we consider that not all the variables are

available for all the countries in the world. Thus, in the descriptive statistics we will see variables such as the mean, the standard deviation, the range of values or the number of countries for which this information is available. This will allow us to have an overview before going into detail. Once this basic information has been displayed, and given that we have information for a significant number of countries, a series of world maps will be displayed that will allow us to present the world distribution of certain variables of interest. This, in turn, will allow us to establish the links between variables, so that we can obtain a more complete picture of the situation in terms of access to water and water governance. The maps are based on the Mapinseconds web tool. A total of six maps are shown, the first three relating to access to water and sanitation (data from the JMP), the fourth to GDP (data from the World Bank), the fifth to the weight of agriculture in the country's GDP (data from AQUASTAT) and the sixth to the HCI (data from the World Bank).

The third consists of two econometric estimations to establish the relationships that can only be intuited by maps and descriptive statistics. These relationships significantly condition the choice of technique, because if access to water and income poverty influence each other, it is necessary to estimate using a simultaneous equations model. Specifically, two stage least squares (2sls) estimations have been performed, which allows addressing the bias arising from the simultaneous determination of the main variables of interest, which in this case will be GDP per capita (used instead of income due to the availability of this data for more countries), the percentage of total population with access to water and the HCI. These will be the endogenous variables that the model will try to explain, for which it is necessary to have other variables (exogenous) that act as instruments and allow obtaining an estimate of the 3 endogenous variables to be included in the model and thus avoid the aforementioned simultaneity bias. This model is used twice based on the following formulas:

$$W_c = X_c\beta + \varepsilon_c \quad (1)$$

$$\mathrm{GDP}_c = X_c\beta + \varepsilon_c \quad (2)$$

$$\mathrm{HCI}_c = X_c\beta + \varepsilon_c \quad (3)$$

Where W represents water access; GDP the gross domestic product; HCI the Human Capital Index; X is a vector of individual explanatory variables (each equation with its own variables, as can be seen in Table 3) plus a constant term; β is a vector of parameters and ε is a random error term. The sub-index c refers to the unit of analysis used, the countries.

Therefore, each estimation using 2sls is performed twice based on the three formulas described above. The first one consists of explaining access to water, GDP and human capital using only access to water and GDP as regressors, while the rest of the variables will be included only as instruments. The second estimation will add these variables as regressors in the appropriate equations (Table 3) to increase the explanatory power of the models, since the first estimation will be limited and will only allow establishing a basic relationship. If we just express economic poverty as a function of access to water or vice versa, the mechanism by which both variables are related is out of the analysis. In addition to the three endogenous variables, the estimations include the percentage of urban population, population density, total water withdrawals per capita, food trade balance, agricultural value added (as a percentage of GDP), water use efficiency and food supply.

4 | RESULTS AND DISCUSSION

4.1 | Descriptive statistics

First, Table 1 shows the descriptive statistics for all the variables included in the analysis. This allows us to get a general idea of what the situation is in terms of access to water in the world. We know the percentage of the population that has access to water in a significant number of countries, which indicates several factors. Globally, countries have an average access to water for basic needs of about 90%. However, there is great inequality, as the country with the worst access to water has only 37% and the standard deviation is 15, that is, there is a certain imbalance in access to water despite the fact that it is recognised as a human right. If we look more closely at access according to whether one lives in rural or urban areas, we find that access is significantly higher in urban areas. Furthermore, there is less dispersion in urban areas. This is a result that has been found on other occasions due to the greater ease of providing the service in urban areas and which is associated with various shortcomings in the country (Chaudhuri & Roy, 2017; Luh et al., 2013; Pullan et al., 2014).

Second, the variables related to agricultural activities and available and consumed water resources are highly dispersed. This is reasonable, as less developed economies tend to have an agricultural sector with a relatively larger value added as a share of GDP, and the distribution of water resources is not equitable across the world. Per capita water abstraction and water stress are two very important variables that show a wide dispersion, which we will detail below using the maps we have produced. In modern economics it is common to value the financial return we get from water, which shows, both for the overall return and for the return from irrigated agriculture, important differences between countries. From the descriptive statistics it is not possible to assess the inequalities between countries, but we can expect a concentration of negative aspects in developing countries that hinder progress to a large extent, as we will see below. This is because the lower economic progress of developing countries could be related to a higher relative weight of agriculture and lower efficiency. Considering that developing countries are also the ones where water access problems are concentrated, it is to be expected that water stress will be reduced in countries with large water access problems and a small agricultural sector. However, a developing country with a large agricultural sector could show high water stress.

Finally, the variables of: (i) income, (ii) GDP, (iii) human capital, (iii) trade balance of crops and livestock products; and (iv) food supply, also show differences, but not at the level of the previous ones,

TABLE 1 Descriptive statistics of the variables included in the analysis.

Variable	Observations	Mean	Standard deviation	Min	Max	Mode
At least basic access to water–National	211	89.73	15.00	37.20	99.50	99.50
At least basic access to water–Rural	164	81.24	21.42	21.98	99.50	99.50
At least basic access to water–Urban	175	94.55	7.94	49.66	99.50	99.50
Percentage of water supplied through pipelines–National	198	78.65	25.30	5.18	99.50	99.50
Percentage of water supplied through pipelines–Rural	159	64.07	31.99	0.70	99.50	99.50
Percentage of water supplied through pipelines–Urban	167	84.89	20.67	8.67	99.50	99.50
At least basic access to sanitation services–National	202	78.95	27.38	8.91	99.50	99.50
At least basic access to sanitation services–Rural	161	68.78	32.45	3.56	99.50	99.50
At least basic access to sanitation services–Urban	172	81.01	23.82	18.54	99.50	99.50
Arable land area	197	7031.77	20812.36	0.00	157736.80	2.00
Percentage of area cultivated	198	18.30	15.37	0.09	62.33	60.00
Percentage of urban population	200	59.22	23.75	0.00	112.65	–
Population density	200	300.41	1470.01	2.03	19083.37	–
Agriculture value added	195	10.89	11.43	0.02	64.49	–
Total renewable water resources per capita	197	17030.54	48712.22	0.00	504881.00	0.00
Agricultural water withdrawal as percentage of total water withdrawal	180	52.68	33.35	0.00	99.48	0.00
Total water withdrawal per capita	180	431.70	500.22	8.13	4777.73	–
Freshwater withdrawal as percentage of total renewable water resources	178	61.26	327.66	0.01	3850.50	–
Water stress	178	69.32	327.21	0.03	3850.50	–
Water use efficiency	168	45.56	100.45	0.19	1096.77	–
Irrigated agriculture water use efficiency	174	1.12	4.04	0.00	47.33	–
Human Development Index	188	0.71	0.15	0.38	0.95	0.724
Adjusted net national income per capita	144	11067.59	14280.76	205.36	64638.05	–
GDP per capita	203	16518.33	23785.79	281.97	171716.00	–
Human Capital Index	167	0.57	0.15	0.30	0.89	–
Trade balance of crops and livestock products	193	−1211.45	86700.00	−976000.00	561000.00	–
Food supply	177	2881.27	457.46	1707.00	3862.00	2770.00

although again it is to be expected that less developed countries show significantly different values than advanced countries. Due to the higher relative weight of agriculture in developing economies, as well as its lower efficiency, it is logical to think that less developed countries will have lower GDP per capita and income. The weakness of the agricultural sector would also be related to food supply and international food trade. In other words, by presenting the information in maps and looking at the geographical distribution of the variables, it is to be expected that relationships will emerge that connect the different aspects we are working on.

