

Artículo de Revisión

# Green Infrastructure in Rural Communities of Mexico\*

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## Abstract:

Residents of Mexico's communities face considerable health issues. The improvement of green infrastructure bolsters the efforts of rural communities in maintaining high standards of health, subsequently making rural communities as habitable as possible. This paper aims to critically assess the existing literature on this topic between 2000 and 2018 because most sources fell comfortably within this range and no other comparable systematic review, either selective or comprehensive in nature, has been conducted in this respect. The results of the review suggest that a greater focus on the development of green infrastructure in rural areas is required.

**Keywords:** green infrastructure, Mexico, rural communities.

## Infraestructura verde en las comunidades rurales de México

### Resumen:

Los residentes de las comunidades rurales en México enfrentan problemas de salud considerables. El mejoramiento de la infraestructura verde resulta un gran apoyo para los esfuerzos de las comunidades rurales por mantener altos estándares de salud, logrando consecuentemente que las comunidades rurales sean habitables al máximo posible. El objetivo de este artículo es evaluar en un sentido crítico la literatura existente producida sobre este tema entre 2000 y 2018, debido a que la mayoría de las fuentes se encontraron con mayor facilidad dentro de este rango y aún no se ha realizado ninguna otra revisión sistemática semejante sobre este aspecto, ya sea selectiva o general. Los resultados de la revisión sugieren que se requiere una mayor focalización en el desarrollo de la infraestructura verde en áreas rurales.

**Palabras clave:** infraestructura verde, México, comunidades rural.

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# Infraestrutura verde nas comunidades rurais do México

## Resumo

Os moradores das comunidades rurais no México enfrentam consideráveis problemas de saúde. A melhoria da infraestrutura verde resulta grande apoio aos esforços das comunidades rurais para manter altos padrões de saúde, consequentemente tornando as comunidades rurais o mais habitáveis possível. O objetivo deste artigo é avaliar num sentido crítico a literatura existente produzida sobre esse assunto entre 2000 e 2018, devido a que a maioria das fontes foi mais facilmente encontrada nessa faixa e ainda nenhuma outra revisão sistemática parecida foi realizada sobre esse aspecto, nem seletiva, nem geral. Os resultados da revisão sugerem que é preciso maior focalização no desenvolvimento da infraestrutura verde nas áreas rurais.

**Palavras-chave:** infraestrutura verde, México, comunidades rurais

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## Introduction

Residents of Mexico's communities face considerable health issues, albeit less intense than those faced by citizens living in the country's largest urban centres, including Mexico City – where health issues are the worst in the country (Barraza-Lloréns, Bertozzi, González-Pier & Gutiérrez, 2012). Significant failures in urban and rural green infrastructure across Mexico are the key culprit in this sense, referring to it as strategically technical planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services (Villa, 2018). The improvement of green infrastructure bolsters the efforts of rural communities in maintaining high standards of health, subsequently making rural communities as habitable as possible (Salinas, Al Snih, Markides, Ray & Angel, 2010).

Over time, the literature shows that there are many factors which have been taken into consideration and interpreted in various ways so that governments and non-governmental bodies, and a broad range of other stakeholders, are best equipped to work towards making rural communities as healthy and habitable as possible in the circumstances (Yoonhee & Bontje, 2016). Green is just one of these, with others including: smart; resilient; human; sustainable; ecologic; biophilic and many more (Villa, 2018). Among these factors, the notion that a habitable community must be a healthy one has been given little value until relatively recently irrespective of how germane such an idea is. Rural communities are, first and foremost, the people who reside in them (Flora, 2001). Individuals often live in rural communities because they were born there and also their families live there (Racher et al., 2004). The development of rural communities in Mexico in recent years – in social, economic, educational or recreational terms – means that more people are drawn to remain in rural communities instead of relocating to larger cities for their perceived opportunities (Zamora Areli, Jiménez-Velázquez & García Cué, 2017). However, it is vital that rural communities are able to offer their citizens a good standard of health and habitability above all else (Villa, 2018).

Various factors play an important role in the accomplishment of a high standard of health and the good quality of life associated with it (Pantoja, Barreto & Panisset, 2018). Two of the most paramount factors are: the quality of air that citizens breathe; and the level of physical activity that citizens demonstrate (Borbet, Gladson & Cromar, 2018). Of course, there are countless influences affecting these factors, and others, but a pressing question must be asked: do the methods employed to design land use planning have a marked impact on the health of rural citizens and thus on the quality of their lives? The answer to this appears to be yes, they do. The rate at which rural communities have been growing over the past two decades (Silvers & Crosson, 2015) has been a major contributor to the health and habitability of these rural environments, and the gap between health in urban and rural areas in Mexico is closing, although in urban areas it is still worse (World Bank Group, 2004; Aguila et al., 2012). It is evident, then, that land use planning in rural areas across the country has been less effective than it could or should be (Caballero, 2006).

