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Notes

# Improving rural water supply in Mexico in times of pandemics

# Mejoramiento del suministro de agua rural en México en tiempos de pandemia

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## Abstract

The efficacy of public administration strategies has been gauged on how they handle pandemics and the knock-on effects that occur on the environment or society, and in this case, in the rural water supply in Mexico in times of pandemics. Water access in rural Mexico and how the government has managed the rise in demand during pandemics are explored using a systematic review into 51 documents. Mexico's water system is below par and there is a need for more investments to be pumped into community management schemes. The involvement of the

public in the development of community management schemes is necessary to find a solution to the changing demand and supply.

**Keywords**: COVID-19, pandemic, rural water, SARS-COV-2, water supply.

## Resumen

La eficacia de las estrategias de la administración pública se ha medido en la forma en que manejan las pandemias y los efectos en cadena que se producen en el medio ambiente o la sociedad, y en este caso, en el abastecimiento de agua rural en México en tiempos de pandemia. El acceso al agua en las zonas rurales de México y cómo el gobierno ha manejado el aumento de la demanda durante las pandemias se exploran mediante una revisión sistemática de 51 documentos. El sistema de agua de México está por debajo de la media y es necesario realizar más inversiones en los planes de gestión comunitaria. Se requiere la participación de la ciudadanía en el desarrollo de esquemas de gestión comunitaria para encontrar una solución a la demanda y oferta cambiantes.

**Palabras clave**: COVID-19, pandemia, agua rural, SARS-COV-2, suministro de agua.

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# Introduction

Binswanger-Mkhize, De-Regt, and Spector (2010) highlight that intrinsic and extrinsic factors like the increased population, as well as agriculture, have led to the pressure on water resources intensifying. This, in turn, leads to increased tensions, conflicts among communities, and the exertion of pressure on the environment (Carlsson & Berkes, 2005; Castro, 2006; Binswanger-Mkhize *et al*., 2010).

The continued demand for water access in Mexico has been propagated by the basic strategies used by Mexican health authorities in a bid to stem a jump in coronavirus infections. Esposito (2020) cites that the authorities have made the phrases "stay at home" and "wash your hands" their mantras. Suffice to say that implementing such initiatives in the ground level is easier said than done especially because most people living in rural Mexico are mired in poverty, and they lack the requisite access to clean water (Esposito, 2020; Fewtrell & Bartam, 2001; Hargrove, Borrok, Heyman, & Tweedie, 2013; Mott-Lacroix & Megdal, 2016).

The new dilemma posed by the lack of access to clean water has raised concerns on whether it is high time for the government to recognize, in practice, the human right to water and put in place strategic initiatives that will allow for an effective and equitable democratic governance of water systems. The concern is guided by the sustainable





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development goals overview presented by Holmes (2020), who argues that the main objectives of Mexico at the start of the millennium were to;

- Achieve equitable and universal access to water for all.
- Provide adequate and equitable sanitation and hygiene to all, with special attention being paid to gender inequality.

The attainment of the aforementioned sustainable development goals has, however, been undermined by the fact that there is a general lack of confidence in the government when it comes to the provision of access to clean water (Holmes, 2020). A report presented by Esposito (2020) highlights that Mexico has the highest per capita consumption of bottled water in the world at 127 gallons annually. Addendum to this, only 11 % of the homes in rural areas receive water at least two times a week with Feldman (2020) noting that five million people lack access to clean water. Feldman (2020) cites that women and children are tasked with collecting water in rural areas, with the men deciding how water rights will be allocated. This has created conflicts and increased inequality with the United Nations recognizing water problems as environmental justice challenges (Esposito, 2020; Feldman, 2020; Coates & De-Albuquerque, 2020).

Organisation for Economic Co-operation and Development (OECD) (OECD, 2020) indicates that governments have to balance the demands and supply of the rural and urban centers, especially because the former provide essential goods and services such as food and energy during the confinement period. Moreover, most people have shifted from the urban areas since the start of the pandemic to rural areas in a bid to observe social distancing guidelines and avoid being caught up in crowded areas.





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Taking a longer perspective, it goes without saying that the coronavirus has exerted more pressure on the government to improve water access and supply to the rural areas (Hargrove & Heyman, 2020; Hargrove & Devlin, 2010; Rodríguez-Izquierdo, Pérez-Jiménez, Merino-Pérez, & Mazari-Hiriart, 2020; Delgado-Ramos, 2015; Gleeson, Wada, Bierkens, & van Beek, 2012).

The main objective of this paper is to examine water access in rural Mexico and how the government has managed the rise in demand during pandemics. The researcher asks to what extent is the constitutional right to water-related to improved water access. Also, the query on how the government can improve the current infrastructure and shield rural communities from water scarcity in the future is explored. The paper theorizes that rights likely operate more effectively when they take place in a milieu which is characterized by democratic governance of water infrastructure.

