Review

Ecohealth Villages: A Framework for an Ecosystem Approach to Health in Human Settlements

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Abstract: As life emerged on Earth, it began to affect its environments. It still does. The complex interactions between living things and their environments mediate the character of both. Today, this is apparent in the global impacts humans have made on ecosystems, with resultant reciprocal impacts on human health. This paper is concerned with that reciprocity, which may be considered as a link between ecosystems and human populations. We will distinguish an ecosystem approach to human health—or ecohealth—from One Health and planetary health perspectives. We will also propose a conceptual framework that can be used to distinguish human settlements as Ecohealth Villages. Broadly defined, an Ecohealth Village is a settlement that recognizes the interactions between healthy ecosystems and the health of people who live, work, learn, and play in it. The key principles of an Ecohealth Villages are as follows: community ownership, ecological restoration, sustainability, social and gender equity, integrated perspectives, and traditional practices and knowledge. Together, they support a holistic, ecosystem approach to health in human settlements, as demonstrated in case studies from Mexico and Aotearoa New Zealand.

Keywords: ecohealth; ecohealth villages; ecological restoration; ecosystem health; Mexico; Aotearoa New Zealand

1. Introduction

Public health professionals and institutions aim to protect and improve the health of people and the communities where they live and work. This cannot effectively be accomplished without a broad perspective that includes the social, economic, and environmental conditions in communities. Sometimes known as the "determinants of health", this approach recognizes the underlying factors influencing health risks and outcomes—e.g., income and/or wealth, education level, physical environment, and social attitudes [1,2]. The concept of ecohealth expands this one step farther, with science and practice recognizing ecosystems as another important determinant of human health [3–6].

The three most prominent holistic, non-Indigenous approaches to human health are ecohealth, One Health, and planetary health [7]. Although these terms are sometimes used interchangeably, they have important distinctions. One Health is a trans-disciplinary field with no formal organizational structure, membership, or affiliated journals. It is primarily concerned with the link between humans, animals, and the environment in the evolution and emergence of disease [7,8]. It focuses on issues such as zoonotic and vector-borne diseases, antimicrobial resistance, and food safety. Arguments have been made for the merger of One Health and ecohealth [9,10]. Planetary health could also be incorporated into both, since it describes the intersection of human health, human civilization, and natural systems, as outlined by the Rockefeller Foundation—Lancet Commission—on planetary health in 2015 [11].

These three approaches to holistic human health are all relatively young concepts. Although they share a systems thinking, each have their unique approaches and attractions. For example, veterinarians may be more attracted to the work of One Health than ecohealth because of its connection to animal diseases. However, it is important to acknowledge where they intersect and find inspiration in the common goal of moving toward a healthier planet for people and nature. Given the urgent need for improving ecosystem and human health, their potential for collaboration where they do intersect could provide powerful synergistic outcomes.

We will focus on ecohealth in this study because of its dual attention to ecosystem health and public health and the bridge that ecological restoration provides between the two. Ecohealth intersects with the principles of sustainability and is rooted in the sustainability movement [12]. Cross et al., 2019 [13] expanded on health and sustainability by urging that the foundational philosophies of restoration ecology, ecological economics, and other related health disciplines are linked to "move toward an era of globally connected and science-driven sustainable development that has a dual focus—ecosystem health and human health". It is in restoration ecology that ecohealth finds a partner that continually aims to improve the health of ecosystems and, by doing so, the health of people. This is a match that strengthens both fields.

Ecological restoration may be described as the practice of restoring previously damaged or destroyed ecosystems. Restoration is happening worldwide, with projects and programs spanning the spectrum: from landscape to biome at ecoregional [14], sub-continental, and international scales. Ecological restoration practiced with an ecohealth lens takes into account the relevant public health implications associated with and resulting from restoration activities [4]. Likewise, a public health intervention practiced with an ecohealth lens incorporates restoration activities in its effort to improve health outcomes.