The Report on the Health of Mexicans 2015 – A General Diagnosis of Population Health by the country's Health Secretary (Secretaría de Salud, 2015), argues that the rate of physical inactivity across Mexico is comparatively high. It goes on to state that over 20% of Mexican women and 15% of Mexican men between 15 and 29, as well as 29% of individuals between 15 and 29, lead a considerably inactive lifestyle. Taking this data into account, it is therefore unsurprising that the number of Mexican adults classified as obese has increased from 63.8% in 2000 to 71.3% in 2012. Medina, Tolentino-Mayo, López-Ridaura and Barquera (2017) report similar figures, arguing that more people across Mexico are sedentary and obese than ever before, in both urban and rural areas.

Based on the nature of rural communities across Mexico, many of which are very remote (Schryer, 2017), citizens spend a considerable portion of their time commuting to and from work (Orraca Romano, 2015). People rely either upon their own vehicles or public transportation (where possible) to get to and from work. Depending on the type of employment, once people reach work, they often remain relatively stationary across the day, and once they return home after a long commute, they have little inclination to do any exercise (Medina et al., 2017; Secretaría de Salud, 2015).

Further, while a more troubling issue in urban areas characterised by higher levels of pollution (Molina, De Foy, Vázquez Martínez & Páramo Figueroa, 2009), a key health problem affecting Mexican citizens is respiratory diseases linked to the increasingly low quality of air in rural communities as they develop (Martínez, Suriano, Ryan & Pelto, 1997). For instance, the more opportunities that arise in rural communities, the more money people have (World Bank Group, 2004). This means they can buy their own cars, which of course is detrimental to air quality.

According to the Cities and Climate Change Programme (CiClim), primarily lead by the Mexican Agency for International Development Cooperation (AMEXCID) and the Ministry of Agrarian, Territorial and Urban Development (SEDATU) (Deutsche Gesellschaft für Internationale Zusammenarbeit [GIZ], 2018), 22% of Mexico's citizens do not live in cities, and development in rural communities is increasingly affecting the quality of life for those citizens. The good air quality of rural communities is now being ruined by the increasing use of cars – and the pollution that stems from that. While the approach to rural planning in Mexico is less outdated than the approach towards urban planning, due to less elaborate public policies and poor infrastructure, change is still needed given that very little has been done in this respect (Rueb, 2011). Rural communities are suffering from the effects of climate change (Nawrotzki, Hunter, Runfola & Riosmena, 2015) and are responsible for 30% of the country's greenhouse gas emissions (Villa, 2018). Climate-friendly – that is, green – rural planning is thus vital if Mexico's rural communities are to develop in a sustainable way.

# Green infrastructure development

While the government works towards the development of rural communities for the benefit of the citizens who live in them, doing so in a way that is not green spells disaster for future generations (OECD, 2012). Very few viable solutions have presented themselves in this sense, especially given the limited resources that rural communities have to work with (Holmes, Orozco & Paniagua Borrego, 2017). Nonetheless, CiClim views a stronger focus on green infrastructure development in rural communities as the best possible solution (GIZ, 2018).

The UK Green Building Council (2015) states that green infrastructure has no single definition but suggests the following description by Naumann, Davis, Kaphengst, Pieterse and Rayment (2011); Natural or semi-natural networks of green (soil covered or vegetated) and blue (water covered) spaces and corridors that maintain and enhance ecosystem services. In a 2013 report, the European Commission (EC) defines green infrastructure as a strategically planned network of high quality natural and semi-natural areas with other environmental features, which is designed and managed to deliver a wide range of ecosystem services and protect biodiversity in both rural and urban settings. The EC add that, more specifically, green infrastructure, being a spatial structure providing benefits from nature to people, aims to enhance nature's ability to deliver multiple valuable ecosystem goods and services, such as clean air or water.

While various types of climate exist in Mexico (Molina et al., 2009), overall, its massively diverse nature offers an abundance of opportunity for green infrastructure (Gerritsen, 2002). For that reason, green infrastructure may represent the best method of protecting and preserving rural landscapes (Villa, 2018; ARUP, 2014; EPA, 2015). Aside from the part it can play in the protection, preservation and improvement of rural biodiversity and nature preservation and protection (and, where relevant to the fastest developing rural areas, nature restoration) (Pham, 2017), green infrastructure appears to be the most viable solution (Villa, 2018) capable of addressing a multitude of issues, including poor air quality and high levels of physical inactivity. Case studies from many different countries act as evidence for this (Bottalico et al., 2016; Molla, 2015; Quintero, 2012).