The subsequent paper is divided into five major sections, with the first focusing on the tools used in the collection of the data. The methodology section will also present a summary of the specific documents which are important to the topic at hand. The second section is the results that will briefly highlight the number of documents that were chosen and why some of them were excluded. The third section is the discussion section, which will offer an in-depth analysis of the chosen articles and how they are related to each other. The section will also provide recommendations to the Mexican government on how it can handle the rising demand for water access in rural areas. The final section is the conclusion which will comprise of the deductions derived from the





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study. The researcher will offer a foundation for future research based on the limitations of the current research paper.

## Methodology

As a novel topic revolving around the ongoing COVID-19, the researcher deemed it fit to implement a systematic literature review into previous pandemics and how they have influenced the demand and supply of water in rural Mexico. The main reason why this research methodology was chosen is that it improves the quality and strength of conventional literature review in a select number of ways. First, it increases the breadth of the literature review while retaining focus on pandemics and water access (Mallett, Hagen-Zanker, Slater, & Duvendack, 2012; Boaz, Ashby, & Young, 2002; DFID, 2011). Also, it focuses on empirical evidence presented on pandemics like Ebola or SARS with the knowledge not being preconceived. This is important in mitigating any internal or external bias found in most opinion pieces (Sorensen, Wojahn, Manske, & Calfee, 2013; Vandenbroucke, 2007). Thirdly, the systematic literature review is transparent and replicable, with both criticism-based and government-sponsored articles being used to find a one-size-fits-all strategy (Dixon-Woods & Fitzpatrick, 2001; Gough & Elbourne, 2002; The PLoS Medicine Editors, 2011).





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The first step in the data collection process involved going through the SCOPUS database in a bid to identify any peer-reviewed literature focused on previous and current pandemics. The identification process was guided by the Scimago institutions ranking, which is important in narrowing down the scope of research (Martín-Martín, Orduña-Malea, Thelwall, & López-Cózar, 2018). Created by the Scimago Research Group, the ranking tool is commonly used by researchers to determine whether the journal has the necessary sway in its discipline. The sway is validated by increased visibility and influence levels with impact scores that are normalized, helping pick quality papers for use. The efficacy of research is determined by ratio scales that rank the impact score at either below one or above 1. In the case that a paper has a score of 1, then it means that it is preferred highly by researchers. Having a score of below 1, on the other hand, means that the paper is not of top quality; thus, there is a need for caution to be exercised before referencing it. Additionally, papers with a score of above 1 are of high quality, with scholars being prompted to apply the results as they are replicable, genuine, and authentic.

The researcher further implemented a production scheme that was gauged using percentage variations. The production scheme helped in the determination of the time periods of the journals or literature used. Summative dispositions from the systematic literature review show that the only way to gauge the success of the government in improving water access in rural areas during the coronavirus pandemic is to go back in history. This thus means that the journal articles to be used in the systematic literature review should have been published between 1990 and 2020. The researcher would estimate the percentile variation





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between the years by subtracting the normalized impact of the studies from both years.

The third step in the systematic literature review required the researcher to adopt the Newcastle Ottawa Scale, which is vital in assessing the quality of studies that are non-randomized. The tool implemented at least three quality parameters that divided the studies in terms of their outcomes, comparison levels, and the quality of the content (Wells *et al*., 2019). The parameters were then categorized across eight major items, which differed in the percentage scores. Specific changes were made on the parameter of comparison to ensure that the scale items did not exclude papers that were important in answering the research questions and informing the researcher more on the topic (Martín-Martín *et al*., 2018).

The final step in the review focused on using the STROBE checklist, which contained 21 items that help in classifying research papers (Vandenbroucke, 2007). Au contraire, the researcher deemed it fit to use only 18 of the items since the remaining lot excluded important government and international institutions policy papers, which shed light on previous strategies used in improving water access. The checklist also helped determine the scope of the database used at first with deductions highlighting that there is a need for more databases to be used. The final decision saw the Environment Index, World Bank, Google Scholar, Base, Scopus, and Web of Science being picked as the final databases to conduct the research. The researcher typed in keywords like rural water supply, Mexico, coronavirus, pandemic, the impact of a pandemic, and strategies to improve water supply.

After all the articles had been sourced, it was time for the researcher to determine manually whether they met the inclusion criterion. The first condition of the criteria required the sources to explore the nexus between government agencies and private agencies in water supply and access. The second condition explored whether the papers were quantitative/ informative by nature with the information presented, having to meet set standards of analysis. Also, the researcher required the papers to offer future recommendations on how governments can handle future pandemics using conventional or contemporary strategies. The final criteria required the papers to define how stakeholder engagement can help in the formulation of major decisions on how water resources can be allocated to all and sundry to meet sustainable development goals.

# Results

The four-step systematic literature review produced at least 65 papers. Out of the 65, 10 were deemed to not be applicable to the research since their scope was set in the Latin American continent rather than in Mexico. The researcher then removed 5 of the remaining papers since they did not meet the requirements presented in the inclusion criteria and the STROBE checklist. The remaining 50 documents were deemed to be important for the paper as the results explored previous and current water





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management practices, definition of pandemics as well as offered recommendations to future research. The results derived are shown in Table 1 below.