4.2 | Distribution of key variables among countries

Descriptive evidence has indicated that there are large differences between countries. To address this issue, a series of maps showing the distribution by country of the main variables are shown below.

Figure 1 shows a measure of access to water. The concentration of water access problems at the national level in most of Africa is striking. Furthermore, in Asia, Oceania and Latin America there is also room for improvement. If we look more deeply at the question of area of residence, it is clear that the problem is concentrated in the same places, but it is much less pronounced when we talk about the urban area, as the descriptive statistics indicated. If we add the question of how much of the water supplied is distributed through pipes (Figure 2), we find that the situation changes slightly. Africa still presents a major problem, but there are now also a number of countries in Asia and Oceania and, to a lesser extent, Latin America that show a significant need for improvement. Again, the situation is less problematic when it comes to urban areas, but in the case of rural areas we can see that there is a significant lack of infrastructure. Finally, the data on access to basic sanitation (Figure 3) show a similar situation to that of access to water, that is, a need for improvement in Africa and in some parts of Asia, and a big difference between rural and urban

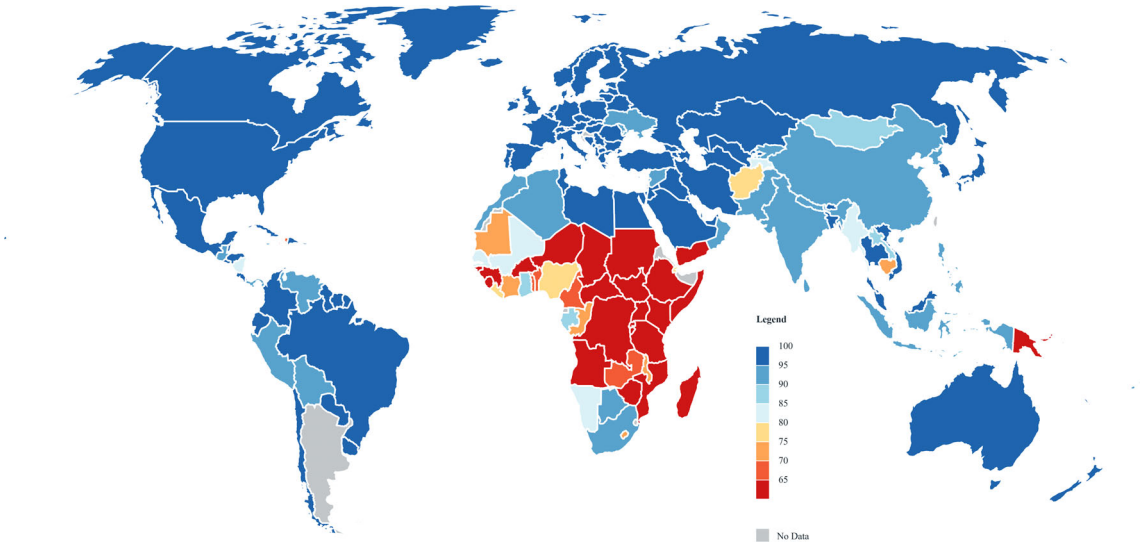

FIGURE 1 Percentage of national population in 2020 per country with basic access to improved water for at least 30 min per day. *Source*: Own elaboration with data from JMP.

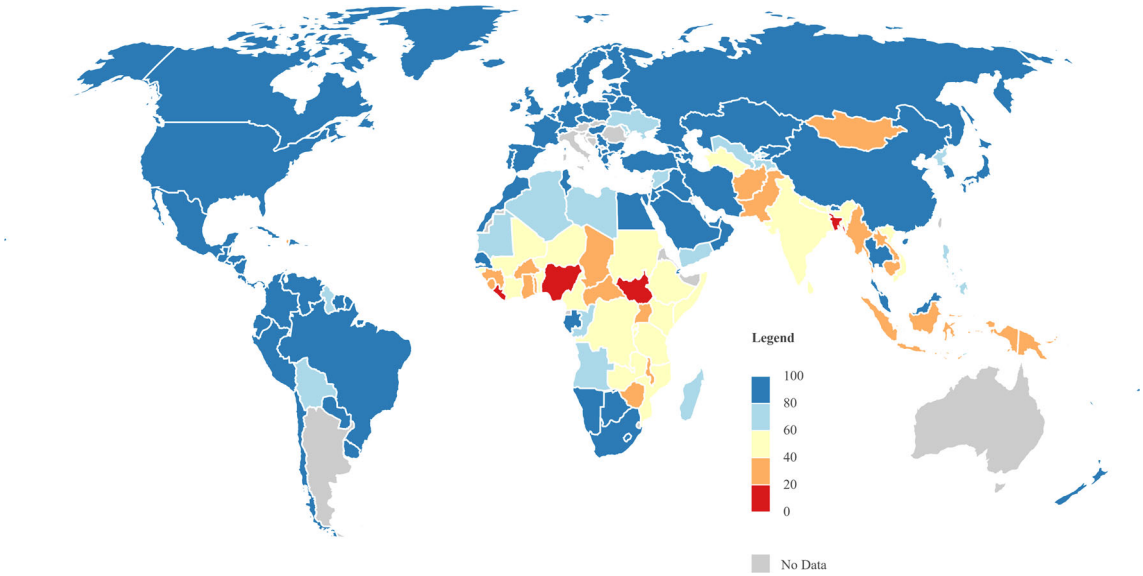

FIGURE 2 Percentage of total water supplied by pipes by country by 2020. *Source*: Own elaboration with data from JMP.

areas. These problems are magnified if we take into account population distribution, as it is the countries with the greatest problems of access to water and sanitation that have the highest percentage of the population living in rural areas.