Greener infrastructures serve to control exposure to weather (Galagoda, Jayasinghe, Halwatura & Rupasinghe, 2018). For example, vegetation, which is just one part of a greener infrastructure, can offer shade or act as a wind barrier (Galagoda et al., 2018; Villa, 2018). Although green infrastructure is not the main reason why people decide to do physical activities or not, it can encourage people into it, given the increased pleasure associated with exercising among vegetation rather than in the bleak, dry and exposed environments (Galagoda et al., 2018; Villa, 2018) that many rural communities in Mexico are known to be (González-Abraham, Ezcurra, Garcillán, Ortega-Rubio, Kolb & Creel, 2015). Additionally, a wide selection of plants and trees can work to decrease levels of pollution in developing rural communities thanks to their ability to absorb both carbon dioxide (CO<sub>2</sub>) and inhalable particles in the air (Galagoda et al., 2018; Villa, 2018).

Lee and Maheswaran (2011) believe that one mechanism by which plant- and tree-rich rural areas can positively affect physical health is through their effect on levels of physical activity. The authors add that, when vegetation is introduced into areas that were formerly arid, the opportunity for and motivation for physical exercise can increase. They observed, for example, that running paths and cycle lanes lined by trees and plants are busier – particularly in hot weather – than those without any vegetation. The result of this is that citizens in rural areas with a stronger green infrastructure are more inclined to walk or cycle between places rather than using vehicles (Villa, 2018), which, of course, can have a knock-on effect on pollution levels and air quality (Sierra-Vargas & Teran, 2012).

In general, the development of green infrastructure has been slow in Mexico, especially in rural areas (Grunewald & Martínez-Zarzoso, 2015). Nonetheless, this review will look at the projects that have been undertaken to date, considering what gaps exist and what potential interventions can be taken in future. The real problem lies with finding new and creative ways to fund green infrastructure projects across the country's rural

communities, especially given the difficult set of economic challenges faced by Mexico at present (Holmes et al., 2017). Within such a context, the government is concentrated on its fiscal balance, which necessitates increasing the impact of limited public resources. One way to achieve this is to have a good strategic approach to leveraging private sector investment in green projects (OECD, 2010, 2017).

The purpose of this study is to systematically review as much of the existing literature on the research topic as could be sourced through multiple database searches in order to make a worthwhile contribution to the research community by offering the most comprehensive analysis of the empirical and non-empirical literature available on green infrastructure developments in rural communities across Mexico, in addition to addressing the outcomes of studies, measures and policies on these communities – namely, their effects on the health of citizens and the habitability of their communities.

## Methodology

The PRISMA tool was selected for use in this study. Widely used by researchers across the world, this 27-item checklist, 4-phase flow chart (Liberati et al., 2009) helps to improve the reporting of systematic reviews (Moher et al., 2015). The flow chart includes: identification; screening; eligibility; and inclusion (PRISMA Statement, 2017). The checklist includes: title; abstract; rationale; objectives; protocol; eligibility criteria; information sources; search; selection; data collection process; data items; risk of bias in individual studies; summary measures; synthesis of results; risk of bias across studies; additional analyses; study selection; study characteristics; risk of bias within studies; results of individual studies; synthesis of results; additional analyses; summary of evidence; limitations; conclusions; funding (not relevant here) (PRISMA Statement, 2017). These are used alongside guidance by Moher et al. (2015) and Liberati et al. (2009).

This review uses what is the best literature available on the green infrastructure initiatives in Mexico's rural communities and their effects. It must be noted that it addresses issues of relevance to the understanding of the development of green infrastructure in Mexico's rural communities (table 1). This gave a better idea as to the popularity of certain types of rural green infrastructure measures between 2000 and 2018.

## Inclusion and exclusion criteria

All sources were found using electronic searches on a range of databases. These were: the variety of EBSCO databases – including Environment Complete and Environment Index; ISI's Web of Science; HERO; Science Direct; GeoRef; Scopus; Water Resources Abstracts, Google Scholar. Additionally, standard Google searches were conducted to source government reports and other official documents, grey literature and doctoral papers. The following keywords were searched for in both the titles and abstracts (if applicable) of sources published in both Spanish and English, linked with or/and: Mexico, Rural, Communities, Green Infrastructure, Public Health, Liveability, Quality of Life. The search of these databases yielded a large volume of sources across a range of journals, given the interdisciplinary character of the topic in question. While sources were chosen from many disciplines, they were only selected for inclusion if they had some social sciences, public administration approach; depending on the search keywords indicated above, those abstracts that were not related to the subject of this research were discarded. Sources with data on rural green infrastructure developments, as well as on their effects on public health and habitability of communities, in other countries were not excluded. The justification for this is that it provides a comparison between the type of government programmes and public policies implemented in these countries and those in Mexico, as well as a comparison

between their results and impacts on citizens. Further to this, some research works were included that set out important ideas about how rural green infrastructure can be developed in general, to offer some guidance as to the trajectory the Mexican government can take in this respect in years to come.