**Table 1**. Literature selected.

| Tile of document | Type of Document | Authors and date | Comments |
|---|---|---|---|
| Governing the commons: The evolution of institutions for collective action | Book | Ostrom (1990) | It provides insight into community management of water resources |
| Rural Reform in Mexico: The view from the Comarca Lagunera | Report | Gortari and González (1994) | It explores how water systems have been reformed in rural Mexico |
| Sanitation and hygiene promotion: Programming guidance | Report | WHO (2005) | It explores the importance of promoting hygiene and sanitation |
| Meeting the need for safe drinking water in rural Mexico through point-of-use treatment | Article | Lang, Kaser, Reygadas, Nelson, and Kammen (2006) | It evaluates key strategies to be used in treating water in rural Mexico |
| Playing it forward: path dependency, progressive incrementalism, and the "Super Wicked" problem of global climate change | Article | Bernstein, Cashore, Levin, and Auld (2007) | It analyzes the impact of climate change on water access |
| Coping with water scarcity: An action framework for agriculture and food security | Report | FAO (2007) | It explores the issue of water access in rural Mexico |





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| Tile of document | Type of Document | Authors and date | Comments |
|---|---|---|---|
| An integrated method for evaluating community-based safe water programs and an application in rural Mexico | Journal article | Kolb, Milman, Flores, Salmerón, and Ray (2008) | It offers insight into water access strategies to be used in rural Mexico |
| Stakeholder participation for environmental management: A literature review | Journal article | Reed (2008) | It offers a literature into the importance of community involvement in water management strategies |
| Turning water stress into water management success: Experiences in the Lerma-Chapala River Basin | Book chapter | Hidalgo and Peña (2009) | It identifies key strategies that can be used to manage water stress |
| Integrated water resources management in practice: Better water management for development | Book | Lenton and Muller (2009) | It offers information into better water management strategies |
| Community managed rural water supply systems in the Dominican Republic: assessment of sustainability of systems built by the National Institute of Potable Water and Peace Corps, Dominican Republic | Master's thesis | Schweitzer (2009) | It assesses the role of community engagement in water management |
| What is a pandemic? | Website | WHO (2010) | It defines a pandemic |





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| Tile of document | Type of Document | Authors and date | Comments |
|---|---|---|---|
| social participation in Mexican river basin organizations: The resilience of coalitions | Book chapter | Mollard, Vargas, and Wester (2010) | It explores the importance of social participation in water management |
| Building the capacity of local government to scale up community-led total sanitation and sanitation marketing in rural areas | Report | Rosensweig and Kopitopoulos (2010) | It explores how communities can implement water management strategies |
| Water communities | Book chapter | Shaw and Thaitakoo (2010) | It explores the concept of water communities in Mexico. |
| Sustainable water resource management and participatory system dynamics. case study: Developing the Palouse basin participatory model | Journal article | Beall, Fiedler, Boll, and Cosens (2011) | It explores the outcome of effective water schemes in rural Mexico |
| Supporting rural water supply | Book | Lockwood and Smits (2011) | It explores the outcome of effective water schemes in Mexico |
| SISAR: An innovative sustainable management model for small decentralized water and wastewater systems in developing countries | Article | Meleg (2011) | It offers insight into the success of water management strategies in divergent nations |





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| Tile of document | Type of Document | Authors and date | Comments |
|---|---|---|---|
| Drinking Water infrastructure and environmental disparities: Evidence and methodological considerations | Journal article | VanDerslice (2011) | It explores key issues undermining water management |
| Regional strategies for the accelerating global problem of groundwater depletion | Journal article | Aeschbach-Hertig and Gleeson (2012) | It offers strategies to be used in water management |
| Climate vulnerability and adaptive strategies along the Rio Grande/Rio Bravo border of Mexico and the United States | Journal article | Hurd (2012) | It offers strategies to be used in water management |
| Regional climatic considerations for borderlands sustainability | Journal article | Gutzler (2013) | It explores key factors to be considered in order to improve watershed sustainability |
| Selecting five common modeling approaches for integrated environmental assessment and management | Journal article | Kelly *et al*. (2013) | It defines key strategies to be used in water management |
| Collaborative modeling for decision support in water resources: Principles and best practices | Journal article | Langsdale *et al*. (2013) | It defines key strategies to be used in water management |

| Tile of document | Type of Document | Authors and date | Comments |
|---|---|---|---|
| OECD studies on water: Making water reform happen in Mexico | Report | OECD (2013) | It highlights the main strategies used to improve water access in Mexico |
| The dilemma of water management 'Regionalization' in Mexico under centralized resource allocation | Book chapter | Scott and Banister (2013) | It analyzes the issues faced in managing water sources in Mexico |
| Constructing a framework for National Drought Policy: The way forward in Mexico | Journal article | Korenfeld- Federman, Arreguín-Cortés, and López-Pérez (2014) | It analyzes how Mexico can improve its drought and water management policies |
| Collective action in water resource management: theoretical perspectives and propositions | Book chapter | Ray (2014) | It defines how communities can be involved in water management |
| Chasing water: A guide for moving from scarcity to sustainability | Book | Richter (2014) | It defines the strategies used to manage water in Mexico |
| Global rise in human infectious disease outbreaks | Journal article | Smith *et al*. (2014) | It explores the outbreak of diseases in modern day society |
| Community water management in Latin America and the Caribbean: Challenges for Mexico | Journal article | Silva-Rodriguez-de-San-Miguel, Trujillo-Flores, Lámbarry-Vilchis, Rivas-Tovar, and Bernal-Pedraza (2015) | It presents recommendations on how communities/governments can manage waters sources better |





