Universitat Autònoma de Barcelona

TÍTOL DEL TFG: Socioeconomic indicators as determinants for water access in rural areas of developing countries: a panel data approach

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1. EXECUTIVE SUMMARY

Millions of people in developing countries still lack access to a safe drinking water, especially in rural areas. Many advancement has been made on this topic the last few years due to the creation of the Millennium Development Goals and Sustainable Development Goals. However, national characteristics of countries may strengthen or hinder this progress. This paper investigates whether certain socioeconomic indicators are related with access to improved water sources in developing countries. More specifically, total improved, piped on premises and other improved sources of access in rural areas for low income, low-middle income and high-middle income countries are examined. The analysis is based on regression models using panel data estimation techniques controlling for country and time specific effects and for problems of autocorrelation and heteroskedascity. Econometric results suggest that, in general, GNI, female primary completion rate, agriculture, growth of rural population, political stability and control of corruption are variables related to water access, although specific associations depend on the source of water and income group examined. Official development assistance presented no significant relation with water access, expect the case for low income countries, in which presented a positive relation to total and other improved sources. Female education presented a positive relation with water access for all countries and water sources while agriculture presented a negative one. Control for corruption results showed that piped on premises sources are more affected by the lack of control that other improved sources. The understanding of these interrelations could be of great importance for decision makers in the water sector as well as for future investigation on the topic.

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2. INTRODUCTION

Water is a basic resource, essential to all environmental, human and social processes. It is a fundamental element for life to exist as well as for human development to thrive. Its basic functions related with food and sanitation makes it an irreplaceable good, as well as an essential resource for economic activity: agriculture and many other industrial and commercial activities make use of hydric resources as raw material. Moreover, water constitutes also a source of energy.

It is essential to remark that, with regard to household water use, which will be the focus of this study, water access is an important determinant of personal development and behavior. The importance of water access goes on beyond its mere vital function and this fact becomes even more evident when not all people have access to water in equal conditions. For example, not having access to water on premises may force some member of the family to have to spend many hours a day fetching water instead of using this time for an income generating activity, going to school or for leisure time.

However, even though in industrialized countries water provision is practically universalized, this is not the case for many other regions in the world. According to the World Health Organization (WHO) and UNICEF Joint Monitoring Programme (JMP), approximately 663 million people in the world lack access to safe water in 2015 (WHO and UNICEF, 2015). A vast majority of these are individuals that reside in developing countries and live in rural areas. Approximately 91% of the global urban population uses improved water sources compared to 84% of the global rural population. (WHO and UNICEF, 2015)

The situation described before is even more alarming than what initially this data shows as it is taking into account total improved water sources and not piped on premises sources. According to the WHO and UNICEF, improved water sources is understood as one that is protected from outside contamination, particularly fecal matter (WHO and UNICEF, 2015). These could be sources of water such as rainwater or protected public taps or dug wells that may not necessarily lie close to where the population may live. Undoubtedly, the criteria for quantifying water access in the world may be initially misleading. In this sense, a more significant figure may seem the piped on premises water source which reduces the percentage of global water access from 91% to 58% of total population and only 33% of total rural population. Moreover, in rural zones of developing countries, there is only 28% of population with access to piped on premises water sources and 3% in the least developed countries (WHO and UNICEF, 2015).

Regardless of having improved or even piped water sources, it does not necessarily imply a good quality of it. Therefore, it can happen that water that may reach homes or dugs are in a non-suitable condition for human consume. This may imply that many households may need to boil or filter the water previous to consumption, indicating more obstacles for water provision. Moreover, the existence of piped on premises or dug sources also doesn't necessarily mean a regular water provision. Circumstances such as rain shortages, bad planning from water management or lack of resources for the maintenance of infrastructures, can create an irregular provision.

It is not possible to think of socioeconomic development without a healthy population. The relation between health and development has such a strong link that is not possible to consider one without the other. The improvement of health in a community depends on development and, at the same time, health is an essential requisite for development. Bad quality of water is one of the most common causes for diseases and deaths in developing countries. Inadequate drinking-water, sanitation and hygiene are estimated to cause 842.000 diarrheal disease deaths per year in low and middle income countries and among children under-five it accounts for 361.000 deaths a year, or over 1000 child deaths per day. (WHO, 2014)

After the previous arguments, it may seem reasonable to think that every human being should have the right to access to water sources. An important step on achieving universal access was on July 2010. Then, the United Nations General Assembly recognized the basic human right to water and sanitation. In this resolution, the UN "calls on States and international organizations to provide financial resources, build capacity and transfer technology, particularly to developing countries, in scaling up efforts to provide safe, clean, accessible and affordable drinking water and sanitation for all" (A/RES/64/292).Even though several treaties, previous to this date, contemplated this fact, this resolution was essential in order to make it binding and therefore that all the means possible were to be applied in order to make effective the access to drinkable water.

During the millennium summit of the United Nations Assembly (UN) held in the year 2000 another important step in universalized water access was made. Leaders from 189 countries, recognizing the urgency to stablish measures oriented to alleviate poverty and advance towards socioeconomic development, stablished eight goals called the Millennium Development Goals (MDG's) with specific and quantifiable objectives and set them to be fulfilled in 15 years. Access to water was included in these goals in Target 7.3, which stated that the goal was to reduce by half the proportion of people without sustainable access to safe drinking water and basic sanitation by 2015 (UNDP, 2015). Assessment in 2015 for this target showed that globally, 147 countries met the MDG sustainable drinking water target and a total of 2.6 billion people gained access since 1990. However, only over half of the global population enjoys water supply piped on premises (58%). The last step in this process has been made in September 2015 where those leaders assessed the development of the MDG's and even though many of the goals were achieved, the finish line was nowhere near. A new set of seventeen goals was agreed on this date called the Sustainable Development Goals (SDG's) with 2030 as a target date. Included in these set of goals was the aim to achieve universal and equitable access to safe and affordable drinking water for all (UNPD, 2016).

As the previous information stated evidences, the lack of improved water sources, especially in developing countries, is a global problem with very severe consequences for human development. Extensive efforts are being put by numerous organizations such as WHO and UNICEF or the UN in order to decrease the magnitude of this problem and make water access a universal one. In the last two decades, much progress has been made on this issue (UNPD,2015) and many countries have seen their access to water sources increased. The national characteristics of countries may intensify or obstruct this progress. However, not much literature has been dedicated to the study of these determinants and the relation it may hold with access to water using panel data analysis and taking into account rural and urban zones. Understanding the underlying motives of such problematic may provide a basis for setting objectives and policy priorities.

The objective of this study is to provide a response to the question of what the determinants of water access are for developing countries and, if possible, identify possible causality relations. This will be done by performing regression analysis using a panel data approach in order to evaluate whether the percentage of population that has access to improved water sources in developing countries is associated with a series of national social and economic indicators. As substantial differences between provision in rural and urban zones and improved and piped on premises sources exist, the analysis regressions will be carried out separately for each zone and taking account different sources. Central analysis will the focused on rural areas, as population with access is much lower in these zones. Moreover, from the whole list of countries that will be studied, these have been grouped as low-income, low-middle-income and high-middle income countries as classified by the World Bank. Regressions will be made for the global list and for each classification. Performing the regression analysis also for groups of countries in the same economic standard will allow for a greater degree of specification of the water access problematic, and may also help guide the development of policies that are more focused.

Data is analyzed from the year 1990 to 2015, and 135 countries throughout the world are included. To obtain data related to the variables analyzed, information available in publicly accessible databases of the World Bank (2015), WHO and UNICEF JMP (2015), and the OECD (2015) were obtained. A database was elaborated using all the information drawn from these sources.

The structure of this paper is as follows. Section 3 of this paper will briefly outline the most significant aspects of the. Section 4 will present the countries included and their classification as well as the variables included and the methodology used. In section 4, the main results of regressions analysis will be discussed and finally, section 5 will present a discussion of the study findings, limitations and further research lines.

