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Technical Article

Economic damage-cost analysis caused by insufficient sanitation in rural Ecuador*

Análise econômica de dano-custo causado por saneamento insuficiente no Equador rural

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ABSTRACT

Sanitation is an unmet basic need in rural areas. Conventional technology to cover the population without access to this human right does not respond to the reality of the segment of the users who are excluded from this service with the corresponding economic damages. This research based its findings on the Economics Sanitation Initiative methodology, running the model to develop a damage-cost analysis due to the lack of any type of sanitation access in rural Ecuador. The inputs considered are enlisted within the toolkit manual and are at the discretion of the analyst which ones can be included in the study. The most relevant outcomes of the research reveal that sanitation has an impact on health of 1.88%, water resources for human consumption of 0.9%, and overall damage of 2.77% of the Gross Domestic Product (GDP). For this reason, ecosanitation is positioned as a simple and inexpensive alternative for rural communities in Ecuador, capable to avert damages and transforming them into economic benefits for users.

Keywords: sanitation; DCA; economic; impact.

RESUMO

O saneamento é uma necessidade básica não atendida em áreas rurais. A tecnologia convencional para atender a população sem acesso a esse direito humano não responde à realidade do segmento de usuários que são excluídos desse serviço com os correspondentes prejuízos econômicos. Esta pesquisa baseia suas descobertas na metodologia *Economics Sanitation Initiative*, executando o modelo para desenvolver uma análise de custo-dano devido à falta de qualquer tipo de acesso ao saneamento na zona rural do Equador. As entradas consideradas estão listadas no manual do kit de ferramentas e ficam a critério do analista quais podem ser incluídas no estudo. Os resultados mais relevantes da pesquisa revelam que o saneamento tem impacto de 1,88% na saúde, de 0,9% nos recursos hídricos para consumo humano e danos gerais de 2,77% do Produto Interno Bruno (PIB). Por isso, o ecossaneamento se posiciona como uma alternativa simples e barata para as comunidades rurais do Equador, capaz de evitar danos e transformá-los em benefícios econômicos para os usuários.

Palavras-chave: saneamento; análise de custo de danos; econômico; impacto.

INTRODUCTION

Conventional type of toilet cannot solve de the problem of getting rid of excreta for the 2.3 billion people worldwide who do not have access to improved sanitation, including nearly 1 billion people who still resort to open defecation (UNICEF, 2017). While this number can be considered significant, it does not take into account dysfunctional piped sanitation and wastewater management systems that release untreated wastewater into the natural environment. If these are added, around 4.1 billion people — 60% of humanity — could be included among those without improved sanitation (BAUM *et al.*, 2013).

The case toward implementing technologies for a more sustainable sanitation service is growing stronger. Proper sanitation and wastewater management can pay for itself USD $7.3 per US dollar invested in Latin America and the Caribbean (LAC) due to savings related to lower health care demand, reduced losses of productive time due to diseases, and reduced premature mortality (WHO, 2012). The inability of countries in the LAC region to provide adequate sanitation results in considerable economic losses due to greater allocation of resources to less efficient interventions.

In Ecuador, alternative solutions for the treatment of excreta have not yet been approached, despite the significant deficiency in the access to sanitation services that still exists. The coverage of this service in Junín reaches about 33% (INEC, 2020) and it is estimated that it has stagnated around this value due to hydric deficiency, thus worsening the critical water and sanitary situation.

On-site sanitation system (*e.g.* pit latrine, septic tank, dry toilet) can be considered an alternative to meet the needs and constraints of a specific context.

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Globally, it has been adopted for 2.7 billion people, although it requires fecal sludge management. On-site sanitation users are expected to nearly double by 2030 (STRANDE *et al*., 2014). The success of this system lies in establishing, through design, the maximum relation between all the elements or components of human settlements (system) to satisfy our demands and the needs of other forms of life that may inhabit the place (WINBLAD *et al*., 1985).