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| Tile of document | Type of Document | Authors and date | Comments |
|---|---|---|---|
| Rural water sustainability in Latin America and the Caribbean | Doctoral thesis | Prado (2015) | It analyzes the main issues affecting water availability |
| Stakeholder engagement for inclusive water governance: "Practicing What We Preach" with the OECD water governance initiative | Journal article | Akhmouch and Clavreul (2016) | It explores how communities can be engaged in water management |
| Estadísticas del agua en México | Report | Conagua (2016) | It provides an overview of the success of water policies in Mexico |
| Drought risk management in Mexico: Progress and challenges | Journal article | Ortega-Gaucin, López-Pérez, and Arreguín-Cortés (2016) | It provides an assessment of the main schemes used for water management |
| Environmental-mechanistic modelling of the impact of global change on human zoonotic disease emergence: a case study of Lassa fever | Journal article | Redding, Moses, Cunningham, Wood, and Jones (2016) | It highlights key strategies to be used to determine the impact of diseases on communities |
| UNEP Frontiers 2016 Report: Emerging issues of environmental concern | Report | UNEP (2016) | It offers recommendations on how to improve water access and management |





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| Tile of document | Type of Document | Authors and date | Comments |
|---|---|---|---|
| A half-baked solution: Drivers of water crises in Mexico | Journal article | Godinez-Madrigal, van der Zaag, and van Cauwenbergh (2018) | It analyzes the main factors behind water crises in Mexico |
| The economics of aquifer protection plans under climate-water stress: New insights from hydro-economic modeling | Journal article | Ward, Mayer, Garnica, Townsend, and Gutzler (2019) | It offers recommendations on how to improve water access and management |
| The coronavirus pandemic should focus our attention on the water crisis | Communication | Barbier (2020) | It explores how the coronavirus has affected water sources |
| Opinion: COVID-19 a collective failure, an unprecedented opportunity | Article | Coates and De-Albuquerque (2020) | It defines the coronavirus and its impact on society |
| A comprehensive process for stakeholder identification and engagement in addressing wicked water resources problems | Journal article | Hargrove and Heyman (2020) | It highlights the importance of involving stakeholders in water management |
| Increase access to water, sanitation, hygiene (SDG 6.1 & 6.2) | Article | Holmes (2020) | It explores the importance of attaining sustainable development goals |
| The impact of COVID-19 on the water and sanitation sector | Report | International Finance Corporation (2020) | It explores the impact of coronavirus on water security |





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| Tile of document | Type of Document | Authors and date | Comments |
|---|---|---|---|
| Assessment of the impact of COVID-19 pandemic on water, environment and related ecological and human systems | Report | Kumar *et al*. (2020) | It explores the impact of coronavirus on water security |
| Preparedness for emerging epidemic threats: A Lancet infectious diseases commission | Journal article | Lee *et al*. (2020) | It highlights how communities can prepare for epidemics |
| Water in Mexico | Report | Netherlands Enterprise Agency (2020) | It explores the availability of water in Mexico |
| The pandemic is laying bare a global water crisis | Article | Nicol (2020) | It explores the impact of coronavirus on water security |
| Policy implications of coronavirus crisis for rural development | Note | OECD (2020) | It explores the impact of coronavirus on rural development |
| Water in the COVID-19 crisis: Response, recovery, and resilience | Report | Sadoff and Smith (2020) | It explores the impact of coronavirus on water security |

Source: own elaboration.





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# Discussion

Scientists have explored the concept of zoonotic diseases ever since the 1930's with specific reference being drawn on how they replicate themselves once they get into the human body (Redding *et al*., 2016). One of the topmost zoonotic diseases of modern times is the coronavirus, with causes diseases in birds and mammals. The first-ever case of the coronaviruses was discovered in the 1930s when domesticated chickens were shown to have infectious bronchitis virus (UNEP, 2016). The virus caused widespread mortality rates for newborn chicks, with practitioners being unable to control its spread. However, more studies were put in place to study how the disease was transmitted from the birds to human beings with the first-ever pandemic being recorded in 2003 in the form of the SARS-COV, followed by the HCoV-NL63 in 2004 and the most recent SARS-COV-2 in 2019 (Decaro & Lorusso, 2020).

Nicol (2020) highlights that the modus operandi for the pandemics was and still remains the same as they started out as isolated cases and then spread all over the world, bringing the international community to a halt. Redding *et al*. (2016) cite that the epidemics were further influenced by key factors like change in land usage, deforestation, destruction of habitat, and extractive activities, which reduced the barriers between host animals and humans. Furthermore, the increased interaction between mammals and the coronavirus carrying birds altered the distribution of the vectors and reservoirs of the diseases which in turn caused an influx





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in the manner through which they are transmitted (Lee *et al*., 2020; UNEP, 2016; Prado, 2015). Some scholars have argued that the causal factors behind the occurrence of the disease are correlated to climate change, whereby an increase in landscape suitability has also accentuated the rate of contact between the birds and humans (Lee *et al*., 2020).