These issues are related to economic and developmental aspects of the countries. Without adequate financial resources, it is very difficult to have the necessary infrastructure to provide the service in the adequate conditions. However, as can be seen from the distribution of GDP per capita in the world in Figure 4, the economic capacity of the country is not the only factor that explains access to water, as there are many countries with a low GDP per capita but with good access to water. Thus, other factors such as economic and social inequality or the geographic and demographic characteristics of the country may play an important role in the pursuit of full access to water. The economic factor that can be linked to water access problems is the contribution of agriculture to a country's GDP, which is shown in Figure 5. When this contribution is high in relative terms is a symptom of an economy at an early stage of its development. These economies at an early stage of their development may also have a high degree of inequality, which, combined with a lack of public sector investment capacity, conditions access to water for the population in general, but especially for low-income people. At this stage the benefits of economic activities are low and the financial resources needed to invest in infrastructure are very difficult to obtain, and

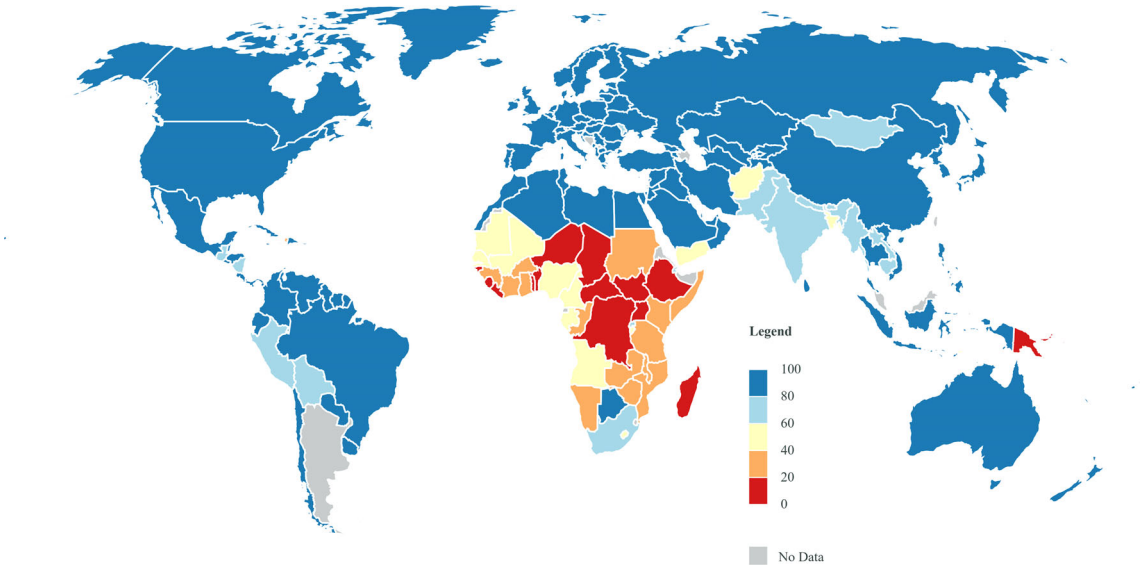

FIGURE 3 Percentage of national population in 2020 by country with basic access to sanitation services. *Source*: Own elaboration with data from JMP.

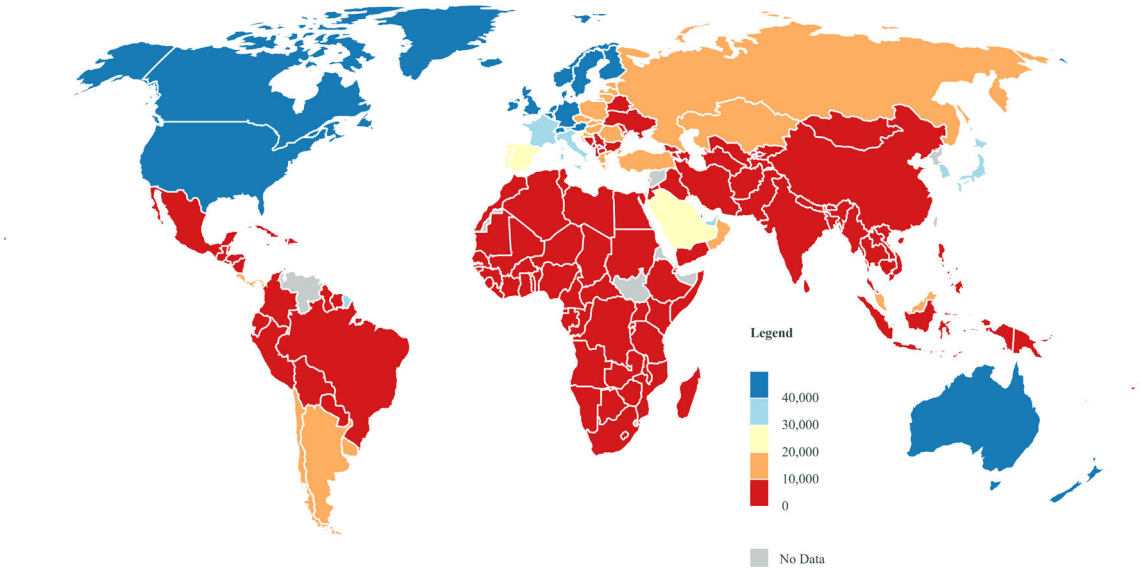

FIGURE 4 2020 GDP per capita by country in constant 2015 dollars. *Source*: Own elaboration with data from the World Bank.

consequently problems of access to basic services arise, as well as being a major constraint to development. The relatively high importance of agriculture as an economic activity can also be seen from the amount of water abstracted to meet agricultural needs. The distribution of this variable shows a great dispersion, but industrialised countries spend a smaller proportion of their water resources on agriculture than countries that are still developing. This may be due to the increased use of modern technology, which reduces water consumption at the cost of higher energy consumption. At this point, it is essential to know the yields obtained from water by different countries, first in general and second, specifically, in agriculture. In terms of overall yields, we again find higher yields in industrialised countries and very low yields in developing countries, with a few exceptions. There are many determinants that explain agricultural performance, but in an international perspective, aspects such as cropping patterns, climate and the level of modernisation of agriculture stand out, the latter being higher in industrialised countries. Given that industrialised countries have a more developed industry and service sector, activities with a higher value added than agriculture, it is reasonable that more developed economies get a higher return on water. In terms of water efficiency to meet agricultural demands, what we find is very low efficiency in most countries and only a few stand out with higher profits. However, many of the countries with water access problems have very low agricultural water yields, which, together with the over-

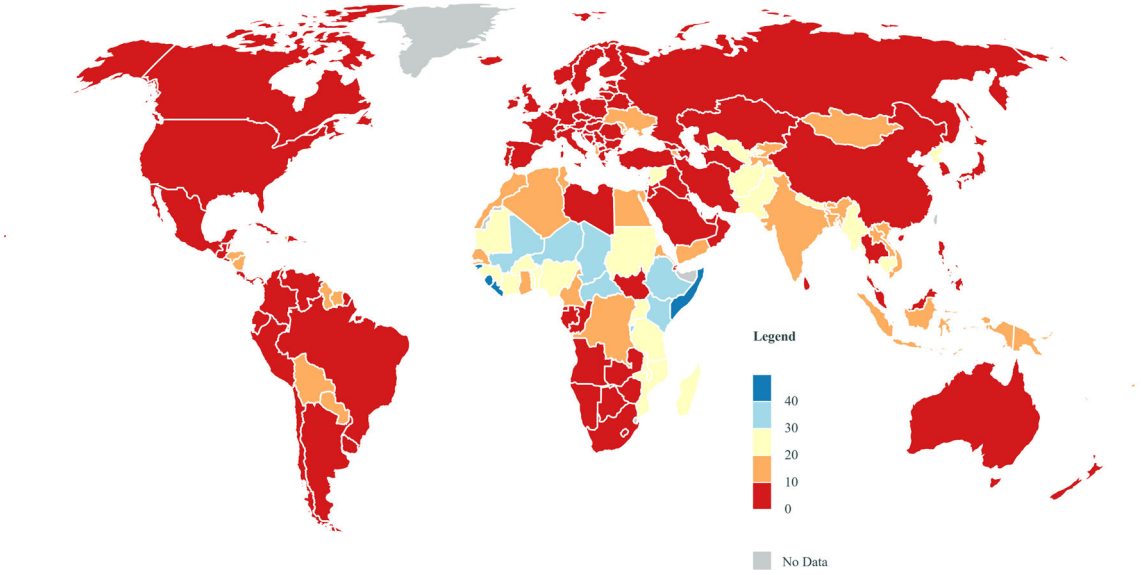

FIGURE 5 Share of agriculture in total 2020 GDP by country. *Source*: Own elaboration with data from AQUASTAT.