The vast majority of contemporary human settlements degrade the ecosystems and landscapes in which they are established [15–17]. However, when ecological restoration and related restorative activities are practiced in these villages, towns, and cities, ecosystem quality and human health jointly improve [15,17–20]. For example, urban ecological restoration includes protecting and expanding urban green space, which can promote native vegetation [21], improve soil biodiversity [15], and positively impact the human microbiome [4,18,22,23]. Urban ecological restoration can also impart a feeling of well-being and improved mental health for those using green spaces [18,24,25]. Microclimate regulation can be another outcome of ecological restoration. Increasing tree canopies has been shown to reduce land surface temperatures, ultimately having an impact on heat-induced human illness [16,17,26,27]. Regenerative agriculture practices in urban and peri-urban areas also have a place in the arc of restorative activities, which can have significant impacts on health and well-being; they improve food security, soil biodiversity, and flood protection [28,29].

Governments, Indigenous communities, academic institutions, and non-governmental organizations around the world are rapidly becoming engaged in ecological restoration and related activities. One example is the restoration of Brazil's Atlantic Forest—a large region constituting a 'hotspot' biome, characterized by high biodiversity, multiple ecosystems, and widespread deforestation. The Pact for the Restoration of the Atlantic Forest (PACTO) was created in 2009 as a bottom-up, multi-stakeholder movement that includes corporate, government, non-profit, research, and academic institutions in its governance. Its goal is to restore fifteen million hectares of degraded and deforested lands in its biome by 2050 (http://www.pactomataatlantica.org.br/, accessed on 18 March 2022). This number of hectares corresponds to roughly 30% of the Atlantic Forest biome as it is thought to have existed prior to European colonization. By 2017, nearly one million hectares had been restored or was well on the way to restoration [30].

In this study, we will introduce the concept and provide a conceptual framework for an Ecohealth Village, which includes ecological restoration as a core principle, and present other key principles underpinning its establishment using case studies from Mexico and

Aotearoa New Zealand. The case studies are used as a research strategy, with document analysis guiding the exploration of core concepts.

2. Results

2.1. Ecohealth Villages

Broadly defined, an Ecohealth Village is a settlement that recognizes the interactions between healthy ecosystems and the health of people who live, work, learn, and play in it. The key principles of an Ecohealth Villages are as follows: community ownership, ecological restoration, sustainability, social and gender equity, integrated perspectives, and traditional practices and knowledge (Table 1). Together, they support a holistic ecosystem approach to health in human settlements, as demonstrated in case studies from Mexico and Aotearoa New Zealand.

Table 1. Six Key Principles of Ecohealth Villages.

Principle	How It Is Enacted and Manifested
Community ownership	Strengthens the capacity of inhabitants to adapt to changes in their social, economic, and ecological environments, with community members at the forefront of decision making and program implementation.
Ecological restoration	Incorporates the restoration of ecosystems that directly influence the health and well-being of a Village and enhances ecosystem services, such as the restoration of soils in urban gardens and forests that impact and protect the watershed from desertification, fragmentation, and degradation.
Sustainability	Interventions are based on ecosystem management in order to create lasting and enhancing changes, simultaneously, in the health of the human population and the natural and cultural ecosystems undergoing restorative change and do not compromise the environmental, social, or economic elements of health in the region.
Social and gender equity	Considers social and gender inequities that exist in the community throughout a project's timeline; operating from a social justice lens, Villages work to protect their vulnerable members and provide opportunities for their full participation.
Integrated perspectives	Incorporates cultural perspectives and local knowledge and practices together with the sciences—natural and social—to achieve shared goals.
Traditional practices and knowledge	Values Traditional Ecological Knowledge holders and their Indigenous practices while acknowledging the history of place.

2.2. Magnolia Ecohealth Framework

The six key principles of Ecohealth Villages are drawn directly from the Magnolia Ecohealth Framework (Figure 1). In May 2019, at the Missouri Botanical Garden in St. Louis, MO, USA, twenty-five people from seven countries representing interdisciplinary interests in health and the environment—among them farmers, economists, soil scientists, medical doctors, public health educators, engineers, and ecologists—met for a workshop to explore the interface between ecological restoration and public health. During this workshop, sponsored by the EcoHealth Network (ecohealthglobal.org, accessed on 21 February 2022), a set of principles, described here as the Magnolia Ecohealth Framework, began to take shape that would help communities apply an ecohealth approach to their management and development.

The Magnolia Ecohealth Framework weaves together the goals of ecological restoration and public health with the understanding that ecosystems and human activities are interactive parts of a whole. Public health with an ecological restoration overlay (or vice versa) puts the determinants of health into sharp focus, making ecohealth a social justice and human development pursuit [13]. The application of the ecohealth concept in this framework is distinguished from others that encompass human, animal, and ecological health due to its focus on ecological restoration as a public health intervention [4].