The SARS-COV-2 initially started in China as an epidemic with its epidemiologic features typifying acquisition from common sources as well as a short period of incubation which is likened to the previous pandemics (Smith *et al*., 2014; Kumar *et al*., 2020). The spreading process occurred through coming into contact with an infected person or surface, with the attack rates being high (WHO, 2010; Coates & De-Albuquerque, 2020). Contrary to pretensions to historicize previous finds but consonant with the novel nature of the virus, it goes without saying that the international community has been unable to control the spread of the disease or even find a cure (Smith *et al*., 2014).

As it stands, Mexico confirms at least 4 000 cases in a day, although the number is lower than the actual cases because of limited testing. Just like any other nation, Mexico was blindsided by the pandemic; thus, they did not have the necessary resources in place to test people. This has, in turn, forced governments to put in place regulations such as lockdowns, curfews as well as hygiene and sanitation programs (Gobierno de México, 2020; Infobae, 2020).

Barbier (2020) cites that cleaning infected surfaces and washing hands frequently have been deemed to be elementary measures. The issue, however, is that water is essential when implementing the tasks with most people having no idea where the water is coming from, who or how it is supplied, and the costs incurred when paying for it (Barbier,

2020). The virus came at a time when there is a rise in freshwater scarcity in the international community, whereby 2.4 billion people are living in watersheds that lack the necessary supplies and are more susceptible to climate change (Holmes, 2020; Hargrove & Heyman, 2020).

Barbier (2020) denotes that even though the areas are influenced by environmental factors, the main culprit behind the lack of access is the policies, governance structures, and institutions used in managing water. The author argues that most of the institutions were formulated at a time when the resource was abundant, although, with time, demand led to it becoming a scarce commodity. The end outcome is continued exploitation of freshwater as if it is abundant even as the communities and entities recognize its growing scarcity (Beall *et al*., 2011; VanDerslice, 2011).

International Finance Corporation (2020) backs the findings presented by Barbier (2020), whereby it argues that the domestic and international water sector was influenced by rapid urbanization, aging infrastructure, and an influx in the number of people living in areas that faced water scarcity prior to the pandemic. The occurrence of the disease and its spread, however, led to water access improvement plans being shelved to channel the resources into other crucial sectors such as health which form the backbone of the society (International Finance Corporation, 2020; Redding *et al*., 2016). The resource allocation was done with the insight being drawn on the operational expenditure and capital expenditure to be used in the restoration or establishment of water access schemes. Investor insight shows that most international firms have stopped funding domestic initiatives out of fear of the looming economic recession (International Finance Corporation, 2020). The International Finance Cooperation (2020) cites that the disease has





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increased the cost of disruption with shifts in the demand and supply rates bringing to light newer operational needs. This has, in turn, affected people living in the rural areas because the government has held out on improving water supply due to the lack of clear cut framework even though the people are expected to practice individual and collective hygiene (International Finance Corporation, 2020).

An article presented by Sadoff and Smith (2020) denote that the virus has shown that the sustainable development goals and objectives of improving water access to all and sundry have been undermined. The article is clear that rural communities are deprived of the most basic protections due to the lack of water access. The researchers used a recovery framework to explore the social and administrative impact of the virus and how society can get back to the right trajectory through water management (Sadoff & Smith, 2020). The framework highlights that water management is significant in the reinforcement of food systems stability. The social impact of the virus on the rural areas has caused a rise in inequality since most people in the areas relied on agricultural cycles where demand and supply were evened out (Beall *et al*., 2011). The income derived from the cycles would be used in catering to their individual and collective needs, although the virus has led to a dip in both with losses rising by the day (Sadoff & Smith, 2020).

Additionally, there has been a slow resumption in Mexico's activities, which has caused a small rise in demand. Sadoff and Smith (2020) argue that this presents a new dilemma to the public administrators as the demand of irrigation water is rising, especially with the looming dry season. However, the demand for irrigation water will not be addressed by the government, as mentioned earlier, because the funds





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have already been diverted into getting personal protective equipment for the medical practitioners (Sadoff & Smith, 2020). This will cause an endless cycle of poverty and increase the gap between the rich and the poor (Bernstein *et al*., 2007; Aeschbach-Hertig & Gleeson, 2012).

## Efficacy of current water supply infrastructure in Mexico

Lang *et al*. (2006) presented a research paper which explored the conventional water supply structures used in Mexico. The authors indicate that most people in rural Mexico collect untreated water from sources that are unprotected, which exposes them to dangerous waterborne diseases like cholera, shigella, or even salmonella. It is no shock that Mexico has one of the highest rates of waterborne diseases in the world, with most of the cases being recorded in the rural areas (Hidalgo & Peña, 2009; OECD, 2013; International Finance Corporation, 2011). Lang *et al*. (2006) further note that the lack of access to clean water in Mexico cost the government at least 3.6 billion dollars in healthcare expenditures, which could have been avoided or saved if the requisite infrastructures had been put in place.