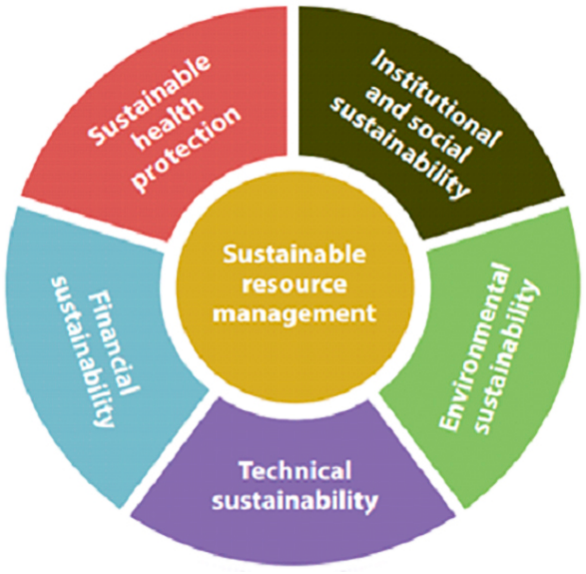
When it comes to sustainable sanitation, it is necessary to acknowledge that sanitation has played a key role in enabling and catalyzing development throughout history. The mixture of sanitation and sustainability is relatively new and is defined as: "the one that minimizes depletion of the resource base, protects and promotes human health, minimizes environmental degradation, is technically and institutionally appropriate, socially acceptable, and economically viable in the long term. It should be sustained and contribute to broader socioeconomic and environmental sustainability" (SUSANA, 2008).

The absence of sustainability in the strategy to reach Millenium Development Goals of reducing by half the share of the population without access to basic sanitation resulted in the non-compliance of this target by 9%. Therefore, it is of vital importance to plan, design, and build human settlements in a harmonic way with natural patterns and cycles.

Sustainable development goals

Due to the poor performance of sanitation in Millennium Development Goals (MDG) in the global context, the United Nations approached the Sustainable Development Goals (SDG) with resource management at the heart of sustainable sanitation and wastewater management systems. In order to implement this logic, the medium of many changes should come out of households. With simple water separating systems, resources could be reused without the need to dispose of it through sewage, even more so if these systems are vulnerable to drastic climate changes (Figure 1).

Ecosanitation emerges as an innovative solution to the sanitation crisis due to particular conditions of ruralhood. It is based on the principles of zero emissions and recycling of all its products, turning each of the residues into a useful material for agriculture, in a hygienic and safe manner and with a notable water savings, or even without using this resource (CRUZ *et al*., 2006).



Source: Stockholm Environment Institute.

Figure 1 – Key sustainability dimensions in sanitation and wastewater management.

The concept of ecological sanitation (EcoSan) may be interpretated as a holistic approach to the management, disposal, and reuse of human waste (fluid and solid) in rural and urban settlements, thus preventing pollution instead of solving it after its production.

The Pan American Center for Sanitary Engineering and Environmental Sciences (2003) (*Centro Panamericano de Ingenieria Sanitaria y Ciencias del Ambiente* – CEPIS) considers ecological sanitation a solution given the absence of this service in several countries, particularly in rural areas. This technology arises due to the high costs implied in the construction of sewage networks and further treatment; these costs increase in places with scattered houses typical of rural communities.

This paper aimed to demonstrate that alternative sanitation is not only an adequate and cost-effective investment for sustainability, but also practical and affordable for rural territories. Also, it is a way to overcome unsafe management of excreta and widespread wastewater, creating significant health and environmental risks.

The model installed and assessed in a rural household

The model installed as part of this research project collects and treats urine and feces separately for resource recovery. Feces are composted into a drying vault which uses solar radiation to boost temperature within the vault while urine is treated by storage. Greywater from showers and sink is channeled to an irrigation network to drip into a cocoa plantation.

This system, in addition to achieving a secure sanitary treatment of excreta, brings important benefits, among which:

- Preserving drinking water.
- Use as an agriculture substrate, full of nutrients.
- Decreasing the cost of building and maintenance of sewage networks.
- Preventing the contamination of water bodies.
- Less vulnerable to extreme natural phenomena such as earthquakes, hurricanes and droughts, among others.

The system above is different from conventional ones since it includes urine-diverting dry toilets to minimize water use. The unit has a single vault in which feces are collected in 30-liter plastic containers and urine in 20-liter jerry cans. Fecal matter is composted for about two months in the vault attach to the water, sanitation and hygiene (WASH) unit, under the black metal plate oriented toward the sun to maximize the effect of solar radiation inside the plastic container. The immediate consequence of this innovation is to accelerate the destruction of pathogens by exposure to moderately elevated temperatures (Figure 2).