3. LITERATURE REVIEW

It is essential to understand the underlying causes of the different percentages to access to water in order to provide more effective solutions to this worldwide problematic. Reviewing the literature, previous studies conducted around the issue of determinants for water access have been identified. A study by Luha and Bartrama (2015) for the WHO and UNICEF also centers its analysis in understanding the determinants for water access but using a dependent variable that is not access to water resources but an indicator of progress for the years 2000-2012. Independent variables consist of 9 indicators previously chosen. Results of this study indicate that none of the indicators used in the regressions performed held any significance in relation with indicator of water progress. It suggested that this could be due to the fact that data for the independent variables are taken for the last year available and not for the whole period in which the study was being analyzed. This paper intends to provide results that may contrast with the ones provided by these authors as using a different approach to the same aim initially set out and taking into account a longer period: 1990-2015 as well as different indicators than those taken by these authors. Though the paper by Luha and Bartrama (2015) is the main literature by which this paper takes its basis, other papers also addressed the water problematic by assessing the relation between indicators and water access: Bain, Luyendijk and Bartram, (2013), Wayland (2014) and Ndikumana and Pickbournwho (2015) focused on the relation between foreign aid and access to water and Dondeynaz, Carmona Moreno and Céspedes Lorente (2012) developed a study based on principal components (factor) analysis of the indicators for water access, but provided few insights on relation between water access and the indicators.

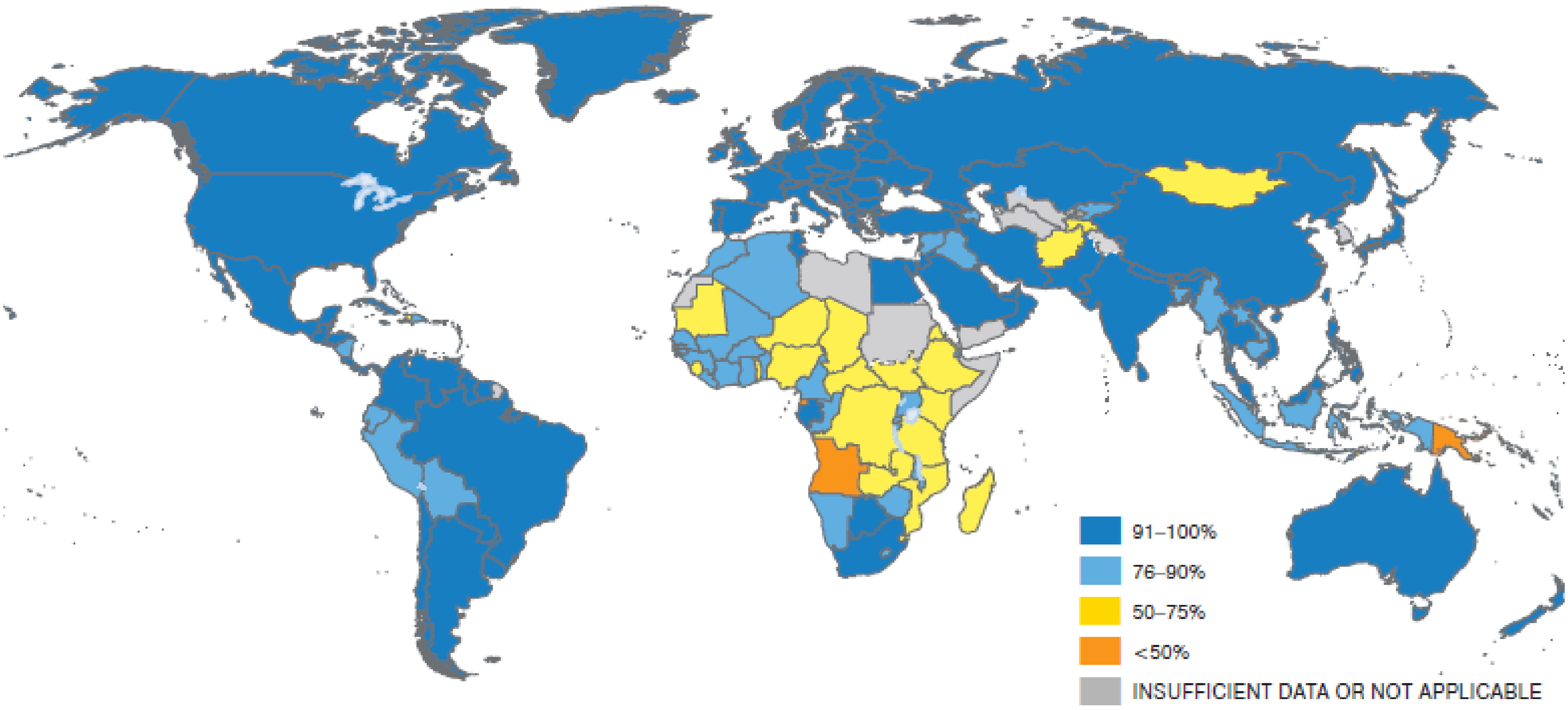
Although some literature on the study of determinants to water access and their relation with such, was found, none of it developed the analysis using a panel data approach and instead provided insights taking into account individual years which may undermine the global perspective of the problematic. Moreover, no specific literature was found that addressed water access as a disaggregated variable depending on the zone of the country being studied, whether urban or rural, and the type of water access, whether piped on premises or improved, although many differences in water access between these are known to exist. Additionally, performing regressions by income-country groupings may also provide different insights on the problematic of improved water service access. This paper takes on a different approach that has not been examined up to date as such in the existing literature found.

4. EMPIRICAL ANALYSIS

4.1. Countries selected for the analysis

The information facilitated by the WHO and UNICEF helps identify the regions in which the population is more vulnerable in the access to water services. As it can be evidenced in Figure 1, Sub-Saharan Africa is the region in the world with worst water access. It can also be evidenced that in some countries of Southeast Asia and South America important efforts in order to improve water services are needed.

Fig. 1 Proportion of the population using improved drinking water sources in 2015



Source: WHO and UNICEF, 2015: 6

In order to perform this study, the classification of countries by the World Bank (2015) was chosen, more specifically, the classification by income group. Economies are divided into four income groupings: low, lower-middle, upper-middle and high. Income is measured by the Gross National Income (GNI) per capita, in U.S. dollars, converted from local currency using the World Bank Atlas method (World Bank Group, 2015). Although it is known that GNI does not completely summarize a country's level of development or measure welfare, it has been proven to be useful and easily available indicator. However, there are some limitations associated with the use of GNI that should be considered. For instance, GNI may be underestimated in lower-income economies that have more informal, subsistence activities. Nor does GNI reflect inequalities in income distribution. (Datahelpdesk.worldbank.org, 2016a).

Countries are reassigned on July 1 each year, based on the estimate of their GNI per capita for the previous year. For the current 2016 fiscal year, low-income economies are defined as those with a GNI per capita, calculated using the *World Bank Atlas* method, of $1,045; middle-income economies are those with a GNI per capita of more than $1,045 but less than $12,736; high-income economies are those with a GNI per capita of $12,736 or more. Lower-middle-income and upper-middle-income economies are separated at a GNI per capita of $4,125 (World Bank Group, 2015). High-income countries were eliminated from this study since the population that had access to water services was practically 100% for the vast majority.

In the classification of low-income there are 31 countries included (Fig.1; App.1), 51 in the classification of lower-middle-income (Fig. 2; App.2) and 53 in the higher-middle-income (Fig.3; App.1). The majority are from Sub-Saharan Africa, and some are from South America and Southeast Asia. Regressions will be performed for the global list of countries and for every income level in order to highlight difference in results.

4.2. Dependent variables

As what it is being studied in this paper are the indicators that may hold significance with respect to access to improved water services, all dependent variables that will be used in the different models provide information of the different levels of population that has improved water access, for different zones and type of water access. An improved water source includes piped water on premises sources (piped household water connection located inside the user's dwelling, plot or yard), and other improved drinking water sources (public taps or standpipes, tube wells or boreholes, protected dug wells, protected springs, and rainwater collection stored in tanks or cisterns until used). Unimproved drinking-water sources include unprotected dug wells and springs, carts with small tank or drum, tanker truck, surface water(river, dam, lake, pond, stream, canal, irrigation channel) and bottled water which come from unimproved sources(WHO and UNICEF, 2015). The dependent variables used in the models of this study is divided into three categories that show source type of water access: total improved, piped on premises and other improved and is presented for total population, rural and urban population.

4.3. Independent variables

The variables that have been chosen to be part of this study as independent variables all will be defined and briefly analyzed in the following sections. They all represent an indicator of development. Initially, 19 variables were chosen as independent variables. The first basic criteria in order to include them in the different models of regression was the availability of their data for several years and for the countries needed. However, unfortunately, it was not possible to find an observation for each of the 26 years and for all 135 countries for all variables. Several has to be eliminated because they reduced the total number of observations of the regressions. Among these are Tax Revenue (% of GDP), Renewable internal freshwater resources per capita (m3). Poverty headcount at $1,9 /day, GINI Index, GI Index and Corruption Perception Index. These variables that would have been interesting to include, but due to the restricted number of observations they offered, had to be excluded from the analysis. Figure 2 shows the final variables included in the study.