The decision was made to include both empirical and non-empirical sources. This was based on three contributing factors. Firstly, it was deemed beneficial based on the utility of both positivistic, typically systematic, quantitative approaches to the research issue, as well as reflective, experience- and observation-based, qualitative approaches. Secondly, sources – academic or otherwise – specifically pertaining to the development of green infrastructure in rural communities and its effects on health and the habitability of rural communities in Mexico were comparatively limited. Thirdly, much of the most useful information on the measures taken by governments to date in respect of rural green infrastructure development, as well as planned future developments in this respect, are located in a range of technical reports and other types of documents provided the OECD, UNESCO, government institutions, and so on.

2000 to 2018 was selected as the date range for inclusion because it covers a significant period of just short of two decades, and most sources on green infrastructure development in Mexico fell comfortably within this range. Moreover, many of the statistics published in official reports or documents use 2000 as the date with which to compare statistics.

TABLE 1  
LITERATURE SELECTED

Title	Type of document	Author and date	Comments
OECD Perspectives: Mexico Key Policies for Sustainable Development	Report	OECD (2010)	The report takes a number of factors relating to Mexico's sustainable development into consideration, one of which is the country's green growth. The chapter on green growth looks at both urban and rural green infrastructure, covering water management and infrastructure, as well as nature and biodiversity. It argues that the former requires better financing through strategic financial plans, and that the conservation and sustainable use of biodiversity through a better green infrastructure is a key factor in enabling green growth – again, though, requiring increased funding.
Policy Analysis of Rural Development Strategy in Mexico: Creation and Management of Infrastructure Systems	Thesis paper	Rueb (2011)	The author explores the public policies, economic conditions and social climates that affect rural development strategies in Mexico, arguing that lessons obtained from the successes and failures of various programmes offer potential solutions to future problems that Mexico faces in the modern age of globalisation and environmental concerns. Further, the author suggests that various initiatives, including those relating to green infrastructure, can improve the standards of living and levels of social welfare in rural communities, which have traditionally been neglected by consecutive Mexican governments.
The Health Benefits of Urban Green Spaces – A Review of The Evidence	Academic Journal Article	Lee and Maheswaran (2011)	While the authors focus on the health benefits of urban green infrastructure, they review a range of literature that covers rural green infrastructure in various countries. The article discusses the importance of evidence-based approach to planning. The authors argue that, while green infrastructure is beneficial to health, the causal relationship is difficult to establish and that basic interventions may fail to address the underlying determinants of health that can't be remedied by green infrastructure.
Principles, Practices, and Challenges for Green Infrastructure Projects in Latin America	Discussion Paper	Quintero (2012)	The author looks at green infrastructures across Latin America, but specifically discusses some of those in Mexico. He argues that Mexico has some good examples of green infrastructure projects that address natural habitat issues in the growing field of wind power, as well as some good examples of mechanisms applied at the policy level to control ecological flows – something sorely needed in many Latin American countries.
Building a Green Infrastructure for Europe	Report	European Commission (2013)	The report explores green infrastructure (in both an urban and rural context), what it is, what it consists of and how it is built up. It offers a number of strong examples of green infrastructure in action, discussing the EU strategy for green infrastructure.
OECD Economic Surveys – Mexico	Report	OECD (2017)	This report explores a range of areas, including long-term economic growth, natural resources and environmental outcomes, fiscal policy and both poverty and inequality. There is a significant section on the need to scale up green investment, both in the public and private sectors. They argue that development banks, public investment schemes, and private sector investment have played a significant role in green infrastructure financing to date, including projects in wind energy projects, transportation, and water service infrastructure.