However, over-elevated temperature can be counterproductive to producing good compost. High temperatures will only produce a desiccated substrate because bacteria and other agents, for compost formation, operate in the mesophilic range (19-45° C). For this reason, composting latrines need to provide optimal temperature and time for excreta decomposition (RAPAPORT, 1993).

As per request of the family members living in the household, showers and hand-washing sinks were installed to improve hygiene. The greywater that leaves the system does not need to be pre-treated (except for the grease trap), since

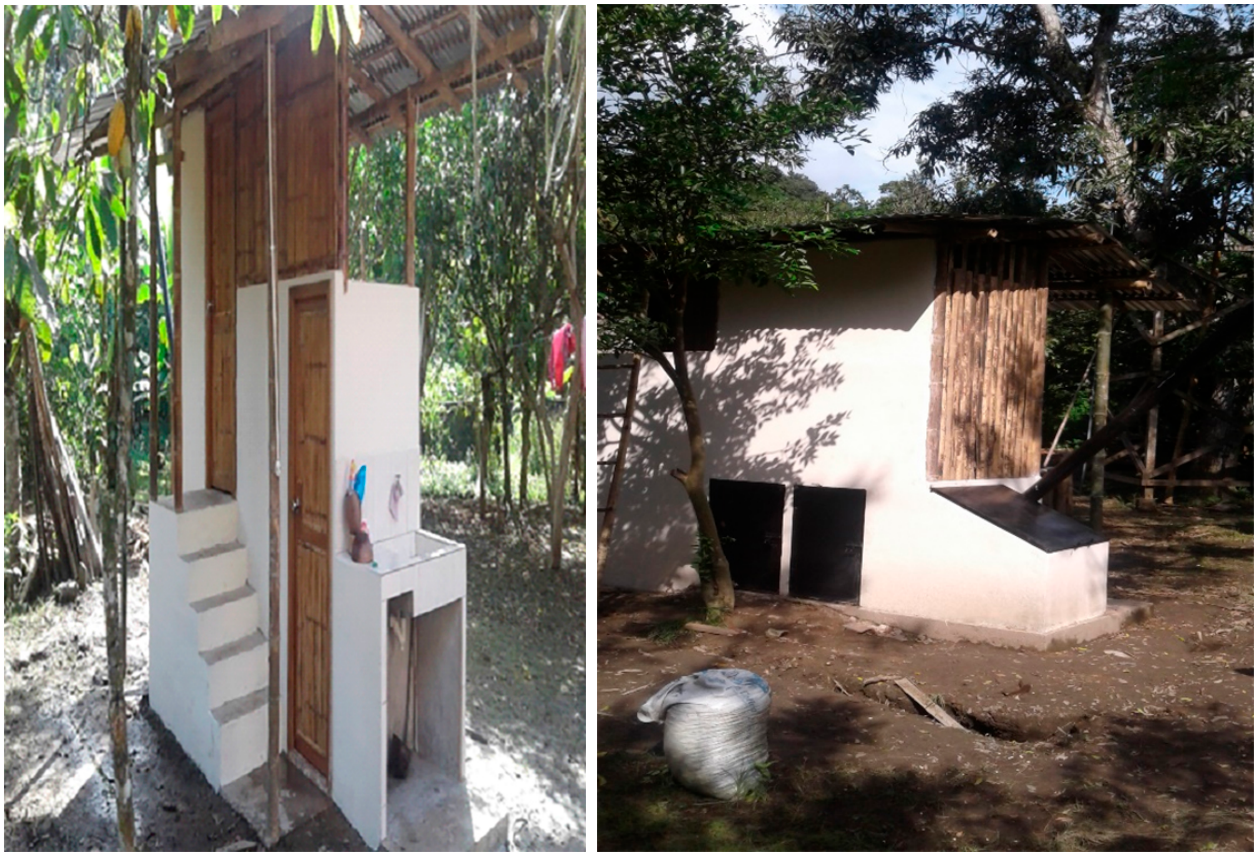


Photo: Bruno Bellettini.

Figure 2 – A Water, Sanitation and Hygiene (WASH) unit installed in a rural community of Ecuador.

only biodegradable soap is used by the benefiters. Currently, about 50 kilograms of solids (feces and sawdust) and 125 liters of urine are collected and processed monthly on the farm and used for the family's orchard.