Fig. 2 Explanatory variables used in the regressions

1. GNI per capita
2. Primary completion rate, female
3. Agriculture (%GDP)
4. Official level of development assistance
4. Population growth
5. Governance indicators

Source: Own elaboration

GNI per capita

GNI per capita World Bank Atlas method (formerly GNP per capita) is the gross national income, converted to U.S. dollars using the World Bank Atlas method (Datahelpdesk.worldbank.org, 2016b), divided by the midyear population. GNI is defined by the World Bank as the sum of value added by all resident producers plus any product taxes (less subsidies) not included in the valuation of output plus net receipts of primary income from abroad (World Bank Group, 2015). Although calculated in national currency, is usually converted to U.S. dollars at official exchange rates for comparisons across economies.

In this analysis, variables that define a country's development are used as independent variables. As development includes many factors - economic, environmental, cultural, educational, and institutional - no single measure provides a complete picture. However, the total earnings of the residents of an economy, measured by its gross national income (GNI), is a good measure of its capacity to provide for the well-being of its people (World Bank Group, 2015). Therefore, what is being tested by using this variable is whether higher capacity to provide well-being translates in higher access to water resources or not. Expected results are a high and positive relation between these two variables, since higher economic standards should mean higher access to water resources.

Rather than the original raw value, this variable was transformed into its natural logarithm. This was done because the relationship between the GNI and the access to water is not a linear one, and if a linear model is fitted, the errors would not have the distributional properties that a regression model may assume. A way for normalizing these errors was doing a natural log transformation of the variable GNI. In the case in which the independent variable is transformed into its logarithm and the independent variable remains the same, our case, the interpretation is done in terms of percentage change. (Wooldridge, 2015). A one percentage increase in the independent variable increases (or decreases) the expected dependent variable by (coefficient/100) units (Ats.ucla.edu, 2016).

Primary completion rate, female

Women play a critical role in proving for their families and communities in developing countries. They are major contributors to their households due to the role they play in society as caretakers. Consequently, they are largely affected by water scarcity. The task of fetching water is most of the times, the burden of women and younger girls in developing countries (Webbink, Smits and Jong, 2013). In Africa, 90% of the work of gathering wood and water is done by women (UN Water, 2013). This was evidenced by the UN Water (2013) and by Demie, Bekele and Seyoum (2016) who estimated in their studies on women's relation to development activities, that about 6 hours are spent by girls and females fetching water every day. Moreover it was estimated by the World Water Assessment Programme by UNESCO (2015) that girls walk an average of 3.7 miles a day just to fetch water. Rather than spending this significant amount of time and effort in engaging in income generating activities, caring for family, going to school or simply for leisure time, these women and children have to spend most of their dais focused on providing water for their families or communities. Many studies have revealed a link between education and water scarcity (Kookana et al, 2016; Demie et al., 2016). One in four girls does not complete primary school compared to one in seven boys and school enrolment rates have been shown to improve by over 15% when they had clear water facilities, due to fact that they no longer have to walk miles every day to fetch water (World Water Assessment Programme by UNESCO, 2015).

As mentioned before, women are a very important part of obtaining water access. However, they face many challenges in accessing resources and participating in decision making processes within their communities as compared to men. Paradoxically, as principal administrators of water resources, women are often not included in decision making regarding water services as well as in the implementation and planning stages of the project. Several studies have revealed that failure of many community-based water resource management projects has been caused by the exclusion of women at all levels of the project and to the inability of planners to take their knowledge into account (Ray, 2007; Figueiredo & Perkins, 2013). Also, UN Water (2013) argues that involving women can increase the effectiveness of water related projects up to 6 or 7 times. A link between women's education and the effectiveness of water projects was highlighted by Mensah (2015) who argued that women that were educated were the ones to normally participate in not only decision marking but also on the implementation and continuity of the project and that their contributions were fundamental for the success of the project.

As we have seen, the access to water is closely correlated to women's role in the communities. Therefore it was important to reflect women's contribution to water access in the models that are being studied in this paper. Initially, the Gender Inequality Index was considered to be part of the regressions but insufficient observations for the years and countries that were needed, made it unable to use it in the study. The variable chosen to be included in the model was primary completion rate as estimated by the World Bank (2015) and UNESCO Institute for Statistics from official responses to its annual education survey. Primary completion rate, or gross intake ratio to the last grade of primary education, is the number of new entrants (enrollments minus repeaters) in the last grade of primary education, regardless of age, divided by the population at the entrance age for the last grade of primary education and multiplied by 100 (World Bank Group, 2015). This indicator is increasingly being used as a core indicator of an education's system performance, in this case, for women. Nevertheless, it conveys some limitations as adjustment for students that drop out during the final year, therefore it should be taken as an upper estimate of primary completion rate. Also, it may sometimes exceed 100% because it sometimes includes late entrants and repeaters.

Agriculture (%GDP)

Although some developed countries have prioritized the commercial and industrial sectors, history shows that agriculture is one of the most important motors of growth especially in early stages of development, as being a basic source for food, income and employment. In 2014, agriculture contributed approximately 33% of GDP in low income countries, a 17% in lower middle income countries and only a 7,4% in upper middle income countries (World Bank Group, 2015). Especially for low income countries, agriculture constitutes a very important source of income. The link between agriculture and water access is straightforward as water is a necessary resource for any plant, fruit or vegetable to grow. The agrarian sector is the major consumer of water of the planet, since takes most of total world water resources. Therefore, it is important to make compatible the use of water resources for agriculture and for human consumption. This paper seeks to understand deeply the relation that there might exist between agriculture and the access to water resources.

Official level of development assistance

This variable refers to the grants (do not have to be repaid) or loans (have to be repaid) to countries and territories on the Development Assistance Committee (DAC) list of Official Development Assistance recipients. The DAC is a committee of the OECD in charge of development and co-operation matters in which 29 member countries participate. This list of recipients, designed for statistical purposes, include developing countries that are considered eligible for receiving Official Development Assistance (ODA). These grants and loans could be from countries that are part of the DAC committee, not part of the DAC committee or other multilateral agencies such as development banks (e.g.World Bank), United Nations Agencies and regional groupings(e.g. European Union).

The data was drawn from the Query Wizard for International Development Statistics (QWIDS), an online platform to easily access statistical data from the OECD database. In particular, the variable that was used in this study is the disbursement (in million USD) that each of the countries studied received as grants or loans from years 1995 to 2015 for water and sanitation from all donors. The amount is expressed in 2014 constant USD million dollars in order for data to be comparable over time and countries. A disbursement, in this particular case, is the placement of resources at the disposal of the recipient country. It was considered that this variable should be included as the quantity of aid received with respect to GDP.

It should seem coherent to anyone that countries that receive more financing from external sources for water services should be able to improve its capacity to provide safe water access to its population. However, literature on the subject illustrates that there has not been a clear consensus on the effect of aid in the improvement of water access. While studies by Wayland, J. (2014) and Botting et. at. (2010) both show that aid does have a positive impact on water access, some authors such as Bain et al.(2013) and Hopewell & Graham (2014) illustrate the opposite point of view. This is mainly due to differences in methodology and approaches used. By including the ODA variables in this analysis, this papers seeks to add on to the discussion on aid effect on improved water services.

Many definitions are found in the literature around the concept of governance and there is no consensus on one single definition. It can be understood, in a broad way as "rules, enforcement mechanisms and organizations", as defined by the World Bank. These affect a country's freedom of its citizens, infrastructures and access to basic resources among many other factors. As we have seen previously in this paper, water is a key factor for human development. Therefore it should be high up in the list of government priorities to provide safe water access to its citizens. Several studies in the literature were found that linked governability issues with water access (Dondeynaz et al., 2012; Biswas and Tortajada, 2010; Davis, 2004; Luha and Bartrama, 2015). This paper seeks to examine this link in deeper by performing an econometric analysis using panel data and seeks to find a clear connection between governability issues and access to water.

Governance indicators

The indicators that were chosen to be part of this study as independent variables were the Worldwide Governance Indicators (WGI) studied by the World Bank. Definitions of all indicators can be found in Appendix 2 (Kaufman, Kraay and Mastruzzi, 2011). The two used in this study are the following:

Political Stability and Absence of Violence/Terrorism (PV) – capturing perceptions of the likelihood that the government will be destabilized or overthrown by unconstitutional or violent means, including politically-motivated violence and terrorism.