emphasis of their agricultural sector, explains their low GDP and low capacity to invest in infrastructure. In other words, countries with water access problems have an economy with an agriculture that, in addition to low yields, is excessively important in the country's total production.

Countries with a weak but important agricultural sector and with problems of access to water and sanitation do not show, in general, a great abundance of water resources either, but this lack of development explains low per capita water withdrawals and, consequently, very low water stress in most African countries. However, given the perspectives of population growth and low water use efficiency, water stress can be expected to increase in the future. In addition, we must bear in mind that climate change affects the poorest countries the hardest (Tol, 2018). In Asia, on the other hand, water withdrawals are higher and, since the available resources are not particularly high either, this explains a higher water stress compared to African countries. North African countries do have high water stress, but they also have better access to water than the rest of the continent, which is explained by the capacity of these countries to invest in infrastructure, especially desalination plants. Therefore, we have seen that neither GDP nor the amount of resources available are, on their own, factors that can explain inequality in access to water in the world. There must be other reasons for these problems of access to water, highlighting the country's internal inequality, which links the problem of access to water to a problem of governance, especially since the wealthy sector of the population has good access to water almost everywhere.

Given this situation, one would expect developing countries to benefit from agriculture through international trade, but since the performance of their agriculture is low and water-intensive, the price obtained for exported products is also low and what we can observe is that countries like India or several African countries have a negative crops and livestock products trade balance. These low-priced, water-intensive products are imported by countries with greater pressure on their water resources, thus benefiting from virtual water trade and conditioning the cropping pattern of developing countries. Despite this, the food supply in these countries is low, which can pose health problems and a major constraint to development, especially when seen in conjunction with problems of access to water. All these data coincide with the global distribution of the HDI which, without showing a direct link with all the variables used, shows that the same countries that present most of the problems mentioned are the countries with the lowest level of development. The same issue, but in an even clearer way, emerges from the HCI, shown in Figure 6. In virtually all of Africa and parts of Latin America and Asia we find reduced human capital, which limits the capacity to solve existing problems. This last map indicates a correlation between human capital (education) and the two main variables, GDP per capita and access to water, which justifies its inclusion as one of the central variables in the analysis.

4.3 | Econometric estimations

The relationship between economy and access to water is well known, but the details on how this link is produced are limited. For this reason, econometric estimation using the available data seeks to bring a greater level of detail to this relationship. First, Table 2 shows simple estimates to test the basic relationships. As would be expected, access to water is significant in explaining GDP and vice versa, and both variables are significant in explaining human capital. However, the explanatory power is very low in the models of access to water and GDP, so although they appear to be related variables, the key lies in identifying how lack of access to water affects GDP and how GDP limits progress in terms of access to water. Human capital, related to both variables, is a key factor in the vicious cycle that connects water and economic poverty.

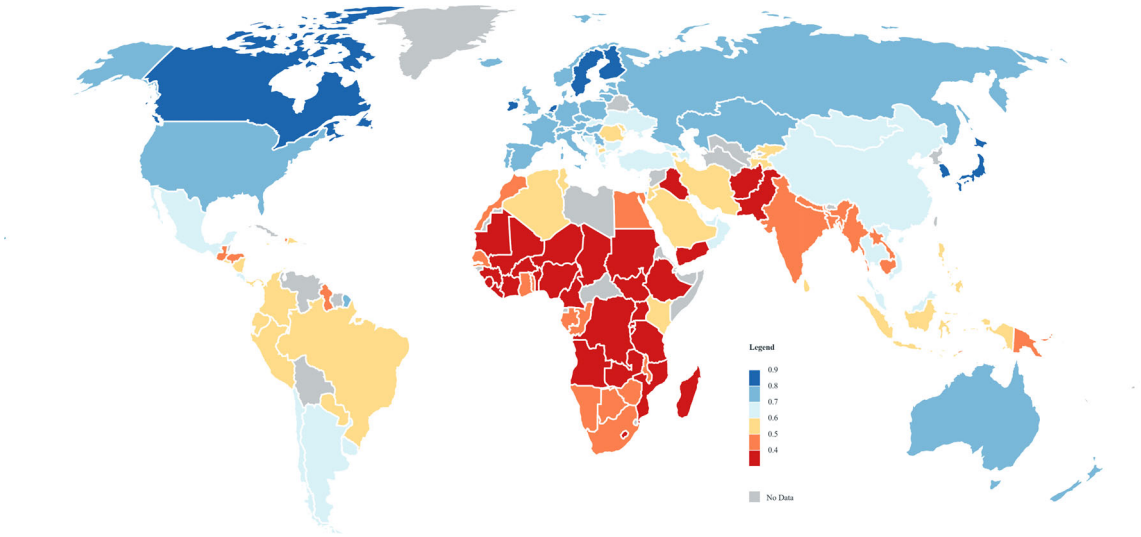

FIGURE 6 Human Capital Index per country in 2020. *Source*: Own elaboration with World Bank data.

TABLE 2 Estimation of Equations 1, 2, and 3 using 2sls including only the endogenous variables as regressors.

	At least basic access to water–National	GDP per capita	Human capital index
GDP per capita	0.001		0.000
	(0.000)***		(0.000)***
At least basic access to water–National		880.197	0.008
		(116.716)***	(0.001)***
Human Capital Index			
Constant	80.234	−63422.598	−0.145
	(1.569)***	(10370.935)***	(0.063)**
N	137	137	137
R^2	0.17	0.17	0.68

**$p < .05$; ***$p < .01$.

In order to extend the previous results, this second estimation shown in Table 3 incorporates a greater number of variables as regressors in each of the equations. In this case, the explanatory capacity of the model is greater for GDP and access to water but worsens for human capital. Starting with access to water, it can be observed that the only variable significant at 1% is human capital. The situation varies slightly for GDP, where human capital is significant, but food trade balance and, above all, water use efficiency also show relevance. Finally, in the human capital equation, only access to water appears as a significant variable, but it is significant at 1%. This confirms a series of relationships that place human capital as a fundamental element in the relationship between water poverty and economic poverty. This relationship can be explained in a very simple way, since not having an adequate water supply implies the need to invest time to obtain it. The impact of the lack of access to water is not direct, but rather the loss of time implies not being able to perform a job or receive an education, the final effects of which are both poverty for people without access to water and economic backwardness in society due to lack of knowledge.