METHOD

The assessment of the damage cost analysis is carried out using the Economics of Sanitation Initiative (ESI) toolkit, developed by the World Bank's Water and Sanitation program.

The ESI Toolkit is an online software that enables an analyst to practically implement an economic evaluation. In addition, the Toolkit provides a range of economic assessments that can be conducted using the same tool — hence encouraging the consolidation and comparison of different measures of economic and financial performance.

This software supports every stage of a damage cost analysis (DCA), starting with data collection and the organization of results to be presented and for stakeholder engagement. It was developed in its first phase to estimate the economic costs of poor sanitation in five countries of East Asia and the Pacific (HUTTON *et al.* 2008)

To implement DCA, data were gathered from the database of institutions of the Ecuadorian government. The National Institute for Statistics and Census (INEC) and the Ministry of Public Health are the ones with the most reliable information concerning the consequences of inadequate sanitation services. Once the inputs are in the model, the outputs are analyzed and interpreted according to the manual.

RESULTS AND DISCUSSION

The ESI Toolkit presents a detailed list of health parameters associated with economic variables that enables analysts to assess the damage costs associated with poor sanitation. Damage cost estimates provide the basis for a benefit analysis, which estimates the benefits of investing in different sanitation interventions. Benefit analysis serves as the basis for further economic evaluations by which costs are compared with benefits to assess program and intervention efficiency.

For the evaluation of the economic impact, each of these effects were captured using economic variables that represent the resulting harm. Table 1 presents different types of damages and their associated economic variables.

Inputs

The ESI allows analysts to assess the harm associated with the following diseases related to poor sanitation and hygiene: mild and severe diarrheal disease, hepatitis A, malnutrition, enteropathy, malaria, helminth infection, scabies, and trachoma. Malaria, acute lower respiratory infection, and measles are linked to

poor sanitation and hygiene through their impact on malnutrition, which makes people, especially children, more susceptible to those diseases and increases their mortality rates (FISHMAN *et al.* 2004; BLACK *et al.* 2008)

The cost of premature death is calculated by multiplying the number of deaths by the unit economic value of a death, using the human capital approach (HCA) to estimate value of life. Total time spent on accessing sanitation is estimated using data on the time taken by individuals to access different types of facilities and the number of times they access facilities per day. The time is then valued using the unit value of time estimated by the researcher, which in the case of rural Ecuador is around USD$ 4,453.00 (agricultural wage).

Poor sanitation normally pollutes water resources. This situation produces shortage of sufficient potable water, causing households to either have to purchase water from utilities or other water vendors, or access water from more distant but cleaner alternative water sources such as wells and springs. Each of these options carries a direct financial or opportunity cost, and sometimes both.

Table 1 – Economic Effects Covered by the ESI Toolkit.

Category	Characteristic	Associated Economic Variables
Health	Health Care Cost	Disease treatment costs
	Health-related productivity cost	Labor productivity, schooling, or leisure time value
	Cost of premature mortality	Value of life
Time	Time spent accessing sanitation	Labor productivity or leisure time value
Water Resources Impacts	Household access to clean water	Water access and treatment costs
	Flooding (health impact)	Health costs of floods
Tourism impact	Recreational uses of water	Income from tourism lost due to poor sanitation

Source: Own elaboration (2021).

During the rainy season, flooding in areas with poor management of fecal waste can cause disease outbreaks.

Inadequate sanitation seriously harms the tourism industry. The Toolkit estimates the potential net income gains from increased number of tourists due to improved sanitation. This parameter requires reliable data from institutions and stakeholders linked to tourism sector with sufficient understanding of tourists' perceptions of the importance of sanitation.

Outputs

Table 2 illustrates the differences between sanitation-related diseases after entering the number of cases per year, assuming an attribution rate as a percentage of diseases cases due to poor sanitation, considering cost of medication, among other factors. Severe diarrhea can be very costly in all age groups and can go as high as USD $525 for people below 4 years old due to the additional support required from parents. In the context of Ecuador, the average number of members per household is 5, distributed into 2 adults, 2.5 adolescents, and 0.5 members under 4 years of age, out of what the cost per household is calculated. The ESI considers hygiene diseases in the analysis. Sanitary facilities are not complete without hand washing services in order to prevent costs of related diseases as presented above.