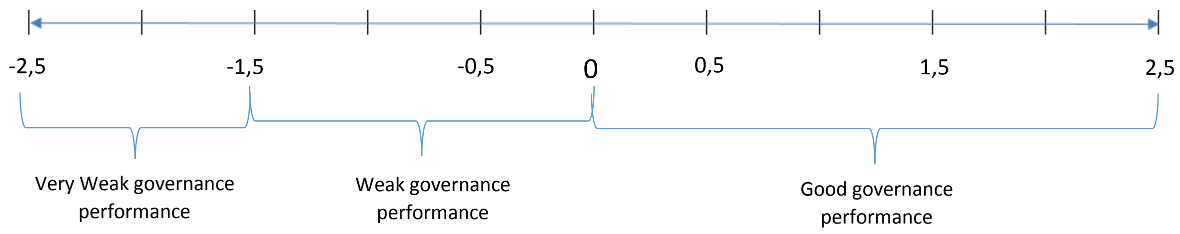
-Control of Corruption (CC) – capturing perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests.

These compile and summarize information from over 30 existing data sources that report the views and experiences of citizens, entrepreneurs, and experts in the public, private and NGO sectors from around the world, on the quality of various aspects of governance. These data sources were combined to make them into the six aggregate government indicators using the statistical tool, unobserved components model (UCM) and by standardizing these variables. The units of these variables range from -2.5 to 2.5, being -

2.5 very weak governance and 2.5 a strong one. It is possible to make cross-country and across time comparisons although changes may not only be due to actual changes in governance but in the data sources (Kaufman et al., 2011). Although data also presented several other limitations, it was the most reliable source of governance indicators found and therefore was the one used in the study.

Since the variable's estimates took the range from -2.5 to 2.5, in order to make the interpretation of the variables simpler and more straightforward, a scale was elaborated that assigns ranges of estimates into a category. These were introduced into the database as dummy variables. Figure 3 shows the scale.

Fig. 3 Scale for governance estimators



Source: Own elaboration

5. METHODOLOGY: MULTIVARIATE REGRESSION USING PANEL DATA

5.1. Multicollinearity test

Multicollinearity tests were ran for the independent variables. First the correlation coefficients matrix was analyzed. Results showed very high correlation between some of the governance variables (0.8; 0,7) as seen in Figure 1 in Appendix 3. In order to decrease multicollinearity, some of the governance indicators were dropped from the model. Although this may imply loss of information, some of the variables were so highly correlated that information contained in them are also present in the variables that were finally in the model and therefore, not a great amount of information is loss. The selection of final governance indicator variables was based on both their degree of collinearity with other variables and the importance that these variables were given with respect to the study. Final variables chosen were: Political Stability and Control of corruption. Final variables were tested for multicollinearity using the Variance Inflation Factor (Fig. 2;

App. 3) and results showed that there is hardly any variance inflation and therefore the multicollinearity problem is corrected.

5.2. Econometric models[1]

This paper wants to study the relation between water access and several socio-economic indicators and for this type of analysis a regression is performed. The purpose of such analysis is to understand cause and effect relationships between one dependent, water access in our case, and our 6 independent variables. As the data that is being treated in this study is two dimensional cross-sectional time-series data, a panel data regression analysis is used.

A linear fixed effects model was chosen for the regressions because it was assumed that the differences between countries were constant or "fixed" rather than random. Compared to the random effects model, the fixed effects is a less restricted model because it doesn't assume a common interception for all countries (it includes country dichotomizing variables). This model is expressed as follows:

$$(1) \qquad Y_{it} = v_i + \beta_1 X_{1it} + \cdots + e_{it}$$

Where v_i is a vector of the dichotomic variables for each country.

In order to know if the fixed model (1) was the correct one compared to a pooled OLS regression model an F-test for the significance of the fixed effects was ran and results indicate that we can H_0 can be rejected and therefore it is preferable to use fixed effects model (2) instead of pooled OLS (Fig. 3 App. 3).

Moreover, apart from incorporating a dichotomic country variables to the model it also possible to add temporary variables by adding one dichotomic variable for every year in the sample. This variable would be capturing common events to all the countries during a period or another.

Adding temporary effects, the equation (1) is transformed into:

$$(2) \qquad Y_{it} = v_i + \eta_t + \beta_1 X_{1it} + \cdots + e_{it}$$

[1] Theory based on class notes elaborated from the material "Diagnóstico y Especificación de Modelos Panel en Stata 8.0 (*Javier Márquez)"*

Where η_t represents a dichotomic variable vector for every year. This variables will allow to control by those events to which all the countries in a given year are subject and, like fixed effects, can reduce important bias.

5.3. Autocorrelation and Heteroskedasticity Problems

It is important to state that, even though temporary and space heterogeneity have been incorporated to our model, it may still need correction for other problems as panel data usually violates the Gaussian-Markov assumptions for best unbiased estimators.

Serial correlation or "autocorrelation" is a problem we may encounter when errors e_{it} are not independent with respect to time. The Wooldridge test is one used in order to test the existence of autocorrelation in models in which the null hypothesis is that autocorrelation does not exist. Results indicate that the null hypothesis is rejected and therefore that autocorrelation exists (Fig. 4 App. 3)
Another problem that we might find in panel data is heteroscedasticity which means that variance σ^2 of the error e_{it} of each cross-sectional is not constant. A way to test if this problem exists in the data set is through the Wald test. Its null hypothesis states that heteroscedasticity does not exist ($\sigma^2_i = \sigma^2$), when *i* is the number of cross-sectional units or countries. Results indicate that this null hypothesis is rejected and that heteroscedasticity also exists in the data (Fig. 5 App.3)

Both the problems of autocorrelation and heteroscedasticity found in our dataset can be best solved with estimators *Panel Standard Corrected Errors* or PCSE (Beck, 2001).

6. ECONOMETRIC RESULTS

In this section, the most relevant results will be commented as well as some possible explanations of the underlying reasons will be given. In order to make them more straightforward and meaningful, results of individual variables will be analyzed with respect total improved, piped on premises and other improved. All the econometric estimation results which are of the most interest to this study, those of the rural area, are presented in Appendix 5 as well as comparative tables for each income level group, except the table for the comparison of all countries that is found at the end of this section (Figure 4)

Results for the variable GNI indicate that it is a significant variable for explaining water access for all countries though the relation they may hold depends on the source of water that is being analyzed. For piped on premises water source, if GNI increases 1%, the access to piped on premises water is expected to increase 0.1699%. However, for other improved water access, if GNI increases in 1%, the access to other improved sources decreases 0.1259%. This means that population of countries with higher GNI is gaining more access to piped on premises sources while population of countries with lower GNI is accessing to more precarious sources of water. These results were as expected, as countries with higher GNI are expected to have more resources and infrastructure capacities to provide piped water to its population.

The results for women's primary completion rate show in general that, if more females finish primary school, there is higher expected access for all three sources of water. For total improved, piped on premises and other improved access, a 1% increase in female primary completion rate translates into an increase of 0.15%, 0.08% and 0.09 % increase of access respectively when analyzing results of all the countries in the study. The importance of this variable in the model and its positive sign may be linked to the fact that women, especially in rural areas, are the ones in charge of fetching water along with younger daughters and therefore are more conscious of the water problematic as they are the ones most affected by it. Therefore it may be the case that, especially if they are educated, they can exert pressure in their communities to have access to improved water sources and may also value that their younger daughters go to school. Results for income groupings reveal that piped on premises access is the one in which women's education affects the most: in high income countries a 1% increase in women primary completion is linked to an increase of 0.13% of piped on premises access while in low income countries it is linked to a 0.03%. This could be due to the fact that piped on premises sources of water require more planning and women are able to exert more pressure on their installation and maintenance.

Agriculture has also been proven by the results to be closely linked to access to all types of improved water sources. In this case it holds a negative relationship for all the countries studied. If the % agriculture value added of GDP increases by 1% in a country, access is expected to decrease 0.19% of piped on premises access, 0.12% on other improved access and 0.37% on total improved access. This could be explained by the fact that, for all types of improved water sources and since irrigation is intensive, pressures are being exerted by farmers so that more resources are destined to irrigation instead of household consumption or simply because agriculture is taking up most of all water resources, both piped and others. Both in lower-middle and in low income countries results show negative relation with all types of sources of access. Nevertheless, in higher-middle income countries, this relation turns positive and significant for piped on premises access. A possible explanation for this could be that, being these the most industrialized countries from the ones studied, agriculture has a lesser importance in their economies and they probably dispose of more advanced irrigation techniques in order to save water resources and can also probably dispose of more resources to share piped installations to both agriculture and household consumption.