Source: own elaboration

TABLE 1 (CONT.)  
LITERATURE SELECTED

Title	Type of document	Author and date	Comments
Cities Alive – Rethinking Green Infrastructure	Report	ARUP (2014)	This report highlights the importance of green infrastructure in addressing the challenges of the 21 <sup>st</sup> century, stating that it is a natural, service-providing infrastructure that is often more cost-effective, more resilient and more capable of meeting social, environmental and economic objectives than grey infrastructure. The report argues that part of a revised approach to green infrastructure is focusing on rural communities as well as urban areas given the potential of rural green infrastructure projects to perform a range of functions.
Foro Internacional de Infraestructura Verde y Cambio Climático. México	Government Report	Secretaría de Desarrollo Agrario, Territorial y Urbano, Secretaría de Medio Ambiente y Recursos Naturales and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH (2018)	The report, while focusing on urban green infrastructure, also discusses rural green infrastructure. It describes the aim of improving the planning and implementation of green infrastructure strategies and measures, which can mitigate the effects of climate change and consequently harness the considerable potential available for the environment and rural communities, improving health, quality of life, and the liveability of communities.
The Value of Urban Green Infrastructure and Its Environmental Response in Urban Ecosystem: A Literature Review	Academic Journal Article	Molla (2015)	The author explores the best benefits of green infrastructure developments, especially for a range of developing countries. The benefits discussed are health and wellbeing, recreational value, economic, energy saving, job opportunities and environmental. One country that the study considers is Mexico, a country using green infrastructure to attract visitors and to encourage outdoor activities among citizens.
Report on the Health of Mexicans 2015 – A General Diagnosis of Population Health	Government Report	Secretaría de Salud (2015)	The report gives an account of the health situation in Mexico and the factors affecting it, with the intention of providing data to decision-makers, academics and health experts so that they can design, improve and implement better public policies that pave the way for the improved health of citizens. The report advocated for any measures, including better green infrastructure, that encourage exercise.
CDMX Resilience Strategy	Government Report	CDMX Resilience Office (2016)	While this report has an urban focus, it also looks at a range of factors in relation to the rural environment, including green infrastructure, which it argues is vital for both urban and rural areas. The report states that it must be a consideration in planning – for example, planning of a water-sensitive approach to design. The report suggests that a focus on the production and management of green infrastructure has environmental, economic and social benefits that contribute to meeting the needs of the population – two types of project discussed under the green infrastructure umbrella are: keeping watersheds and rivers clean; and storing rainwater to transform empty spaces into green areas, transforming communities.
Green Infrastructure and Storm water Management as triggers of Economic and Tourism Development	Online Article	BECC (2016)	The article looks at how green infrastructure projects can attract tourism to Mexico by creating more attractive communities, boosting economic development and creating tourist attractions, all with the aim of enhancing the environment and the quality of life of communities.
Rural issues in urban planning: current trends and reflections	Academic Journal Article	Dandekar and Hibbard (2016)	The authors argue that while urban planning, green or otherwise, has always had a clear urban focus, it has always been concerned with the rural context too, and with the people, economy and environment of rural places. Their article presents recent literature on rural planning and infrastructure from around the world, arguing that, in general, there is a notable distinction between approaches in developed and developing or recently industrialised countries – the latter of which invest significantly in rural planning and infrastructure because large populations reside in rural areas.

Source: own elaboration

TABLE 1 (CONT.)  
LITERATURE SELECTED

Title	Type of document	Author and date	Comments
Urban Greening in Mexico City	Literature Review	Murray and Kremer (2016)	The authors look at the historical reasons behind the development of green infrastructure in Mexico – including the planning, planting and maintenance of trees and vegetation – as well as the effect of increasing populations in communities on green infrastructure development and what the future holds. They state that the current drivers for green infrastructure development in rural areas (given the large number of people that live in them, as with other developing countries) in Mexico are: the liveability of communities; public health; tourism; population growth; health inequality; building trust; and climate change concerns.
Accelerating Green Infrastructure Financing in Mexico – Towards Sustainable Growth	Briefing Paper	Holmes et al. (2017)	The authors discuss the need to leverage private sector investment in green infrastructure projects in the context of Mexico's current economic challenges. They believe that institutional reform is the way forwards, strengthening economic growth and ensuring capital flows to resilient investments, and that institutional innovation can unlock private investment in green infrastructure while reducing the burden on limited public resources.
Green Infrastructure and Health	Factsheet	TCPA (2018)	This factsheet discusses why green infrastructure is important to health; its role in the promotion of health; how it can encourage physical activity, social cohesion and belonging; how it can reduce air and pollution; and how it can protect biodiversity in both urban and rural areas.
Green Infrastructure in Context: Public Health and Ecosystem Services	Academic Journal Article (Under Review)	Schifman et al. (2018)	The authors state that green infrastructure is useful for storm water control and a range of ecosystem services. They argue that as areas develop, green infrastructure can enhance hydrological services and contribute to public health benefits and enhance the liveability of communities.
Green Infrastructure in Mexico: A Booster for Healthier Cities.	Online Article	Villa (2018)	The author looks at the link between green infrastructure, the liveability of communities, and the health of citizens who live in them, arguing that green infrastructure represents the best opportunity to improve both of these factors.