To measure the cost of time to access sanitation, some hypotheses were elaborated based on interview with rural residents and SENAGUA officials as follows: half of the population that still practices open defecation does so on-plot and the rest, off-plot; that it takes them about 20 minutes for open defecation, considering the moment they leave home and return. It is also estimated that the place where they defecate is between 100 and 200 meters from home; and, finally, that the rural population defecates at least twice a day, regardless of age group or gender.

Table 3 illustrates the annual time spent by families in accessing sanitation in rural settlements expressed in financial costs. Although the total amount seems insignificant, it has an impact on the DCA of the ESI model. The total value of society's loss in terms of time impact represents USD$ 143,799.00, since this time could be used for productive activities, education, and even leisure.

Table 2 – Total health cost in US Dollars per person and per household divided by age group.

	Cost per person			Cost per household		
	0-4 years	5-14 years	15+ years	0-4 years	5-14 years	15+ years
Sanitation-related diseases	-	-	-	-	-	-
Diarrheal disease - Mild	100.84	61.52	62.73	51.93	64.60	215.49
Diarrheal disease - Severe	525.49	186.30	78.81	270.63	195.61	270.72
Hepatitis A and/or Hepatitis E	0.30	1.01	0.11	0.15	1.06	0.37
Malaria	0.06	0.27	0.22	0.03	0.28	0.74
Acute Lower Respiratory-tract Infection (ALRI)	53.48	41.91	42.36	27.54	44.00	145.49
Helminthes	0.01	0.05	0.04	0.01	0.05	0.12
Enteropathy	0.00	0.00	0.02	0.00	0.00	0.08
Malnutrition	1.57	1.19	2.53	0.81	1.25	8.70
Handwashing-related diseases	-	-	-	-	-	-
Scabies	7.28	8.58	4.46	3.75	9.01	15.31
Trachoma	0.00	0.00	0.00	0.00	0.00	0.00
Total	689.04	300.84	191.27	354.85	315.88	657.02

Source: own elaboration (2021).

Table 3 – Annual value of time in US Dollars spent accessing sanitation divided by gender and age group.

	Male			Female		
	0–4 years	5–14 years	15+ years	0–4 years	5–14 years	15+ years
Open defecation, off-plot	0.01	0.01	0.01	0.01	0.01	0.01
Open defecation, on-plot	0.00	0.00	0.00	0.00	0.00	0.00
Shared facility between known neighbors	0.00	0.00	0.00	0.00	0.00	0.00
Community facilities, localized	0.00	0.00	0.00	0.00	0.00	0.00
Public facilities, general public	0.00	0.00	0.00	0.00	0.00	0.00
Own private facility (any type)	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.01	0.01	0.02	0.01	0.02	0.02

Source: Own elaboration (2021).

Table 4 presents information on the cost per hour of hauling water, the percentage of households that treat their water by different methods and the cost according to the method used. To estimate the expenditure of rural households in treating the water they consume, a cost breakdown was made based on the fact that they boil it with domestic gas: the cost of the gas cylinder was estimated at USD$ 3.50 per 15 kg, lasting 30 days. This implies a daily cost of USD$ 0.1167 per day, with a daily use of 6 hours, of which 0.5 hours are allocated to boil 40 liters for all users (family of 5). The result is a cost of USD$ 0.24 per m^3, assuming the family boils half of the daily use. Lack of WASH services implies extra costs for households, which together add up to a total cost of USD$943 million, depriving the family's economy.

Poor sanitation has an adverse effect on tourism. To estimate the economic damage caused by dysfunctional sanitation, information was raised on aspects concerning number of visitors per year, average length of stay, average market value per tourist day, average profits earned per tourist day (in % of market value), target visitors per year, proportional attribution of visitor gains to improved sanitation. Table 5 describes tourism losses segmented into tourist visitors and business visitors. The income lost to society due to poor sanitation is the added value of both segments, representing USD$ 1,793,577.00; this figure represents about one dollar per household among those in rural areas.