Results suggest that rural population growth is a significant variable. It's inclusion in the model was made in order to understand the relation it may hold with access to water taking into account that migration from rural to urban areas could cause that access was maybe increasing not because there was actually more access but because population in rural areas was decreasing. The results generally point to the fact that an increase in rural population is likely to have a positive impact on access to total improved water sources as well as piped on premises, while causing a negative impact on other improved water sources access. This means that rural population increase, in general, mainly affects access to other improved sources and not piped on premises. However, this result includes countries from all income levels in which rural access differs greatly and therefore the effect rural population growth may be somewhat influenced by this fact. Seeing the results for low (Fig.13; App.5) and high-income (Fig. 14; App.6) countries, it can be seen that there is great difference between them. In low-income, although results are not significant in the model, the effect of the growth of rural population is negative for all sources while in high income countries, a positive effect is found for all sources. Lower income countries are affected more negatively than high-income countries by increase in rural population. This could be explained by the fact that lower income countries have higher percentage of rural population, those of which probably lives very far away from each other, and an increase in population will make it more difficult to provide access to all. In higher income countries, rural areas are probably more concentrated and also there is less percentage of total rural population and therefore access is not expected to decrease but to increase as it might be easier to provide access to new population.

In the case of governance indicators, results for control of corruption and political stability indicate that, in general, they are both significant when explaining water access, although its relation with it may vary depending on the water source and on the group of countries being analyzed.

General results for control of corruption suggest that piped on premises access is 2.72 points less in countries where control of corruption is very weak with respect to countries where there is good control of corruption. As expected, for other improved water access, this relation is positive. Countries that have very low control of corruption have access to other improved water source that is 3.38 points higher than countries that have good control of corruption. A possible explanation for the fact that corruption may be affecting more acutely piped on premises access may be that these infrastructures are more expensive and probably many barriers exist for those who want to construct, such as having to pay bribes and extra charges to both public and private entities. These barriers affect construction of these infrastructures and therefore, access to this type of source may be decreasing the less control for corruption there is. At the same time, this situation is creating a positive effect on other improved water sources as these sources need less infrastructures and therefore, probably less barriers are put by corruption to have access to them. Results also suggest that lower income countries are more affected by not controlling for corruption than those of higher income.

Results for political stability indicate that, as expected, there exists a negative relationship between water access and political stability for all countries and income groupings. Countries that have very low political stability have access to total improved water sources that is 0.9560 points lower than countries with good political stability. The instability of the environment might cause that water projects are unable to be finished and also that international aid might be inferior due to the uncertainness for donors if its investment will be useful.

The variable of official development for sanitation and water results show that this variable does not hold a significance relation with access to all sources of water access and for all income-groupings, except for low income countries in which holds a positive relation. A possible explanation for this could be that data could be capturing the effect that as lower income countries are the ones being sent more aid, these are not making significant progress on improving access to water and therefore no clear relation is found with other income groupings.

Fig. 4 Result comparison – global dataset

All countries			
	Total improved	Piped on premises	Other improved
GNI	3.0439 (0.000)***	16.9992 (0.000)***	-12.5991 (0.000)***
Primary completion rate, fem	0.1537 (0.000)***	0.0856 (0.000)***	0.0964 (0.002)***
Agriculture (% GDP)	-0.3748 (0.000)***	-0.1950 (0.000)***	-0.1248 (0.031)**
Development/GDP	2.8392 (0.286)	-4.8092 (0.128)	6.3457 (0.128)
Growth, rural population	0.5491 (0.100)*	1.3907 (0.003)***	-1.2946 (0.008)**
Weak Political Stability	-0.9560 (0.023)**	0.5392 (0.284)	-2.0417 (0.001)***
Very weak political stability	0.3259 (0.619)	1.1744 (0.176)	-15648 (0.110)
Weak control of corruption	-0.1629 (0.748)	0.1349 (0.897)	0.6266 (0.523)
Very weak control of corruption	0.1124 (0.876)	-2.7296 (0.042)*	3.380 (0.009)**

Source: Own elaboration

7. CONCLUSION

It is undeniable that water is an essential motor for life and development of people and societies**.** Inadequate access to it has negative effects on health, which at the same time influences on productivity and human welfare. However, millions of people still lack access to improved water sources, the majority of which live in rural areas of developing and least developed countries. This situation is even more accentuated when taking into account piped on premises access. Many efforts have been made in order to improve water access for those who lack it, but still much advancement is needed. National characteristics of countries could be affecting improvement of water access. Being aware of these may help on providing more accurate solutions to the problematic.

The central investigation of this paper focused on providing insights on the socioeconomic indicators that were determinants for water access and their relation to it, considering rural areas and all types of sources of access. Many of the national socioeconomic characteristics studied in this paper were found to have relation to water access, contrasting the results of previous regression analysis on the topic (Luha and Bartrama, 2015). GNI, primary completion rate for women , the percentage of value added that agriculture contributes to GDP and population growth in rural areas were found to be determinants for water access in rural zones for all countries studied; and therefore variables that should be considered when evaluating access in a country. As expected, poorer countries were found to have more access to more precarious sources of water and richer countries to piped on premises. An important remark from results is that women's education was proved to be a determinant for increasing water access and therefore their empowerment may be directly related to improving access, especially in higher-middle income countries. Another important remark is that although agriculture is an essential part of the least developed countries economies, it was proven to have a negative impact on water access for all countries studied, and regulation with respect to household water access may need to be considered. Control of corruption was also found to be a determinant and surprisingly, other improved water sources seemed to improve its access in countries with very weak control of corruption, as opposed to a decrease in piped on premises. Corruption may be imposing barriers on the construction piped on premises sources of access. Political stability results were as expected and are consistent with the explanation that unstable political environments affect negatively to all population living conditions, water access being one of the. Also, the lack of association between official development assistance for water and sanitation and water access is consistent with previous studies (Bain, 2013; Hopewell & Graham, 2014; Luha and Bartrama, 2015), except for low income countries. This reinforces the idea that investment on its own is not enough to improvement to water access and revision of other determinants is needed. These associations should allow policy makers to best understand the drivers for water access and make better evidence-based decisions in the future.

Although this study provides new insight on the determinants on water access and finds associations not found in earlier research, it presents certain limitations. As data used were of low income countries, it was of high difficulty to find many observations. Many of the variables that were initially considered to be part of the studied had to be eliminated due to the unavailability of observations. This may affect results as it meant eliminating possible determinants from the models used. Furthermore, regarding the variable of primary completion rate for women it could be the case which, instead of explaining water access, it could be the other way around. Future research may need to focus on causality associations for this variable. Also, the governance indicators considered in this study were too correlated between them to all be used in the model and future studies should consider other governance indicators to be able to include them as part of the research. Further investigation on the same line of research should also consider incorporating exploratory methods such as principal components analysis as well as clustering countries based on their intrinsic characteristics and not only on their income level.

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APPENDIX 1 – Country list

Fig. 1 List of low income economies

Low-income economies ($1,045 or less)		**31**
Afghanistan	Gambia, The	Niger
Benin	Guinea	Rwanda
Burkina Faso	Guinea-Bisau	Sierra Leone
Burundi	Haiti	Somalia
Cambodia	Korea, Dem People's Rep	South Sudan
Central African Republic	Liberia	Tanzania
Chad	Madagascar	Togo
Comoros	Malawi	Uganda
Congo, Dem. Rep	Mali	Zimbabwe
Eritrea	Mozambique	
Ethiopia	Nepal	

Source: World Bank Group, 2015

Fig. 2 List of lower-middle income economies

Lower-middle income economies ($1,046 to $4,125) 51		
Armenia	Indonesia	Samoa
Bangladesh	Kenya	Sao Tomé and Principe
Bhutan	Kiribati	Senegal
Bolivia	Kosovo	Solomon Islands
Cabo Verde	Kyrgyz Republic	Sri Lanka
Cameroon	Lao PDR	Sudan
Congo, Rep	Lesotho	Swaziland
Côte d’Ivoire	Mauritania	Syrian Arab Republic
Dijbouti	Micronesia, Fed. Sts.	Tajikistan
Egypt, Arab Rep.	Moldova	Timor-Leste
El Salvador	Morocco	Ukraine
Georgia	Myanmar	Uzbekistan
Ghana	Nicaragua	Vanuatu
Guatemala	Nigeria	Vietnam
Guyana	Pakistan	West Bank and Gaza
Honduras	Papua New Guinea	Yemen, Rep.
India	Philippines	Zambia