5 | DISCUSSION

Therefore, the current situation is that countries with problems of access to water and sanitation not only have this problem, but their economies are at an early stage of development, they have little financial capacity to invest in the necessary infrastructure and they also have insufficient food supply and even a certain dependence on the outside to feed the population, which absorbs part of the available financial resources. In this situation, it is very difficult for these countries to solve the existing problems on their own. Access to water has been internationally recognised as a human right since 2010, but in many countries, this has not been fulfilled yet, as they do not have the capacity to progress due to the presence of other difficulties. Thus, many people find themselves in a long vicious cycle because, as they do not have access to water, the difficulties in obtaining water, which can sometimes require a large investment of time (for example having to walk many kilometres to fetch water) or money (requiring the development of infrastructure), are very high. This investment means either the loss of financial resources to meet other needs or a significant loss of time that could be spent on work or education activities. This is a major constraint to development and creates major problems in both the short and long term, as disposable income and time of households is reduced and people, unable to attend the educational centres, do not acquire human capital. In other words, not having access to water reduces the disposable income of families and prevents many people from receiving an adequate education (as children cannot attend school because they need to fetch water for their households), which leads to a situation of struggle or poverty that, in turn, limits access to water. This has been shown in our analysis, as it

TABLE 3 Estimation of Equations 1, 2, and 3 using 2sls including both endogenous and exogenous variables as regressors.

	At least basic access to water–National	GDP per capita	Human Capital Index
GDP per capita	−0.000		−0.000
	(0.000)*		(0.000)
At least basic access to water–National		−453.256	0.009
		(560.030)	(0.002)***
Human Capital Index	96.603	131237.557	
	(15.328)***	(59079.484)**	
Percentage of urban population	0.110	115.798	−0.000
	(0.062)*	(71.315)	(0.001)
Population density	0.006		
	(0.005)		
Total water withdrawal per capita	0.005		−0.000
	(0.003)*		(0.000)
Trade balance of crops and livestock products		−0.000	
		(0.000)***	
Agriculture value added		293.567	
		(146.702)**	
Water use efficiency		81.249	0.000
		(14.890)***	(0.001)
Food supply			0.000
			(0.000)
Constant	25.941	−34490.881	−0.321
	(5.748)***	(18052.438)*	(0.248)
N	137	137	137
R^2	0.65	0.73	0.56

*p < .1; **p < .05; ***p < .01.

is key to explaining economic backwardness, water poverty and why low-income households are not able to get out of this precarious situation. Public policies, laws and other formal institutions should address this problem, which begins with poor people not having adequate access to water and ends up as a problem that affects society as a whole. Lack of water generates poverty, inequality, lack of education and knowledge and, in short, an economic and social backwardness that impedes development by not meeting basic human needs.

It is therefore a question of governance, since the people who need the improvements are not able to obtain them on their own due to household economic and water poverty, lack of human capital and economic backwardness, criteria that stand as major barriers to development. Progress on this issue is complicated, it is not only that there is poverty and this prevents access to water but both problems feedback on each other. Additionally, the fact that education plays such an important role in alleviating both problems gives the whole issue a very long term component. This explains the slow rate of progress, since it takes many years to obtain an adequate education. Even worse, education is the fundamental pillar for guaranteeing access to water, but the lack of access to water limits ones capability to obtain a education These problems explain the low economic efficiency and the relative oversizing of the agricultural sector, which generates insufficient profits for investments in infrastructure and basic services. However, the problem is not limited to financial benefits, low agricultural productivity leads to food insecurity and the need to import food from abroad, which again leads to a loss of financial resources. If we take into account that food insecurity coexists with problems of access to water, it is logical to think that there are also health problems in these places. All these problems are barriers that limit even further the capacity of governments to act and explain the slow progress in terms of access to water. In other words, we have a vicious cycle in which problems of access to water, the difficulties faced by households, reduced economic efficiency and problems of governance and development all feedback on each other. In this sense, solving one of the problems that form part of the cycle would have major benefits for the other sectors and for the general situation. For example, a dynamic economic activity that generates profits could be a major stimulus for development through the generation of additional financial resources, but this does not apply to most developing countries, which have low human capital, over-emphasis on agriculture and low water efficiency. If access to water were improved, the situation of households would change enormously and have positive effects at all levels. Citizens would be able to get a proper education, which would facilitate to obtain a good job, and thus improve citizen's well-being and the country's economy, generating funds to improve public services and stimulating development.

Inequality plays an important role in this whole process, both in terms of access to water and sanitation services and in economic terms. Thus, from the data on access to water according to income level, shown in Table A2, what we can observe is a greater concentration of low-income people in rural areas. As income levels rise, the proportion of the population living in urban areas increases, so that there is a correlation between access to water, income and place of residence. That is to say, as income decreases, the higher probability of residing in rural areas is coupled with lower income, generating a great inequality in access to water. This is clearly shown by the available data, as both access to water and access to sanitation are significantly better as income increases. Therefore, low-income households are the ones who suffer most from water access problems and are the most affected by the process we have detailed in this article, as they have to make the investment of time and/or money to get water, with all the consequences that this entails.

Figure 7 shows the development of the vicious cycle explained in this article. Not having access to water has consequences on the family economy and the possibility of obtaining an education and/or getting a good job. It is this educational issue that has turned out to be the central component according to the econometric estimation. It is not only that there is a lack of access to water, with its consequences on welfare, but that being forced to invest time in obtaining it is an enormous opportunity cost, the consequences of which are not only