Table 6 underlines the overall damages to a society with insufficient sanitation services. The ESI model demonstrates how inadequate sanitation management places a heavy burden on national economies as well as on household economies. This attempt to quantify the economic damages at national level for rural areas has estimated 2.77% of the gross domestic product (GDP). The worldwide sanitation gap is correlated with low GDP and consumer poverty (ROSEMARIN *et al.* 2008), underlining the fact that the gap is strongly connected to broader issues of development and inequality.

The outputs presented in Table 6 demonstrates that the costs of providing adequate sanitation are lower than the health-related costs due to inadequate sanitation, and that sanitation pays for itself several times over, the case for national investment in sanitation is strong. Globally, there is a new estimate for the cost of capital investment to meet the SDG targets for safe WASH by 2030 of US$74–166 billion per year (HUTTON *et al.*, 2016). Most of this investment would need to be in rural areas, at an urban-to-rural ratio of about 1:1.75.

To complement the results of this research, texts such as "Methodology manual: The Economics of Sanitation Initiative", developed by Hutton *et al.* (2016), should be mentioned. Here, he points out that costs are transformed into benefits as a result from the removal of the underlying condition that caused the damage. An intervention with any technology — such as the one proposed

Table 4 – Economic impact for water resources disposed for human consumption.

Costs of access per household	
Water piped to household	12.18
Water purchased from vendor	0
Bottled water	410.63
Other purchased source	0
Water accessed for free (implicit cost)	78.93
Costs of treatment per household	
Piped	85.52
Protected (ground water)	8.43
Unprotected (ground water)	7.71
Surface water	14.45
Other free sources	0.00
Total damages to all households	**943,699,597.63**

Source: Own elaboration (2021).

Table 5 – Impact for tourism in terms of economic losses due to poor sanitation.

	Tourist Visitors	Business Visitors
Additional net income gain from meeting visitor target	17,536,500.00	399,269.47
Income from tourism lost due to poor sanitation	1,753,650.00	39,926.95

Source: Own elaboration (2021).

Table 6 – Overall economic damage costs related to lack of sanitation in rural Ecuador.

	Per Capita	Per Household	Population-wide
Health impacts	266	1,328	2,027,997,523
Health Care Cost	234	1,168	1,784,212,934
Health-related productivity cost	30	152	231,746,219
Cost of premature mortality	2	8	12,038,369
Time impacts	0.02	0.09	143,799
Water resource impacts	124	618	944,169,578
Household access to clean water	124	618	943,699,598
Flooding (health impact)	0.06	0.31	469,980
Tourism impacts	0.23	1	1,793,577
Total	389	1,947	2,974,104,476

Source: Own elaboration (2021).

in this research — which mitigates or averts damages can be associated with benefits usually derived from reports or published studies related to the context.

CONCLUSIONS

Measuring damage costs using the ESI toolkit required reliable data gathered at the household level, if possible. The Ministry of Public Health and the Ministry of Water register and publish information at the national level with some existing data gaps, complemented with research studies from countries in the region.

The most relevant finding of DCA is how health is affected by poor sanitation. It has a cost to society of 1.88% of the GDP considering health care cost, health-related productivity cost, and cost of premature mortality segmented by age group. The highest damage on health-related issues is assumed by the 0-4 years of age group with a cost of USD$ 690.00 per individual.

Another relevant finding is the impact on water resources for human consumption. About 0.9% of the country's GDP is being lost due to pollution with direct consequences on household budgets. Some of society's poorest families spent around USD$ 618.00 to boil water or purchase water from vendors for drinking and cooking.

In aggregated terms, as a country, the impact of inadequate sanitation on rural tourism is not yet very important. This is due to the fact that the number of visitors who give up visiting the country or national tourists in rural areas is not very important in terms of national goals; and the expense of each one in protected natural areas is low (USD$ 140.00 per day for foreign tourists, for example) and because their stay is also low (average of 1 to 2 days).

Finally, ecosanitation represents an opportunity to overcome the economic losses derived from the lack of public infrastructure aggravated by aspects such as climate change. Resources recovery and reuse is the new paradigm to change the economics of sanitation with direct economic benefits for households and the environment.

AUTHORS' CONTRIBUTIONS

Bellettini, B.: Conceptualization, Data curation, Formal analysis, Funding Acquisition, Investigation, Methodology, Resources, Writing-original draft. García-Marín, A.P.: Project administration, Software, Supervision, Writing – review & editing

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