Source: World Bank Group, 2015

Fig. 3 List of high-middle income economies

High-middle income economies ($4,126 to $12,735) 53		
Albania	Fiji	Namibia
Algeria	Gabon	Palau
American Samoa	Grenada	Panama
Angola	Iran, Islamic Rep.	Paraguay
Azerbaijan	Iraq	Peru
Belarus	Jamaica	Romania
Belize	Jordan	Serbia
Bosnia and Herzergovina	Kazakhstan	South Africa
Botswana	Lebanon	St. Lucia
Brazil	Libya	St. Vincent and the Grenadines
Bulgaria	Macedonia, FYR	Suriname
China	Malaysia	Thailand
Colombia	Maldives	Tonga
Costa Rica	Marshall Islands	Tunisia
Cuba	Mauritius	Turkey
Dominica	Mexico	Turkmenistan
Dominican Republic	Mongolia	Tuvalu
Ecuador	Montenegro	

Source: World Bank Group, 2015

APPENDIX 2 – Definition of governance indicators

Fig. 1 Definition of governance indicators not used in the study

Voice and Accountability (VA) – captures perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media.
Regulatory Quality (RQ) – capturing perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development.
Government Effectiveness (GE) – capturing perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.
Rule of Law (RL) – capturing perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence.

Source: Kaufman et al., 2011

APPENDIX 3 – Econometric test results

Fig. 1 Correlation matrix

	gniper~s	primar~e	agricu~p	develo~a	politi~e	govern~s	regula~y	voicea~y	ruleof~w	contro~n
gnipercapi~s	1.0000									
primarycom~e	0.5492	1.0000								
agricultur~p	-0.6700	-0.6696	1.0000							
developmen~a	0.1424	0.0963	-0.1043	1.0000						
politicals~e	0.2973	0.2925	-0.2816	0.1914	1.0000					
government~s	0.5665	0.4458	-0.5552	0.1239	0.4561	1.0000				
regulatory~y	0.4528	0.3320	-0.4210	0.0915	0.3470	0.7530	1.0000			
voiceandac~y	0.3803	0.2826	-0.3141	0.2210	0.5145	0.5886	0.6563	1.0000		
ruleoflaw	0.4177	0.3588	-0.4084	0.2445	0.6327	0.7835	0.6487	0.6728	1.0000	
controlofc~n	0.4186	0.2993	-0.4313	0.1581	0.6005	0.7743	0.5388	0.5663	0.8067	1.0000

Source: Own elaboration

Fig. 2 Variance Inflation Factor

Variable	VIF	1/VIF
survivalra~m	2.29	0.435935
primarycom~e	2.26	0.441671
gnipercapi~s	1.86	0.537114
regulatory~y	1.50	0.667386
controlofc~n	1.40	0.712459
developmen~a	1.06	0.947374

Source: Own elaboration

Fig. 3 Results of F-test for the significance of fixed effects

```
F test that all u_i=0:     F(106, 799) =    293.83             Prob > F = 0.0000
```

Source: Own elaboration

Fig. 4 Wooldridge test for autocorrelation in panel data

```
Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
    F(  1,       90) =   2817.586
           Prob > F =      0.0000
```

Source: Own elaboration

Fig. 4 Modified Wald test for groupwise heteroscedasticity in fixed effects models

```
Modified Wald test for groupwise heteroskedasticity
in fixed effect regression model

H0: sigma(i)^2 = sigma^2 for all i

chi2 (107)  =    1.2e+33
Prob>chi2 =      0.0000
```

Source: Own elaboration

APPENDIX 3 – Regression Results

Fig. 1 Results for rural piped on premises – global dataset

```
Group variable:    cntry                              Number of obs      =      1004
Time variable:     time                               Number of groups   =       107
Panels:            heteroskedastic (unbalanced)       Obs per group: min =         1
Autocorrelation:   common AR(1)                                      avg =  9.383178
                                                                     max =        16

Estimated covariances      =       107                R-squared          =    0.8964
Estimated autocorrelations =         1                Wald chi2(107)     = 152897.29
Estimated coefficients     =       113                Prob > chi2        =    0.0000
```

ruralpipedonpremises	Coef.	Het-corrected Std. Err.	z	P>|z|	[95% Conf.	Interval]
GNIln	16.99928	1.23285	13.79	0.000	14.58293	19.41562
primarycompletionratefemale	.0856456	.0237867	3.60	0.000	.0390244	.1322667
agriculturevalueaddedofgdp	-.1950832	.0544652	-3.58	0.000	-.3018331	-.0883334
devgdp	-4.809214	3.313448	-1.45	0.147	-11.30345	1.685024
ruralpopulationgrowthannual	1.390798	.4744164	2.93	0.003	.460959	2.320637
weakpoliticalstability	.5392733	.5035317	1.07	0.284	-.4476308	1.526177
veryweakpoliticalstability	1.174482	.8678329	1.35	0.176	-.5264397	2.875403
weakcontrolofcorruption	.1349668	1.038259	0.13	0.897	-1.899983	2.169917
veryweakcontrolofcorruption	-2.729683	1.339095	-2.04	0.042	-5.354262	-.1051051

Source: Own elaboration

Fig. 2 Results for rural other improved – global dataset

```
Group variable:    cntry                              Number of obs      =      1009
Time variable:     time                               Number of groups   =       108
Panels:            heteroskedastic (unbalanced)       Obs per group: min =         1
Autocorrelation:   common AR(1)                                      avg =  9.342593
                                                                     max =        16

Estimated covariances      =       108                R-squared          =    0.8689
Estimated autocorrelations =         1                Wald chi2(106)     = 138158.07
Estimated coefficients     =       113                Prob > chi2        =    0.0000
```

ruralotherimproved	Coef.	Het-corrected Std. Err.	z	P>|z|	[95% Conf.	Interval]
GNIln	-12.59919	1.318496	-9.56	0.000	-15.1834	-10.01499
primarycompletionratefemale	.0964793	.030576	3.16	0.002	.0365515	.1564071
agriculturevalueaddedofgdp	-.1248033	.0577192	-2.16	0.031	-.2379309	-.0116756
devgdp	6.345779	4.173802	1.52	0.128	-1.834722	14.52628
ruralpopulationgrowthannual	-1.294615	.4886356	-2.65	0.008	-2.252323	-.3369067
weakpoliticalstability	-2.041785	.6387777	-3.20	0.001	-3.293766	-.7898034
veryweakpoliticalstability	-1.564857	.9789398	-1.60	0.110	-3.483544	.3538298
weakcontrolofcorruption	.6266566	.981533	0.64	0.523	-1.297113	2.550426
veryweakcontrolofcorruption	3.380382	1.298982	2.60	0.009	.8344234	5.92634

Source: Own elaboration

Fig. 3 Results for rural total improved – global dataset

Group variable:	cntry	Number of obs =	1012
Time variable:	time	Number of groups =	108
Panels:	heteroskedastic (unbalanced)	Obs per group: min =	1
Autocorrelation:	common AR(1)	avg =	9.37037
		max =	16
Estimated covariances =	108	R-squared =	0.9632
Estimated autocorrelations =	1	Wald chi2(107) =	1.14e+06
Estimated coefficients =	113	Prob > chi2 =	0.0000

ruraltotalimproved	Coef.	Het-corrected Std. Err.	z	P>|z|	[95% Conf.	Interval]
GNIln	3.043992	.8272164	3.68	0.000	1.422677	4.665306
primarycompletionratefemale	.1537687	.018168	8.46	0.000	.11816	.1893773
agriculturevalueaddedofgdp	-.3748045	.0564068	-6.64	0.000	-.4853598	-.2642492
devgdp	2.83929	2.660735	1.07	0.286	-2.375654	8.054234
ruralpopulationgrowthannual	.5491781	.334213	1.64	0.100	-.1058673	1.204224
weakpoliticalstability	-.9560348	.4199395	-2.28	0.023	-1.779101	-.1329685
veryweakpoliticalstability	.3259406	.6549763	0.50	0.619	-.9577893	1.609671
weakcontrolofcorruption	-.1629889	.5080866	-0.32	0.748	-1.15882	.8328426
veryweakcontrolofcorruption	-.1124521	.7217397	-0.16	0.876	-1.527036	1.302132