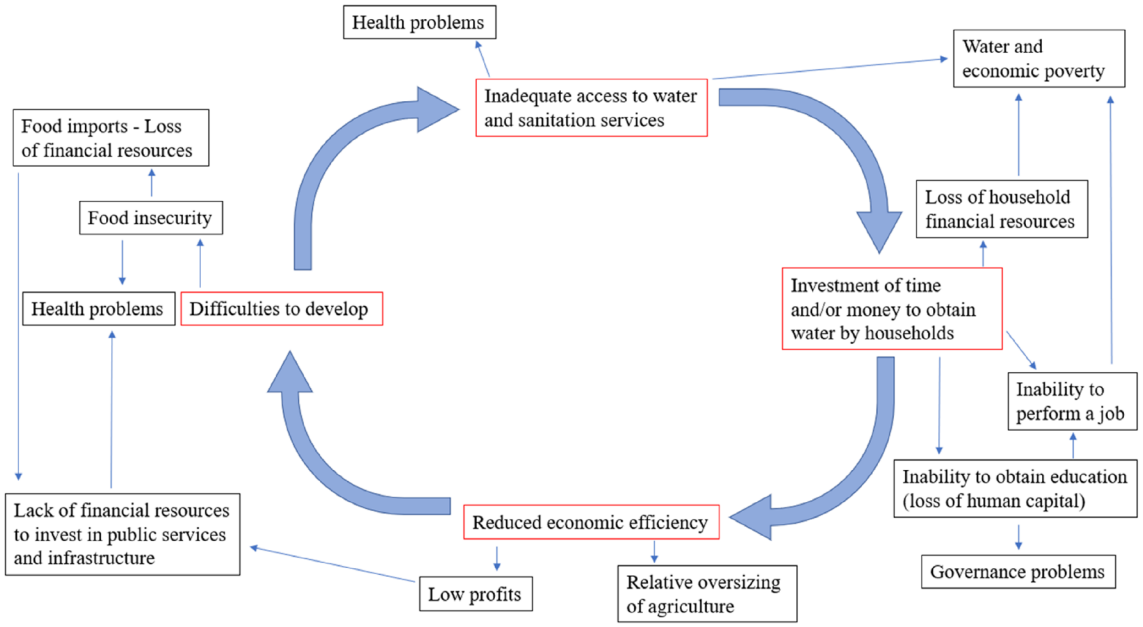

FIGURE 7 Diagram of the vicious cycle of lack of access to water and economic poverty. *Source*: Own elaboration.

problems of poverty and inequality, but also the inability to develop society due to the lack of human capital and public financial resources. This relationship also implies that improvements in access to water must be accompanied by the possibility of receiving an education and/or obtaining a job, otherwise part of the problems will persist, maintaining the limit to development.

6 | CONCLUSIONS

This article has demonstrated the problems of access to water in a significant number of countries. This has been possible due to the information obtained from international organisations such as the JMP, the FAO and the World Bank. From the data obtained from these sources we have been able to untangle the problem of access to water not in isolation, but as part of a set of key problems that severely constrain alleviation of poverty. This is an issue of great importance, since despite recent progress, the human right to water, and the human right to sanitation, have not yet been fully realised and there is still a long way to go, especially in several countries in Africa, Asia, Latin America and Oceania (these two last ones to a lesser extend).

The article has focused on studying the relationship between lack of access to water and economic poverty. The aim has been to indicate that the connection between the two issues is not direct and isolated, but has components of great social importance. The mechanism through which lack of access to water generates poverty and economic backwardness is education. Human capital is an essential factor for the development of a territory and the lack of access to water affects society by preventing it from being obtained. The investment of time needed to obtain water when it is not accessible impedes participation in the labour market or education, so it is not possible to obtain income or knowledge, factors that would allow to get out of this situation. When they are not just isolated cases, the lack of educational insertion is not limited to generating poverty for those specific individuals, but the effect is transferred to society due to the lack of human capital. Therefore, access to water is one of the pillars of a society and its absence affects key institutions such as health services, education and the overall country's economy.

In this way, this article has developed a series of links from international information that are useful for analysing the problem of access to water and, therefore, for dealing with it. The countries with the greatest problems of access to water also have the other problems studied in this research, so it is clear that it will be difficult for them to meet some basic needs and that it is necessary for them to receive help from abroad, not only in financial terms, but also in the form of qualified managers and institutions. The latter type of assistance is key to accelerate the progress of societies with lack of access to water, as obtaining adequate education is a long-term process. Lack of human capital is the main mechanism by which lack of access to water affects the whole society, so receiving an external boost in this regard would have a positive effect. Undoubtedly, financial resources are also necessary to make progress in the provision of basic services, but without properly trained managers these resources will not be well invested, leading to inefficient use of scarce resources and slowing down progress. In other words, monetary aid would not be effective if it is not accompanied by management support from experienced managers. The problem is, in short, much broader than simply access to water, since the effects reach the whole of society through the great opportunity cost of not having such access. It is therefore a question of governance, of implementing the necessary policies to ensure that access to water and education initiate development in the coming years.

The vicious cycle presented in this article leaves open the interesting possibility of studying how countries have evolved in recent

years. As is well known, there has recently been a positive evolution in terms of access to water in various countries, and studying this from information such as that used in this article could be useful to study in depth the relationship between access to water and the general functioning of an economy. However, some of the variables used in this article are not available for all countries, so there are some limitations in the analysis. In any case, working with data showing the evolution of countries over time would be a good continuation of this research using cross-sectional data. Apart from the temporal aspect, the main limitation of this study is the lack of information on variables detailing the consequences of households not having access to water. This lack of access may result in loss of time and/or money.

AUTHOR CONTRIBUTIONS

Marcos García-López: Conceptualization, Methodology, Formal analysis, Investigation, Writing–Original Draft, Visualisation, Funding acquisition. **Gabriela Cuadrado-Quesada**: Conceptualization, Formal analysis, Investigation, Writing–Original Draft, Writing–Review & Editing, Supervision, Funding acquisition. **Borja Montano**: Conceptualization, Writing–Review & Editing, Supervision, Funding acquisition.

ACKNOWLEDGEMENTS

This work was supported by the Office of the Vice President of Research and Knowledge Transfer of the University of Alicante, by the Water Chair of the University of Alicante-Alicante Provincial Council, by the University Institute of Water and Environmental Sciences of the University of Alicante, by the IHE Delft Institute for Water Education and by the Hábitat5U network of excellence.

FUNDING INFORMATION

This work was financed by the Office of the Vice President of Research and Knowledge Transfer of the University of Alicante, Spain (Marcos García-López has a scholarship for The Training of University Teachers from the University of Alicante [UAFPU2019-16]).

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

Data about households come from the INE website (https://www.ine.es/index.htm). The rest of the data come from the World Bank website (https://databank.worldbank.org/source/world-development-indicators), the FAO website (https://www.fao.org/faostat/en/#data) and the AQUASTAT website (https://www.fao.org/aquastat/statistics/query/index.html?lang=en).

ORCID

Marcos García-López https://orcid.org/0000-0001-7184-1809

REFERENCES

Adams, E. A. (2018). Intra-urban inequalities in water access among households in Malawi's informal settlements: Toward pro-poor urban water policies in Africa. *Environmental Development*, *26*, 34–42. https://doi.org/10.1016/j.envdev.2018.03.004

Adams, E. A., Boateng, G. O., & Amoyaw, J. A. (2016). Socioeconomic and demographic predictors of potable water and sanitation access in Ghana. *Social Indicators Research*, *126*(2), 673–687. https://doi.org/10.1007/s11205-015-0912-y

Adil, S., Nadeem, M., & Malik, I. (2021). Exploring the important determinants of access to safe drinking water and improved sanitation in Punjab, Pakistan. *Water Policy*, *23*(4), 970–984. https://doi.org/10.2166/wp.2021.001

Antunes, M., & Martins, R. (2020). Determinants of access to improved water sources: Meeting the MDGs. *Utilities Policy*, *63*, 101019. https://doi.org/10.1016/j.jup.2020.101019

Bartram, J. (1999). The World Health Organization in Europe and its role in water and health. *Environmentalist*, *19*(1), 17–22. https://doi.org/10.1023/a:1006528704346