As of 2006, Lang *et al*. (2006) cite that the coverage of potable water and sanitation was grossly unequal. The percentage of the population served by piped water differed highly from the percentage of





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people with access to working sewage systems and drinking water. Conclusive denotations drawn show that the lack of improved water supply and sanitation facilities accentuates the risks of water scarcity and thus creates room for the rise in coronavirus pandemics (Lang *et al*., 2006).

The Food and Agriculture Organization (FAO, 2007) backed the findings presented by Lang *et al*. (2006) by exploring how and why water access needs to be improved in the rural areas. The author's focus is on crop production, which consumes a lot of water in Mexico. The food production requires at least 3 000 liters of water to produce the daily food needs of a person with 2 to 3 liters being used for daily drinking purposes while 20 to 300 liters per day might be needed for domestic needs. The increase in the rural population means that more people will require more water to cultivate industrial crops, fiber, and food (FAO, 2007). Estimates further show that the food and crop demand has doubled in the previous years, with the main factors driving the trends being inclusive of dietary change and population growth (FAO, 2007). Due to the fact that the rural area is the backbone for food production, more water is needed to counter the threat of food scarcity (Schweitzer, 2009; Ortega-Gaucin *et al*., 2016; Richter, 2014).

The Food and Agriculture Organization (FAO, 2007) further explains that rising incomes and continued urbanization has exerted pressure on the rural areas to meet the food demand because food habits have changed towards varied diets. The end outcome has been a shift in consumption patterns among cereal crops with livestock and fish products being preferred. Also, Food and Agriculture Organization (FAO, 2007)

argue that the opportunities for increased productivity cannot be attained because the gap in the national water balance in Mexico is unsustainable.

As per Godinez-Madrigal *et al*. (2018), Mexico's current gap stands at 11 500 $hm^3yr^{-1}$ with the water use of all users being set at 78 400 $hm^3yr^{-1}$. At least 36 % of the water used in Mexico is derived from groundwater, with the gap being expected to double from the 11 500 to 23 000 $hm^3yr^{-1}$ by 2030 (Godinez-Madrigal *et al*., 2018). The widening process is linked intermittently to agricultural, public, and industrial use. The nation currently has six rivers among the most depleted freshwater sources in the world, with high competition between the users exerting more pressure on the people in rural areas. Summations highlight that at least 23 % of the aquifers in Mexico present saline intrusion and overexploitation with this making it the largest groundwater user in Latin America (Godinez-Madrigal *et al*., 2018; Ward *et al*., 2019).

Silva-Rodríguez-de-San-Miguel *et al*. (2015) opine that the management and provision of water supplies to the rural communities, coupled with rural sanitation, has provided the national and local government with a major dilemma. Most of the concern revolves around the financial toll that comes with setting up and managing the infrastructure with the income derived from providing water services to the people in Mexico being nominal by nature, even though water is a significant source of revenue for most nations (WHO, 2005). The Organization for Economic Cooperation and Development (OECD, 2013) highlights that the Mexican government has, over time, now been the subject of criticism because they have ignored the intricacies and complexities that come with rural water management (OECD, 2020). Scholars agree that there has never been a clear-cut strategy in place

since the start of the century, which can be used to provide people in rural areas with the necessary access to water resources. However, the increased criticism prompted the government to put in place changes that are geared towards decentralizing the water supply in Mexico.

Silva-Rodríguez-de-San-Miguel *et al*. (2015) indicate that the first initiative put in place by the Federal Government of Mexico has been building new water treatment plans and expanding the water networks into the rural areas. This mandate was specifically implemented by the Programme for the Construction and Rehabilitation of Drinking Water and Sanitation Systems in Rural Areas (Prossapys), which addresses the water access needs of rural communities with below 2 500 inhabitants. Silva-Rodríguez-de-San-Miguel *et al*. (2015) argue that the national government coordinates the Prossapys, and its correspondents to the implementation of state laws even though it is not involved in the development of policies. The scheme has undergone a myriad of structural changes with the latest version providing community organizations with the autonomy to implement the set regulations.

Fewtrell and Bartam (2001), and Scott and Bannister (2013) denote that before the improvements, only 30 % of the people in rural Mexico had access to clean water and sanitation facilities. The investments are extensive and ongoing with the Federal Government of Mexico achieving a high level of cooperation in rural areas with the sanitation levels going up to 70 % and water access up to 80 %.

Deductions drawn by Gortari and González (1994) indicate that the decentralization systems put in place before the 21st century have seen the federal government tasking both water supply and sanitation to every municipal area. Juntas or water boards are used to regulate the supply of

water to every homestead in rural areas with several mechanisms that are facilitated by government legislation being used to control the processes (Scott & Banister, 2013). Gortari and González (1994) provide an example of how the Juntas work whereby they are required to set up sustainable development and community organizing initiatives. The initiatives have to be guided by the sustainable development goals, with the federal government continuously reviewing their performances to check whether the strategies have been effective (Gortari & González, 1994).