Source: Own elaboration

Fig. 4 Results for rural piped on premises – low income countries dataset

Group variable:	cntry	Number of obs =	254
Time variable:	time	Number of groups =	24
Panels:	heteroskedastic (unbalanced)	Obs per group: min =	2
Autocorrelation:	common AR(1)	avg =	10.58333
		max =	16
Estimated covariances =	24	R-squared =	0.9624
Estimated autocorrelations =	1	Wald chi2(44) =	4659.20
Estimated coefficients =	44	Prob > chi2 =	0.0000

ruralpipedonpremises	Coef.	Het-corrected Std. Err.	z	P>|z|	[95% Conf.	Interval]
GNIln	.7554782	.2867616	2.63	0.008	.1934359	1.317521
primarycompletionratefemale	.0376161	.0062417	6.03	0.000	.0253825	.0498497
agriculturevalueaddedofgdp	-.0363513	.007935	-4.58	0.000	-.0519036	-.020799
devgdp	-.8141978	.6282696	-1.30	0.195	-2.045584	.417188
ruralpopulationgrowthannual	-.1532319	.1128036	-1.36	0.174	-.3743229	.0678591
weakpoliticalstability	-.2112747	.1092479	-1.93	0.053	-.4253965	.0028472
veryweakpoliticalstability	-.122875	.1509645	-0.81	0.416	-.41876	.1730099
weakcontrolofcorruption	.1110447	.1727669	0.64	0.520	-.2275722	.4496615
veryweakcontrolofcorruption	0	(omitted)				

Source: Own elaboration

Fig. 5 Results for rural other improved – low income countries dataset

Group variable:	cntry	Number of obs =	256
Time variable:	time	Number of groups =	24
Panels:	heteroskedastic (unbalanced)	Obs per group: min =	2
Autocorrelation:	common AR(1)	avg =	10.66667
		max =	16
Estimated covariances =	24	R-squared =	0.9515
Estimated autocorrelations =	1	Wald chi2(43) =	6116.23
Estimated coefficients =	44	Prob > chi2 =	0.0000

ruralotherimproved	Coef.	Het-corrected Std. Err.	z	P>|z|	[95% Conf.	Interval]
GNI1n	3.585668	1.855486	1.93	0.053	-.0510174	7.222353
primarycompletionratefemale	.0354487	.0482749	0.73	0.463	-.0591683	.1300658
agriculturevalueaddedofgdp	-.3489973	.0715674	-4.88	0.000	-.4892668	-.2087278
devgdp	5.961374	3.311004	1.80	0.072	-.5280736	12.45082
ruralpopulationgrowthannual	-.3296926	.5881549	-0.56	0.575	-1.482455	.8230699
weakpoliticalstability	-1.387024	.7274945	-1.91	0.057	-2.812887	.0388392
veryweakpoliticalstability	-.2919439	.9028625	-0.32	0.746	-2.061522	1.477634
weakcontrolofcorruption	.4580067	.7947026	0.58	0.564	-1.099582	2.015595
veryweakcontrolofcorruption	0	(omitted)				

Source: Own elaboration

Fig. 6 Results for rural total improved – low income countries dataset

Group variable:	cntry	Number of obs =	256
Time variable:	time	Number of groups =	24
Panels:	heteroskedastic (unbalanced)	Obs per group: min =	2
Autocorrelation:	common AR(1)	avg =	10.66667
		max =	16
Estimated covariances =	24	R-squared =	0.9561
Estimated autocorrelations =	1	Wald chi2(44) =	84559.57
Estimated coefficients =	44	Prob > chi2 =	0.0000

ruraltotalimproved	Coef.	Het-corrected Std. Err.	z	P>|z|	[95% Conf.	Interval]
GNI1n	4.53427	1.880529	2.41	0.016	.8485009	8.220038
primarycompletionratefemale	.0700015	.0506653	1.38	0.167	-.0293007	.1693038
agriculturevalueaddedofgdp	-.4200411	.0782718	-5.37	0.000	-.5734511	-.2666312
devgdp	5.704622	3.495946	1.63	0.103	-1.147307	12.55655
ruralpopulationgrowthannual	-.519124	.6380001	-0.81	0.416	-1.769581	.7313333
weakpoliticalstability	-1.725214	.7759516	-2.22	0.026	-3.246051	-.2043767
veryweakpoliticalstability	-.4033761	.9591596	-0.42	0.674	-2.283294	1.476542
weakcontrolofcorruption	.702833	.8774217	0.80	0.423	-1.016882	2.422548
veryweakcontrolofcorruption	0	(omitted)				

Source: Own elaboration

Fig. 7 Results for rural piped on premises – low-middle income countries dataset

```
Group variable:   cntry                        Number of obs      =       408
Time variable:    time                         Number of groups   =        43
Panels:           heteroskedastic (unbalanced) Obs per group: min =         1
Autocorrelation:  common AR(1)                                avg =  9.488372
                                                              max =        16

Estimated covariances      =        43         R-squared          =    0.7944
Estimated autocorrelations =         1         Wald chi2(55)      =  13033.05
Estimated coefficients     =        58         Prob > chi2        =    0.0000
```

ruralpipedonpremises	Coef.	Het-corrected Std. Err.	z	P>|z|	[95% Conf.	Interval]
GNIln	9.057482	3.011316	3.01	0.003	3.155411	14.95955
primarycompletionratefemale	.1941343	.040745	4.76	0.000	.1142756	.2739931
agriculturevalueaddedofgdp	-.2368131	.1202351	-1.97	0.049	-.4724697	-.0011566
devgdp	-5.50512	10.88445	-0.51	0.613	-26.83826	15.82802
ruralpopulationgrowthannual	2.764463	1.257973	2.20	0.028	.2988808	5.230044
weakpoliticalstability	2.015676	.7843815	2.57	0.010	.4783164	3.553035
veryweakpoliticalstability	2.923001	1.904682	1.53	0.125	-.8101076	6.656111
weakcontrolofcorruption	1.232435	1.491689	0.83	0.409	-1.691222	4.156092
veryweakcontrolofcorruption	1.330975	2.147472	0.62	0.535	-2.877993	5.539942

Source: Own elaboration

Fig. 8 Results for rural other improved – low-middle income countries dataset

```
Group variable:   cntry                        Number of obs      =       408
Time variable:    time                         Number of groups   =        43
Panels:           heteroskedastic (unbalanced) Obs per group: min =         1
Autocorrelation:  common AR(1)                                avg =  9.488372
                                                              max =        16

Estimated covariances      =        43         R-squared          =    0.8667
Estimated autocorrelations =         1         Wald chi2(55)      =  17340.63
Estimated coefficients     =        58         Prob > chi2        =    0.0000
```

ruralotherimproved	Coef.	Het-corrected Std. Err.	z	P>|z|	[95% Conf.	Interval]
GNIln	-9.580326	2.574686	-3.72	0.000	-14.62662	-4.534035
primarycompletionratefemale	.0399027	.0468957	0.85	0.395	-.0520113	.1318166
agriculturevalueaddedofgdp	-.456622	.1187606	-3.84	0.000	-.6893885	-.2238555
devgdp	5.762111	9.368371	0.62	0.539	-12.59956	24.12378
ruralpopulationgrowthannual	-1.643572	.9570347	-1.72	0.086	-3.519326	.2321814
weakpoliticalstability	-2.252283	.8297284	-2.71	0.007	-3.878521	-.6260454
veryweakpoliticalstability	-2.639431	1.716733	-1.54	0.124	-6.004166	.7253041
weakcontrolofcorruption	-2.07028	1.438513	-1.44	0.150	-4.889714	.7491536
veryweakcontrolofcorruption	.5938748	2.020476	0.29	0.769	-3.366185	4.553935

Source: Own elaboration

Fig. 9 Results for rural total improved – low-middle income countries dataset

Group variable:	cntry	Number of obs	= 408
Time variable:	time	Number of groups	= 43
Panels:	heteroskedastic (unbalanced)	Obs per group: min	= 1
Autocorrelation:	common AR(1)	avg	= 9.488372
		max	= 16
Estimated covariances	= 43	R-squared	= 0.9254
Estimated autocorrelations	= 1	Wald chi2(55)	= 67286.81
Estimated coefficients	= 58	Prob > chi2	= 0.0000

ruraltotalimproved	Coef.	Het-corrected Std. Err.	z	P>|z|	[95% Conf.	Interval]
GNI1n	-2.254159	2.806041	-0.80	0.422	-7.753899	3.245581
primarycompletionratefemale	.2397537	.0362541	6.61	0.000	.1686969	.3108105
agriculturevalueaddedofgdp	-.7703491	.1576253	-4.89	0.000	-1.079289	-.4614092
devgdp	.0500104	8.854821	0.01	0.995	-17.30512	17.40514
ruralpopulationgrowthannual	.9535608	.8716762	1.09	0.274	-.7548932	2.662015
weakpoliticalstability	-.8075386	.7176518	-1.13	0.260	-2.21411	.5990331
veryweakpoliticalstability	-.3391252	1.49312	-0.23	0.820	-3.265588	2.587337
weakcontrolofcorruption	-.90339	.8627799	-1.05	0.295	-2.594407	.7876274
veryweakcontrolofcorruption	2.465327	1.66324	1.48	0.138	-.7945641	5.725217