Cetrulo, T. B., Marques, R. C., Malheiros, T. F., & Cetrulo, N. M. (2020). Monitoring inequality in water access: Challenges for the 2030 agenda for sustainable development. *Science of the Total Environment*, *727*, 138746. https://doi.org/10.1016/j.scitotenv.2020.138746

Chaudhuri, S., & Roy, M. (2017). Rural-urban spatial inequality in water and sanitation facilities in India: A cross-sectional study from household to national level. *Applied Geography*, *85*, 27–38. https://doi.org/10.1016/j.apgeog.2017.05.003

Cole, M. J., Bailey, R. M., Cullis, J. D., & New, M. G. (2018). Spatial inequality in water access and water use in South Africa. *Water Policy*, *20*(1), 37–52. https://doi.org/10.2166/wp.2017.111

Cuadrado-Quesada, G., Holley, C., & Gupta, J. (2018). Groundwater governance in the anthropocene: A close look at Costa Rica. *Water Policy*, *20*(3), 475–489. https://doi.org/10.2166/wp.2018.158

Cuadrado-Quesada, G., & Joy, K. J. (2021). The need for co-evolution of groundwater law and community practices for groundwater justice and sustainability: Insights from Maharashtra, India. *Water Alternatives*, *14*(3), 717–733.

Dellapenna, J., & Gupta, J. (2008). Toward global law on water. *Global Governance*, *14*, 437.

Dungumaro, E. W. (2007). Socioeconomic differentials and availability of domestic water in South Africa. *Physics and Chemistry of the Earth, Parts A/B/C*, *32*(15–18), 1141–1147. https://doi.org/10.1016/j.pce.2007.07.006

Ezbakhe, F., Giné-Garriga, R., & Pérez-Foguet, A. (2019). Leaving no one behind: Evaluating access to water, sanitation and hygiene for vulnerable and marginalized groups. *Science of the Total Environment*, *683*, 537–546. https://doi.org/10.1016/j.scitotenv.2019.05.207

Flores Baquero, O., & Pérez Foguet, A. (2016). Measuring disparities in access to water based on the normative content of the human right. *Social Indicators Research*, *127*(2), 741–759. https://doi.org/10.1007/s11205-015-0976-8

Flores, O., Jimenez, A., & Perez-Foguet, A. (2013). Monitoring access to water in rural areas based on the human right to water framework: A local level case study in Nicaragua. *International Journal of Water Resources Development*, *29*(4), 605–621. https://doi.org/10.1080/07900627.2012.757017

Fuller, J. A., Goldstick, J., Bartram, J., & Eisenberg, J. N. (2016). Tracking progress towards global drinking water and sanitation targets: A within and among country analysis. *Science of the Total Environment*, *541*, 857–864. https://doi.org/10.1016/j.scitotenv.2015.09.130

Gazzeh, K., & Abubakar, I. R. (2018). Regional disparity in access to basic public services in Saudi Arabia: A sustainability challenge. *Utilities Policy*, *52*, 70–80. https://doi.org/10.1016/j.jup.2018.04.008

Giné-Garriga, R., & Pérez-Foguet, A. (2019). Monitoring and targeting the sanitation poor: A multidimensional approach. In *Natural resources forum* (Vol. 43, pp. 82–94). Blackwell Publishing Ltd. https://doi.org/10.1111/1477-8947.12171

Gupta, J., & Pahl-Wostl, C. (2013). Global water governance in the context of global and multilevel governance: Its need, form, and challenges. *Ecology and Society*, *18*(4), 53.

Hargrove, A. (2020). Economic and social impacts on well-being: A cross-national multilevel analysis of determinants of access to water and sanitation. *Sociological Inquiry*, *90*(3), 497–526. https://doi.org/10.1111/soin.12282

Hutton, G., & Andrés, L. (2018). Counting the costs and benefits of equitable WASH service provision. In *Equality in water and sanitation services* (pp. 286–309). Routledge.

Jiménez, A., & Pérez-Foguet, A. (2010). Building the role of local government authorities towards the achievement of the human right to water in rural Tanzania. In *Natural resources forum* (Vol. 34, pp. 93–105). Blackwell Publishing Ltd. https://doi.org/10.1111/j.1477-8947.2010.01296.x

Joy, K. J., Kulkarni, S., Roth, D., & Zwarteveen, M. (2014). Re-politicising water governance: Exploring water re-allocations in terms of justice. *Local Environment*, *19*(9), 954–973. https://doi.org/10.1080/13549839.2013.870542

Kumar, M. D., & Singh, O. P. (2005). Virtual water in global food and water policy making: Is there a need for rethinking? *Water Resources Management*, *19*(6), 759–789. https://doi.org/10.1007/s11269-005-3278-0

Luh, J., Baum, R., & Bartram, J. (2013). Equity in water and sanitation: Developing an index to measure progressive realization of the human right. *International Journal of Hygiene and Environmental Health*, *216*(6), 662–671. https://doi.org/10.1016/j.ijheh.2012.12.007

Malakar, K., Mishra, T., & Patwardhan, A. (2018). Inequality in water supply in India: An assessment using the Gini and Theil indices. *Environment, Development and Sustainability*, *20*(2), 841–864. https://doi.org/10.1007/s10668-017-9913-0

Maroufpoor, S., Bozorg-Haddad, O., Maroufpoor, E., Gerbens-Leenes, P. W., Loáiciga, H. A., Savic, D., & Singh, V. P. (2021). Optimal virtual water flows for improved food security in water-scarce countries. *Scientific Reports*, *11*(1), 1–18. https://doi.org/10.1038/s41598-021-00500-6

Ostrom, E. (2010). Polycentric systems for coping with collective action and global environmental change. *Global Environmental Change*, *20*(4), 550–557. https://doi.org/10.1016/j.gloenvcha.2010.07.004

Pullan, R. L., Freeman, M. C., Gething, P. W., & Brooker, S. J. (2014). Geographical inequalities in use of improved drinking water supply and sanitation across sub-Saharan Africa: Mapping and spatial analysis of cross-sectional survey data. *PLoS Medicine*, *11*(4), e1001626. https://doi.org/10.1371/journal.pmed.1001626

Requejo-Castro, D., Giné-Garriga, R., & Pérez-Foguet, A. (2020). Data-driven Bayesian network modelling to explore the relationships between SDG 6 and the 2030 agenda. *Science of the Total Environment*, *710*, 136014. https://doi.org/10.1016/j.scitotenv.2019.136014

Schiel, R., Wilson, B. M., & Langford, M. (2021). The determinants of access to sanitation: The role of human rights and the challenges of measurement. *Water*, *13*(12), 1676. https://doi.org/10.3390/w13121676

Sebri, M. (2015). Water affordability and social equity in Tunisian governorates: A distributive approach. *Water Policy*, *17*(1), 26–45. https://doi.org/10.2166/wp.2014.142

Seekell, D. A., D'odorico, P., & Pace, M. L. (2011). Virtual water transfers unlikely to redress inequality in global water use. *Environmental Research Letters*, *6*(2), 024017. https://doi.org/10.1088/1748-9326/6/2/024017