Source: own elaboration

## Results

Using the flow chart element of the PRISMA tool, a total of 43 documents were identified from extensive searches on all databases mentioned in the Methodology section. From these, 3 sources (located on two different databases) were assessed as doubles, so they were excluded. The title, keywords and (once again, if relevant) abstracts of the remaining 40 documents were screened, and 13 of these were then assessed as non-applicable and therefore excluded. The complete texts of the remaining 27 documents were evaluated for eligibility through a close reading, re-reading in a critical way, to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text, and a further 9 of these were assessed as non-applicable and therefore excluded. In total, 18 documents were fit for inclusion.

## Discussion

The review shows that very little headway has been made with regards to the development of rural green infrastructure in Mexico, instead with the majority of funding being poured into urban greening projects, especially in Mexico City. This is a trend seen in other countries too, given that 54% of the world's population is now urban (Dandekar & Hibbard, 2016). However, it is also important to consider the fact that the world's rural population has almost doubled since 1950 and now stands at 3.3 billion (Dandekar & Hibbard, 2016). While 80% of Mexico's citizens live in urban areas (GIZ, 2018), the remainder lives in rural communities. The World Bank (2018) notes a decrease in Mexico's rural population between 2006 and 2017 of almost 4%. Irrespective, 20% is not an insignificant



portion of the population, and neither is the 30% of greenhouse gas emissions for which that 20% are responsible. This means that climate-friendly rural planning solutions are not to be underestimated. Further, there is much to be said for the power of rural green infrastructure to bridge the gap between urban and rural areas, given that it can reconnect habitats that have previously been separated by development creating physical space for natural processes to take place (Molla, 2015).

A literature review of urban greening in Mexico City shows how the planning and maintenance of urban trees and greenspace has been shaped by political ideology and power structures (Murray & Kremer, 2016), the Mexican government has begun to implement – to varying success – green infrastructure projects in rural communities across the country. In doing so, it seeks to address important issues, even if they are more pressing in urban areas, including: pollution; a poor international reputation; climate change; branding communities as green and habitable; attracting tourism (Murray & Kremer, 2016). Of course, public health and the quality of life are also important factors (GIZ, 2018).

The government is working alongside a range of agencies and rural communities to improve planning, supporting communities with planning and decision-making and encouraging the sharing of experiences between communities. All planning is aimed at being climate-friendly, ensuring the protection of ecosystem services and sustainable rural mobility, and is based on new models of green infrastructure that focus on using as few resources as possible (GIZ, 2018).

Rueb (2011) argues that, prior to the last two decades, green infrastructure had been subject to “indecisive and inconsistent development strategies, misguided policies and perverse outcomes,” and that “rural development policies were not conducive to efficiently productivity gains or increased social equity in rural Mexico.” He adds that the installation of green infrastructure was the reason behind many of the problems associated with projects, which negatively affected rural economies, making the poor even poorer, and making the lives of those living in rural communities even worse. According to the OECD (2010), it is now the time to change and to equip the country with a new legislative and policy framework with regards to green growth that fosters a new ecological culture, part of which is a stronger focus on rural green infrastructure. However, even though since the 2003 OECD Environmental Performance Review of Mexico the country has taken major steps in improving its environmental policy and institutional framework, it is vital for Mexico to integrate environmental concerns more deeply into national and sectoral policies to work faster towards a truly green agenda (OECD, 2010).

One of the key ongoing projects, running between 2016-2040, is the implementation of the Borde Activo (Active Edge) initiative – also known as Critical Areas of Occupation of Conservation Areas, which is part of the General City Development Program Project as an area where pilot projects for environmental restoration and urban area containment will be implemented. According to CDMX Resilience Office (2016), this will protect the green infrastructure or rural areas from urban sprawl by creating a productive relationship between socioeconomics and the environment. Such a project may be vital to protect rural communities, but it is a very complex one, involving the participation of multiple different actors.

CDMX Resilience Office (2016) discusses the recovery of the Xochimilco, Tláhuac, and Milpa Alta Heritage Area through the creation of water resilience strategy in the Xochimilco-Tláhuac-Milpa Alta and Resilience Integration in AGE Design Master Plan 2016-2025. The area is currently under pressures from informal settlements and the integration of resilience with water is seen as the “development backbone” of the area. This is also a very complex project, that must be approached from several different angles simultaneously.