Source: Own elaboration

Fig. 10 Results for rural piped on premises – high-middle income countries dataset

Group variable:	cntry	Number of obs	= 342
Time variable:	time	Number of groups	= 40
Panels:	heteroskedastic (unbalanced)	Obs per group: min	= 1
Autocorrelation:	common AR(1)	avg	= 8.55
		max	= 15
Estimated covariances	= 40	R-squared	= 0.9346
Estimated autocorrelations	= 1	Wald chi2(55)	= 27245.92
Estimated coefficients	= 58	Prob > chi2	= 0.0000

ruralpipedonpremises	Coef.	Het-corrected Std. Err.	z	P>|z|	[95% Conf.	Interval]
GNI1n	3.062256	1.914525	1.60	0.110	-.6901437	6.814655
primarycompletionratefemale	.1344206	.038514	3.49	0.000	.0589346	.2099067
agriculturevalueaddedofgdp	1.123385	.2609267	4.31	0.000	.6119782	1.634792
devgdp	-66.64959	46.86059	-1.42	0.155	-158.4947	25.19548
ruralpopulationgrowthannual	.6549094	.536328	1.22	0.222	-.3962742	1.706093
weakpoliticalstability	-3.88157	1.267175	-3.06	0.002	-6.365187	-1.397953
veryweakpoliticalstability	-3.968065	2.123493	-1.87	0.062	-8.130034	.1939042
weakcontrolofcorruption	-.1149839	1.713819	-0.07	0.947	-3.474008	3.24404
veryweakcontrolofcorruption	0	(omitted)				

Source: Own elaboration

Fig. 11 Results for other improved – high-middle income countries dataset

Group variable:	cntry	Number of obs	=	345
Time variable:	time	Number of groups	=	41
Panels:	heteroskedastic (unbalanced)	Obs per group: min	=	1
Autocorrelation:	common AR(1)	avg	=	8.414634
		max	=	15
Estimated covariances =	41	R-squared	=	0.7922
Estimated autocorrelations =	1	Wald chi2(54)	=	129152.60
Estimated coefficients =	58	Prob > chi2	=	0.0000

ruralotherimproved	Coef.	Het-corrected Std. Err.	z	P>|z|	[95% Conf.	Interval]
GNIln	-8.770131	3.002282	-2.92	0.003	-14.6545	-2.885766
primarycompletionratefemale	.1655598	.1251907	1.32	0.186	-.0798095	.410929
agriculturevalueaddedofgdp	-.1439505	.4758704	-0.30	0.762	-1.076639	.7887384
devgdp	60.462	63.97319	0.95	0.345	-64.92314	185.8471
ruralpopulationgrowthannual	.2302569	.5789465	0.40	0.691	-.9044575	1.364971
weakpoliticalstability	-3.954002	2.80282	-1.41	0.158	-9.447428	1.539424
veryweakpoliticalstability	-2.043217	4.305468	-0.47	0.635	-10.48178	6.395345
weakcontrolofcorruption	5.963702	2.838188	2.10	0.036	.4009563	11.52645
veryweakcontrolofcorruption	0	(omitted)				

Source: Own elaboration

Fig. 12 Results for total improved – high-middle income countries dataset

Group variable:	cntry	Number of obs	=	348
Time variable:	time	Number of groups	=	41
Panels:	heteroskedastic (unbalanced)	Obs per group: min	=	1
Autocorrelation:	common AR(1)	avg	=	8.487805
		max	=	15
Estimated covariances =	41	R-squared	=	0.9845
Estimated autocorrelations =	1	Wald chi2(55)	=	60516.71
Estimated coefficients =	58	Prob > chi2	=	0.0000

ruraltotalimproved	Coef.	Het-corrected Std. Err.	z	P>|z|	[95% Conf.	Interval]
GNIln	-.0781564	1.37271	-0.06	0.955	-2.768618	2.612305
primarycompletionratefemale	.0393051	.0198299	1.98	0.047	.0004392	.078171
agriculturevalueaddedofgdp	.2297722	.1598997	1.44	0.151	-.0836255	.54317
devgdp	-5.373231	24.33809	-0.22	0.825	-53.07501	42.32855
ruralpopulationgrowthannual	.6444786	.2655941	2.43	0.015	.1239238	1.165033
weakpoliticalstability	-1.228855	.5540571	-2.22	0.027	-2.314786	-.1429226
veryweakpoliticalstability	.4692653	.9075623	0.52	0.605	-1.309524	2.248055
weakcontrolofcorruption	.0586577	.7214761	0.08	0.935	-1.35541	1.472725
veryweakcontrolofcorruption	0	(omitted)				

Source: Own elaboration

Fig. 13 Comparison of results for low income countries dataset

Low income countries			
	Total improved	Piped on premises	Other improved
GNI	4.5342 (0.016)**	0.7554 (0.008)***	3.5856 (0.053)*
Primary completion rate	0.0700 (0.167)	0.0376 (0.000)***	0.0354 (0.463)
Agriculture (% GDP)	-0.4200 (0.000)***	-0.0363 (0.000)***	-0.3489 (0.000)***
Development/GDP	5.7046 (0.103)*	-0.8141 (0.195)	5.9613 (0.072)*
Growth, rural population	-0.5191 (0.416)	-0.1532 (0.174)	-0.3296 (0.575)
Weak political stability	-1.7252 (0.026)*	-0.2112 (0.053)*	-1.3870 (0.057)*
Very weak political stability	-0.4033 (0.674)	-0.1228 (0.416)	-0.2919 (0.746)
Weak control of corruption	0.7028 (0.423)	0.1110 (0.520)	0.4580 (0.564)
Very weak control of corruption	-	-	-

Source: Own elaboration

Fig. 14 Comparison of results for low-middle income countries dataset

Low-middle income countries			
	Total improved	Piped on premises	Other improved
GNI	-2.2541 (0.422)	9.0574 (0.003)***	-9.5803 (0.000)***
Primary completion rate	0.2397 (0.000)***	0.1941 (0.000)***	0.0399 (0.395)
Agriculture (% GDP)	-0.7703 (0.000)***	-0.2368 (0.049)**	-0.4566 (0.000)***
Development/GDP	0.0500 (0.995)	-5.5051 (0.613)	5.7621 (0.539)
Growth, rural population	0.9535 (0.274)	2.7644 (0.028)**	-1.6435 (0.086)*
Weak political stability	-0.8075 (0.260)***	2.0156 (0.010)*	-2.2522 (0.007)**
Very weak political stability	-0.3391 (0.820)	2.9230 (0.125)	-2.6394 (0.124)
Weak control of corruption	-0.9033 (0.295)	1.2324 (0.409)	-2.0702 (0.150)
Very weak control of corruption	2.4653 (0.138)	1.3309 (0.535)	0.5938 (0.769)

Source: Own elaboration

Fig. 15 Comparison of results for high-middle income countries dataset

Higher-middle income countries			
	Total improved	Piped on premises	Other improved
GNI	-0.0781 (0.955)	3.0622 (0.110)	-8.7701 (0.003)***
Primary completion rate	0.0393 (0.047)**	0.1344 (0.000)***	0.1655 (0.186)
Agriculture (% GDP)	0.2297 (0.151)	1.1233 (0.000)***	-0.1439 (0.762)
Development/GDP	-5.3732 (0.825)	-66.6495 (0.155)	60.462 (0.345)
Growth, rural population	0.6444 (0.015)**	0.6549 (0.222)	0.2302 (0.691)
Weak political stability	-1.2288 (0.027)**	-3.8815 (0.002)***	-3.9540 (0.158)
Very weak political stability	0.4692 (0.605)	-3.9680 (0.062)*	-2.0432 (0.635)
Weak control of corruption	0.0586 (0.935)	-0.1149 (0.947)	5.9637 (0.036)
Very weak control of corruption	-	-	-

Source: Own elaboration