Magnolia Ecohealth Framework

Ecological restoration
the practice of restoring previously
damaged or destroyed ecosystems

Community ownership
community members maintain
control and direction over
programs within their
community

Social and gender equity
the practice and promotion of
equitable treatment and opportunity
of historically disadvantaged members
in a community

Integrated perspectives
the coexistence and intermingling of
natural and social sciences with the
cultural perspectives within a
community initiative

Sustainability
the goal of improving the well-being of
a community while sustaining the
surrounding ecosystem with which it
interacts

Traditional practices
valuing local people as holders of
traditional practices and knowledge

Figure 1. Magnolia Ecohealth Framework.

2.3. Hobart Declaration on Ecohealth

A second international ecohealth workshop was held in Hobart, Tasmania, in March 2020. Out of that meeting came the Hobart Declaration on Ecohealth, with a core message that "ecological restoration activities are good for both ecosystems and people" [31]. The Hobart Declaration outlines three key needs: (1) Establishing holistic research frameworks, which include the robust monitoring of cultural, social, and public health benefits of ecological restoration programs; (2) documenting the beneficial effects that occur when restoration processes are integrated, with attention to human wellbeing; and (3) communicating the results of these findings in an impactful way.

The Hobart Declaration emphasizes the critical importance of listening to and partnering with Indigenous Peoples in ecosystem restoration. Recent calls in the literature [32–35] have similarly championed the involvement of Indigenous Peoples and their Traditional Ecological Knowledge in the ecological restoration of both urban [36] and rural contexts.

2.4. Ecohealth Village Case Study 1: Chemax, Mexico

Chemax is a municipality in the state of Yucatan (Figure 2). It has approximately 27,000 hectares of ejido land (cooperatively owned by members of the community), parts of which are farmed by approximately 300 people who grow corn, beans, spinach, squash, yucca, sweet potatoes, and other crops on small family plots (milpas). Some people build homes on their *ejido* land, although most travel the few kilometers from town and return on the same day. The land is heavily forested, with Ziricote (*Cordia dodecandra*), Chechen (*Metopium brownei*), T'zalam (*Lysiloma* spp.), Jabin (*Ichthyomethia piscipula*), and Cedro (*Cedrela odorata*).

The city center of the same name, Chemax, has roughly 11,000 residents, and nearly all them are Mayan. Families in the area have known each other for generations. People's primary source of income is associated with the tourism industry along the Atlantic coast (an hour away by car), typically as day laborers in the hotel and construction industries. This area experiences high levels of poverty and the majority of homes lack sanitation infrastructure [37]. In light of this and in the spirit of neighbors helping neighbors, in 2007, a group of local Mayans formed the nonprofit, Grupo Ecológico Zayab-Ha, A.C. (Zayab-Ha). The organization has a number of women on its board of directors and in other leadership roles.
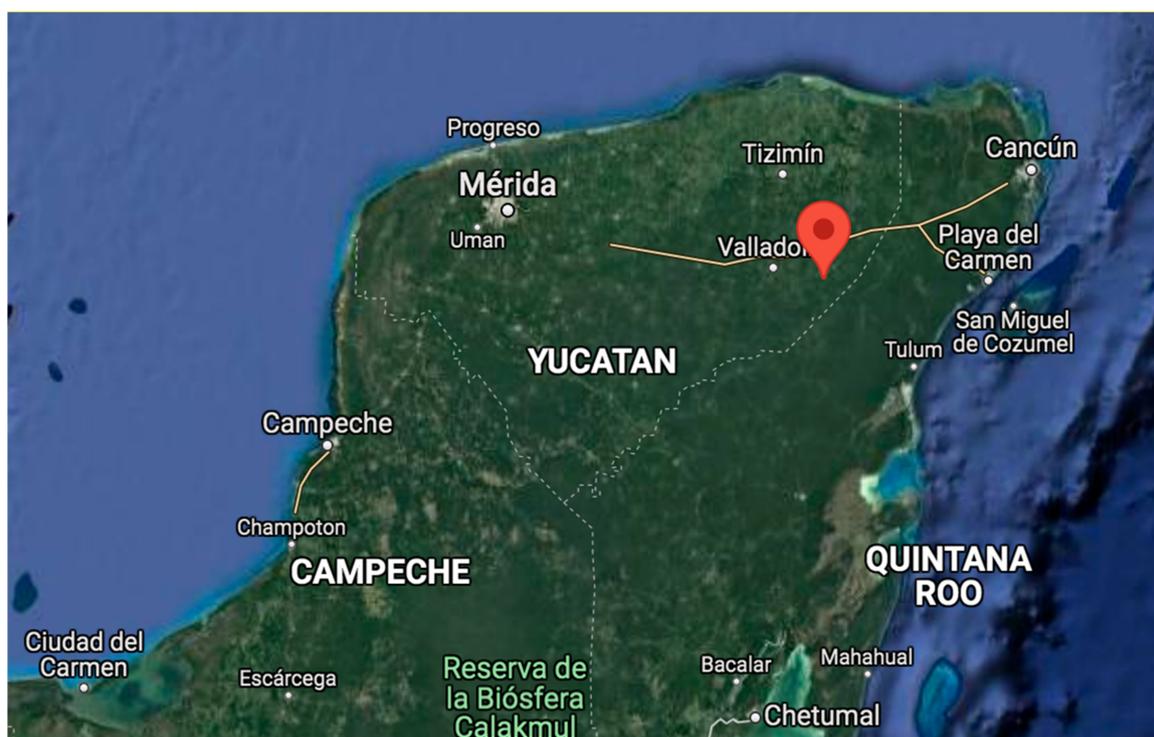
Figure 2. Grupo Ecológico Zayab-Ha, A.C. is located in Chemax, Mexico (red pin), on the Yucatan Peninsula. Nearby towns are marked with white dots (accessed from Google Maps on 21 February 2022).