There is a strong focus on water-based green infrastructure projects in rural areas of Mexico, probably given the importance of water to the environment and society. BECC (2016) states that the harmonisation of rain water with the surface environment is a key part of enhancing rural communities. They add that storm water can be harnessed as a benefit rather than a burden through green infrastructure projects, making communities more beautiful, enhancing the environment and increasing the quality of life of citizens. As part of a green infrastructure

initiative being promoted by BECC (2016) along the US-Mexico border, government officials, consultants, scholars, and professional practitioners have been given training on a range of storm water and green infrastructure practices pertinent to both privately- and publicly-funded projects in rural communities. What has been referred to as the “green infrastructure dream team” is helping Mexico with green infrastructure, “from its general concepts to its economic ramifications, hydrology elements, droughts, plant and local soil types, as well as the land use and legal frameworks associated to this type of infrastructure. Of course, while green infrastructure can help with storm water control, other ecosystem benefits are generated, which depend on hydro-ecological processes and interact with socio-economic features of urban systems. The authors argue that public health is not generally thought of in environmental systems assessment, but it should be.

One of the strongest examples of the application of green infrastructure options across all Latin America at the policy level is the recently passed regulation on ecological flows in Mexico (Quintero, 2012) known as Mexican Norm NMX-AA-159-SCFI of 2012, which establishes the procedures for environmental flow determination in hydrological basins. Quintero (2012) states that it defines ecological flow as the quality, quantity and flow regime or variation of water levels that are required to maintain the components, functions, and processes of aquatic ecosystems.

Mexico does appear to have an unbalanced focus on water-related measures in terms of green infrastructure. However, Quintero (2012) notes that, with regards to the application of options at the project level, there are also some good examples of Mexico addressing a range of natural habitat problems within the ever-expanding area of wind power in the country. In the Yucatan Peninsula, for instance, several wind farms – including La Ventosa and Equus – are conducting broad avifauna surveys and monitoring bird collisions during their operations. Further, Quintero (2012) notes that some wind farms even have bird kill indicators to define thresholds to modify operating rules or complete shutdown of operations.

The government is also developing a range of initiatives that protect communities which are most vulnerable to disasters, such as older and poorer segments of communities, which will not only protect these people but also lead to stronger communities, reduced social inequalities and a better quality of life (CDMX Resilience Office, 2016).

## International comparisons

Some studies reviewed by Lee and Maheswaran (2011) found a range of rural green infrastructure project in the Netherlands and England to have varying effects on health, and some studies conducted by the same researchers conflicted. Maas, Verheij, Groenewegen, De Vries and Spreeuwenberg (2006) found that such projects are associated with perceived general health, especially among lower socioeconomic groups, children and the elderly. Maas, Verheij, Spreeuwenberg and Groenewegen (2008) found that they are scarcely related to levels of physical activity undertaken by people – this conflicts with TCPA (2018) and Villa (2018), who argue that green infrastructure is important for both physical and mental health due to the fact that it encourages people to be outside, even if that just means taking a walk; Maas et al. (2009) found that disease levels were lower in areas with better green infrastructure, especially in children and lower socioeconomic classes; Mitchell and Popham (2008) found that all-cause mortality and circulatory disease mortality can be positively affected by green infrastructure; and Van den Berg, Maas, Verheij and Groenewegen (2010) found that green infrastructure can have a beneficial impact on stress and perceived mental health.

Both the European Commission (2013) and Quintero (2012) – writing on green infrastructure in Latin American countries – call green infrastructure projects “win-win solutions” for habitat conservation and development. In Europe, some of the most successful examples of rural green infrastructure projects in action at present are: creating

large multi-functional landscapes – the UK emphasises the importance of the multifunctional use of land with multiple benefits resulting from the use of land in rural areas by various parties, human or otherwise (ARUP, 2014); the use of plants instead of air conditioning; and protecting people against floods while improving recreation and nature conservation (European Commission, 2013). Collectively, these – and other efforts in Europe – have led to: environmental benefits, including cleaner water and air, pollination enhancement, less soil erosion, rainwater retention, better pest control, and improved land quality; social benefits, including better health and wellbeing, job creation, diversification of local economy, more attractive communities, higher property values, more integrated transport and energy solutions, enhanced tourism and recreation opportunities; climate change adaptation and mitigation benefits, including flood alleviation, better ecosystem resilience, carbon storage and sequestration, disaster prevention; biodiversity benefits, including improved habitats for wildlife. Deller, Tsai, Marcouiller and English (2001) also discuss the significant potential for green infrastructure to bring a range of local economic opportunities to rural areas.