Silva-Rodríguez-de-San-Miguel *et al*. (2015) quipped in with some insight into community water management in Mexico, and the challenges faced. The article highlights that the management strategies used by juntas in Mexico are latent, but they have never been the subject of consolidation. The juntas are established under article 4 of the constitution, which requires the state to guarantee people with the requisite access to water and sanitation. Additionally, their formation is often done after the communities meet and start their own alliances and incentives to improve water access. There are four different strategies, according to Silva-Rodríguez-de-San-Miguel *et al*. (2015) that can be used for water management which include:

1. Self-regulation and management which allows the rural communities to manage the water resources how they deem fit.
2. Scaled operations which are aimed at driving the systems to operate under scalable economies.
3. Capacity development whereby the ability of the leaders to accentuate delivery of services is improved.

4. Cooperative management wherein the national, regional, and municipal governments work together to develop public policies, regulation as well as guidelines for management.

Silva-Rodríguez-de-San-Miguel *et al*. (2015) note that providing support to community-based management is bound to improve the delivery of services. However, the implementation process has to be done using major alliances, namely, private community partnerships and public community partnerships. Specific agreements must be established, which will guarantee the flow of financial and technical resources to the identified alliances (Akhmouch & Clavreul, 2016; Netherlands Enterprise Agency, 2020).

Lockwood and Smits (2011) introduce the triple S Model, which highlights how nations can implement community management strategies in lieu of the available structures at the local, regional, and national levels. The model shows that service supply should be decentralized with specific responsibilities being accorded based on the government level (Lockwood & Smits, 2011). Take, for instance, the national level should be marked by the formulation of policies and normative functions. The regional level will explore service authority functions while the lower level will require the implementation of the policies by the service provider. Silva-Rodríguez-de-San-Miguel *et al*. (2015) denote that applying this model in policy formulation is important, although it has to be detailed and revamped to match the needs of the country where it is applied at.

Innovation is also a key cornerstone in the water access methodology used in Mexico with Scott and Bannister (2013), citing that Conagua has applied such methods in fulfilling the program objectives of the Prossapys. Conagua (2016) reports an increase in the coverage for

drinking water in rural areas in 2015 after an investment of 8 886 million pesos was channeled into conventional infrastructure. The investment was 18.5 % higher than the one recorded in the previous year, with more improvements in water management being made as a result of community water management.

Korenfeld-Federman *et al*. (2014) note that the success of programs geared towards improving water access in rural areas like Prossapys have helped the federal government to relieve some of the pressure noted in rural areas especially in the wake of the fact that a good chunk of the nation's utilities are performing poorly. The reports show that fewer people are willing to spend money on water services because water quality is low, with funding being gleaned because of the utilization of institutional measures and increased public awareness that water is an economic good. Recommendations drawn by Hargrove *et al*. (2013) cite that increasing consumer education can help in ending the vicious cycle whereby customers do not want to pay for services. The education will allow for the collection of funds, which will help improve the status of the facilities.





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# Recommendations

Many infectious diseases leading to pandemics are caused by zoonotic pathogens that were transmitted to humans due to increased contacts with animals through breeding, hunting and global trade activities. The understanding of the mechanisms of transmission of pathogens to humans allowed the establishment of methods to prevent and control infections. During centuries, implementation of public health measures such as isolation, quarantine and border control helped to contain the spread of infectious diseases and maintain the structure of the society. In the absence of pharmaceutical interventions, these containment methods have still been used nowadays to control COVID-19 pandemic (Piret & Boivin, 2020).

The time of onset and the pathogen that will cause the next pandemic are unpredictable. Therefore, pandemic preparedness plans emphasize that non-pharmaceutical interventions should be implemented first to control human-to-human transmission of the pathogen. Furthermore, pharmaceutical interventions should be developed to improve the global response to the pandemic (Piret & Boivin, 2020).

In the case of Mexico, in lieu of the rising number of infections and the need to minimize growing mortality rates, it is important for the national, regional, and local governments to put up infrastructure which will improve water access in the rural areas. Lang *et al*. (2006) indicate that Mexico is fortunate to have a select number of federal institutions

that are not only capable but also enjoy strong networks that extend into the impoverished areas. The first recommendation provided is for the institutions to implement solutions to rural water quality issues. The solutions should be innovative with educational modules being put in place, which will create value for adequate hygiene practices and clean water (Lang *et al*., 2006; Shaw & Thaitakoo, 2010). Addendum to this, a nation-wide program should be used to promote and implement the treatment of water in rural communities. The program has to be led by the Secretary of Health and the Secretary of Social Development. Local support from the municipalities and states is required, with the program being based on existing infrastructure, resources, and expertise (Rosensweig & Kopitopoulos, 2010; Ray, 2014). The government should provide training and technical support to researchers who have the ability to formulate innovative solutions (Gutzler, 2013; Reed, 2008).