Seyoum, S., & Graham, J. P. (2016). Equity in access to water supply and sanitation in Ethiopia: An analysis of EDHS data (2000–2011). *Journal of Water Sanitation and Hygiene for Development*, *6*(2), 320–330. https://doi.org/10.2166/washdev.2016.004

Sintondji, L. O., Vissin, E., Dan, O. F., Dossou-Yovo, E. R., & Amouzouvi, D. (2017). Socio-demographic characteristics of households as determinants of access to water, hygiene and sanitation in so-ava, Benin. *Journal of Environmental Science and Public Health*, *1*(4), 253–267. https://doi.org/10.26502/jesph.96120023

Soares, L. C. R., Griesinger, M. O., Dachs, J. N. W., Bittner, M. A., & Tavares, S. (2002). Inequities in access to and use of drinking water services in Latin America and the Caribbean. *Revista Panamericana de Salud Pública*, *11*, 386–396. https://doi.org/10.1590/s1020-49892002000500013

Sullivan, C. (2002). Calculating a water poverty index. *World Development*, *30*(7), 1195–1210. https://doi.org/10.1016/S0305-750X(02)00035-9

Tol, R. S. (2018). The economic impacts of climate change. *Review of Environmental Economics and Policy*, *12*(1), 1–22. https://doi.org/10.1093/reep/rex027

UNGA. (2010). United Nation General Assembly (UNGA) Resolution 64/292 (28 July 2010) UN Doc A/RES/64/292. Accessed on 21 April 2022. https://documents-dds-ny.un.org/doc/UNDOC/GEN/N09/479/35/PDF/N0947935.pdf?OpenElement.

UNHRC. (2010). United Nations Human Rights Council (UNHRC) Resolution 15/9 (1 October 2010) A/HRC/RES/15/9. Accessed on 21 April 2022. https://www.europarl.europa.eu/meetdocs/2009_2014/documents/droi/dv/201/201101/20110124_301resonwater15-9_en.pdf.

von Benda-Beckmann, F. (2002). Who's afraid of legal pluralism? *The Journal of Legal Pluralism and Unofficial Law*, *34*(47), 37–82. https://doi.org/10.1080/07329113.2002.10756563

World Bank. (2018). *The human capital project*. World Bank https://openknowledge.worldbank.org/handle/10986/30498

Yang, H., Bain, R., Bartram, J., Gundry, S., Pedley, S., & Wright, J. (2013). Water safety and inequality in access to drinking-water between rich and poor households. *Environmental Science & Technology*, *47*(3), 1222–1230. https://doi.org/10.1021/es303345p

Yu, W., Bain, R. E., Mansour, S., & Wright, J. A. (2014). A cross-sectional ecological study of spatial scale and geographic inequality in access to drinking-water and sanitation. *International Journal for Equity in Health*, *13*(1), 1–15. https://doi.org/10.1186/s12939-014-0113-3

Zwarteveen, M., Kemerink-Seyoum, J. S., Kooy, M., Evers, J., Guerrero, T. A., Batubara, B., & Wesselink, A. (2017). Engaging with the politics of water governance. *Wiley Interdisciplinary Reviews: Water*, *4*(6), e1245. https://doi.org/10.1002/wat2.1245

How to cite this article: García-López, M., Cuadrado-Quesada, G., & Montano, B. (2023). Untangling the vicious cycle around water and poverty. *Sustainable Development*, 1–16. https://doi.org/10.1002/sd.2753

APPENDIX A

TABLE A1 List of variables used in the article, with their respective descriptions.

Variable	Description
At least basic access to water – National	Proportion of national population with at least one access to water resources to meet basic needs (%)
At least basic access to water – Rural	Proportion of rural population with at least one access to water resources to meet basic needs (%)
At least basic access to water – Urban	Proportion of urban population with at least one access to water resources to meet basic needs (%)
Percentage of water supplied through pipelines – National	Percentage of water supplied nationally through pipelines as a proportion of the total amount supplied (%)
Percentage of water supplied through pipelines – Rural	Percentage of water supplied in rural areas through pipelines as a proportion of the total amount supplied (%)
Percentage of water supplied through pipelines – Urban	Percentage of water supplied in urban areas through pipelines as a proportion of the total amount supplied (%)
At least basic access to sanitation services – National	Proportion of national population with at least one access to basic sanitation services (%)
At least basic access to sanitation services – Rural	Proportion of rural population with at least one access to basic sanitation services (%)
At least basic access to sanitation services – Urban	Proportion of urban population with at least one access to basic sanitation services (%)
Arable land area	Arable land area in the country (1000 ha)
Percentage of area cultivated	Cultivated area as a percentage of the total area of the country (%)
Percentage of urban population	Percentage of population residing in urban areas (%)
Population density	Population density (inhab./km^2)
Agriculture value added	Value added of agriculture as a percentage of GDP (%)
Total renewable water resources per capita	Total renewable water resources per capita (m^3/year per inhabitant)
Agricultural water withdrawal as percentage of total water withdrawal	Water withdrawn for agricultural use as a percentage of total water withdrawn (%)
Total water withdrawal per capita	Total water withdrawal per capita (m^3/year per inhabitant)
Freshwater withdrawal as percentage of total renewable water resources	Total water withdrawal as a proportion of total renewable resources (%)
Water stress	Total water withdrawal as a percentage of total available renewable water resources after deducting environmental flow requirements (%)
Water use efficiency	Total water use efficiency (US$/$m^3$)
Irrigated agriculture water use efficiency	Irrigated agriculture water use efficiency (US$/$m^3$)
Human Development Index	Human Development Index (0–1)
Adjusted net national income per capita	Adjusted net national income per capita (constant 2015 US$)
GDP per capita	Gross Domestic Product per capita (constant 2015 US$)
Human Capital Index (HCI)	World Bank Human Capital Index. This index quantifies the contribution of health and education to the productivity of the next generation of workers (0–1)
Trade balance of crops and livestock products	Imports minus exports of crops and livestock products (1,000,000 US$)
Food supply	Food supply perceived by citizens (kcal/capita/day)

TABLE A2 Variables of access to water and sanitation by income level by 2020.

	Low-income	Lower-middle-income	Upper-middle-income	High-income
Population (Millions)	686.09	2954.19	2936.97	1214.60
Urban population (%)	33.76	40.17	67.12	81.27
At least basic access to water – National (%)	59.18	88.02	95.43	99.50
At least basic access to water – Rural (%)	46.99	84.26	90.25	99.50
At least basic access to water – Urban (%)	83.09	93.63	97.97	99.50
Percentage of water supplied through pipelines – National (%)	48.65	46.25	83.94	98.23
Percentage of water supplied through pipelines – Rural (%)	32.82	33.38	67.30	95.26
Percentage of water supplied through pipelines – Urban (%)	70.99	64.02	91.56	98.91
At least basic access to sanitation services – National (%)	30.41	67.82	91.43	99.50
At least basic access to sanitation services – Rural (%)	22.53	63.01	85.39	97.72
At least basic access to sanitation services – Urban (%)	45.87	74.98	94.40	99.50