Agnes, Jombach and Mikhazi (2016) carried out a significant research on rural green infrastructure in Hungary, which focused on protecting nature at the same time as enhancing agricultural production, something that is sorely needed in Mexico. The researchers found that the complex approach of green infrastructure development resolved the conflict between the two, reversing former improper agricultural management and the negative effects that result from that – less effective and less profitable production. Water retention capacity was improved, habitats were restored along a creek, and the greening of agricultural production improved the ecologic network and both the efficiency and diversity of production and local economy. However, they noticed that the efficiency of their project depended heavily on the involvement of local stakeholders and the population, so offering incentives can be beneficial.

## Conclusions

Most developed countries across the world are currently promoting green infrastructure. A key part of their strategies is financing (OECD, 2013). For example, the EU's strategy (European Commission, 2013) strives to improve access to financing for green infrastructure projects considering the potential of financed interventions to “change the underlying paradigm.” Given the increasing global rural population (Dandekar & Hibbard, 2016), the amount being spent on rural green infrastructure is increasing. Yet, in developing or recently industrialised countries, green infrastructure developments are failing due to a lack of resources. This is the case in Mexico, where poor financing and poor implementation represent the two top reasons for the failure of rural green infrastructure projects (Rueb, 2011), signalling a desperate need to rethink financing in this field. Even the establishment of the Green Fund in 2011 has failed to inadequately channel domestic and international finance into green projects (OECD, 2010).

Both the public and private sectors play an important role in financing rural green infrastructure projects (European Commission, 2013). For that reason, Mexico must discover new ways to increase financing from both, resulting in greater public investment in initiatives capable of offering long-term value, supplemented by private sector investment that can lead to sustainable growth (Holmes et al., 2017). However, even though the public sector is an important source of financing and can facilitate private sector investment (OECD, 2013), both are fundamentally flawed in different ways. The public sector is hampered by limited financial resources (Holmes et al., 2017), while the private sector is wary of investing in green infrastructure given that such investments are risky, even more so in relation to rural green infrastructure initiatives, and thus not massively attractive for investors (OECD, 2013). Mexico also has a poor reputation as a place worthy of both domestic and foreign direct

investment in green infrastructure (Holmes et al., 2017). This level of risk and such a poor reputation is why, across the years, foreign direct investment has been unsteady; why the public purse has fielded the burden for funding the majority of green infrastructure projects at times; and why they have been associated with such a high level of failure (Rueb, 2011).

With regards to the private sector problem, one solution is using specific financial instruments, including risk-sharing practices, which can minimise the risks associated with such initiatives, increasing the attractiveness of investment in this area (European Commission, 2013). While a lack of public sector funding will always be an issue, the public sector can contribute in other ways. One way is through institutional innovation, which can ensure that any public-sector investments made supplemented by as much private sector investment as possible – can lead to value and long-term sustainability as quickly as possible to demonstrate to potential investors that Mexico has a very serious attitude towards rural green infrastructure (Holmes et al., 2017). This is possible through the creation of an independent green investment agency, which could facilitate the right policy-making environment (Holmes et al., 2017).

Of course, the contributions of international organisations to green infrastructure projects in Mexico are also important (Holmes et al., 2017). International involvement has been a vital part of the development of green infrastructure in Mexico, with organisations like the World Bank providing financial assistance for such initiatives (Rueb, 2011).

The most popular and successful rural green infrastructure initiatives to date have been those involving water management. The reason for this is the increasing financing for such projects – 137% alone between 2003 and 2008 (OECD, 2013). Investment in water resilience projects have been a big part of green infrastructure across Mexico, mitigating the risks and shocks associated with climate change, as well as social and environmental pressures (CDMX Resilience Office, 2016). A number of water funds were established in 2015 in order to finance related projects, the results of which remain to be seen (CDMX Resilience Office, 2016). Despite the fact that Mexico has a well-developed policy framework with regards to water resource management, policy implementation is uneven in terms of financing and better user participation in financing is needed, thus highlighting the importance of “endogenous finance raised from users” in strengthening initiatives (OECD, 2010). And this should be applied to all areas of rural green infrastructure development and not just those that pertain to water management. Such endogenous funding should be supplemented by the robust cooperation of local stakeholders and communities if any initiatives, however they are financed, are to succeed (Agnes et al., 2016).

The review will permit the government, scientists, researchers, policy-makers and decision-makers to make better fully-evidence-based choices as to future planning within the context of rural green infrastructure. This will help rural communities to implement new measures, improve existing measures, and to both assess and maximise the benefits of any measures. By looking at the experiences of other countries, particularly Latin American countries, new models can be evaluated and tested. Along with the data generated by this review, strong cooperation between various actors can make green infrastructure a more commonplace practice in Mexico’s rural areas.

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## Notes

- \* Review article

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