In as well, federal programs should be set up, which will target communities that are marginalized and accord a subsidy on the price of most technologies so that the most vulnerable or poorest groups can gain access to water. The state government is prompted by Lang *et al*. (2006) to send out deputy or sub-deputies who will act as local representatives in the decentralization of the water resources and or programs. The authors also call on institutional cooperation across all sectors and scales for water access to improve in rural Mexico. Owing to the inchoate limitations of single institutions, there is a need for cooperative programs to be formulated to take advantage of the individual strengths of actors in the nonprofit, public and private sectors (Langsdale *et al*., 2013; Lenton & Muller, 2009; Meleg, 2011; Mollard *et al*., 2010). The communities and external agencies can liaise through nongovernmental organizations that





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will also help in incorporating water quality testing and hygiene education programs (Ostrom, 1990).

Barbier (2020) provides the third recommendation, which is to allow for the flourishing of markets that trade water. Summative dispositions highlight that the predominant use of water in Mexico is irrigated agriculture, with at least 80 % of water withdrawals being required. Due to the fact that the demand is higher in urban areas, the people are willing to pay for it compared to the rural farmers. The farmers are therefore left to their own devices, thus calling for the creation of markets for trading water (Barbier, 2020). The markets will be characterized by farmers selling part of their water rights or even leasing their water over a set number of years. The finances collected from the markets will then be used to maintain the water supply infrastructure in rural areas.

Barbier (2020) also recommends that the federal government should stop placing subsidies on water and sanitation services during the pandemic. The author notes that current prices rarely cover the full cost of the water services, with governments paying for all of the investment costs. The overpricing of water and sanitation services will help the local, regional, and national governments to improve cost recovery with the services being expanded to the households that lack them. Also, a fixed service charge has to be introduced, which will pay for the costs incurred when operating and maintaining the water system (Barbier, 2020). There is a high probability that water conservation will be increased if a two-tier block rate charge is imposed on households. Due to the fact that rural community households use less water, the government should put a low price on the first block of water. Monthly water use that goes above 30 to 300 cubic meters will, however, require a higher price (Barbier, 2020).





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The fourth recommendation by Barbier (2020) implores governments and the juntas to finance the adoption of water-saving technologies by rural families in Mexico through rebates and discounts. The juntas will introduce additional programs that will target low-income families and allow for the adoption of solar power irrigation pumps to help in their agricultural endeavors. A normal pump costs at least $1 000.00, with financing models being put in place to subsidize the cost and make them easy to purchase. Nicol (2020) cites that the challenge of water availability being balanced with water quality still remains at the domestic level. Au contraire, new and emerging technologies can be implemented in the long term which will help in monitoring water resources in an accurate and fast manner (Korenfeld-Federman *et al.*, 2014; Kolb *et al*., 2008). Specific technologies like drones and satellites will allow scientists to identify water-related risks and prepare the communities for any changes in supply and demand (Nicol, 2020; Hurd, 2012).

Nicol (2020) concludes that taking an innovative and data-driven approach will help in managing water access during the coronavirus pandemic. Remote sensing technology is momentous in gathering continent-wide data in Mexico over the next few years, with the information being stored ready to be analyzed in a database that is open source (Nicol, 2020). The objective is to equip the regional and governmental agencies with the information needed to formulate decisions concerning water access and resource management (Nicol, 2020; Kelly *et al*., 2013). The information will also help in understanding the complexities and trade-offs of water allocation addendum to safeguarding the future of environmental flows in Mexico's aquifers.





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The principal recommendation to prevent the spread of COVID-19 is to wash your hands frequently, washing surfaces and remaining hydrated remain high on the list as well. Certain organizations are focusing on working together with water-scarce communities to decentralize water supplies by harvesting rainwater (Terrell, 2020).

Also, what has been implemented by Conagua in the short term, and it needs to continue while the pandemic lasts, is the following (Jiménez-Cisneros, 2020): 1. Strategy to serve institutions of Health, due to the quantity of water demanded for example in hospitals; 2. Coordination with states and municipalities; 3. Emerging strategy to attend to vulnerable population, 4. Collaboration with the private sector to serve the population, and 5. Strategy to support agriculture, to ensure food safety.

## Conclusions

Water access and health improvement are two factors that are intimately linked. The preceding research highlights that shortages of water make it hard for people in rural Mexico to gain basic protection against the novel coronavirus. In addition, the decreased access to water has upset the day-to-day income-generating activities of the rural communities, thus maintaining the vicious cycle of sickness and poverty. It is against this





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backdrop that the paper provides recommendations on how the current water access infrastructure can be improved with findings from systematic literature being used.

The papers explored in the discussion section have all offered a new insight into water use in Mexico and pandemics, which undoubtedly contributes to the understanding of the situation that exists since 2019 due to SARS-COV2 and its effects on rural water supply. The results derived from examining the existence of the rights to water and health, as well as governance, is momentous in bridging the existent gap of knowledge into pandemics and water access. They will contribute to future studies on how Mexico can improve its water sustainability measures. Also, the success of the recommendations such as the implementation of solutions by institutions to rural water quality issues, the cooperation across all sectors and scales for water access, and the formulation of cooperative programs to take advantage of the individual strengths of actors in the nonprofit, public and private sectors. The recommendations will provide autonomy to community management entities like juntas, thus improving trust between the government and the people. Nevertheless, additional research in each Mexican entity is necessary to comprehend the particularities of the rural water supply problem.

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