Zayab-Ha has established several health-related projects in Chemax, including environmental education, organic gardening, ecological sanitation, smoke-free stoves, and housing. Each of the organization's projects address how people interact with and improve their indoor and outdoor environments and each incorporates the six key principles of Ecohealth Villages.

For example, Zayab-Ha's sanitation systems include sustainably designed compost toilets and greywater gardens. The compost toilets, locally called Nahi-Xix, improve public health and wellbeing while creating safe organic fertilizers and soil amendments. Household wash water, or greywater, is captured on site and is used to grow herbs, banana trees, and other plants. These systems have been built to reflect what local people want—not just a toilet, but bathroom facilities with showers and sinks that incorporate beauty and sustainability into the design.

The smoke-free stoves, called "Túumben K'óoben", were locally designed and developed. They are built by the same skilled teams from Zayab-Ha that build the ecological toilet facilities. These stoves replace indoor, unventilated three rock wood fires (fogóns), which are the primary cause of respiratory disease in the town, a significant problem especially among women and children [38]. Moreover, Túumben K'óoben stoves are insulated, so the outside of the stove is not hot, making them more comfortable and safer to be around.

In 2016, Zayab-Ha began integrating the ecological toilet facilities, greywater gardens, and Túumben K'óoben stoves into new housing for community members living in degraded and unhealthy living conditions. These are simple, two room houses with ecological sanitation and cooking technologies comprising its "healthy heart". As the family's housing needs change, its built environment can grow around its "healthy heart".

Zayab-Ha's work embodies Ecohealth Village principles through its understanding of place, culture, customs, and attitudes in the community. The people who lead and execute Zayab Ha's projects are Mayans that live and work in Chemax. Their work incorporates broad environmental health themes, such as ecological sanitation and sustainable building; clean cooking possibilities and what that means for addressing respiratory illness; deforestation (2/3 of the wood that would be used as fuel is saved by using the specially

designed cook stoves); compost production and use; and the production and use of other organic fertilizers. This is ecohealth in action. With this ecohealth foundation, people in Chemax have been actively trying to influence policies at the local and state level to bring improvements to their community. In 2016, the President of Zayab-Ha, Alfredo Tec, ran as a Green Party candidate for mayor of Chemax, losing by only a few hundred votes.

The initiatives in Chemax, while being supported by Zayab-Ha, consider the goals of environmental health while working toward a restorative culture. An example of this is the establishment of an Indigenous women's center by local community members. It is a place where women can engage with community peers to, for example, seek help from domestic abuse, learn new skills, find a patient advocate to join them at a medical appointment (many elder women do not speak Spanish), participate in and lead educational programs, learn about traditional uses of plants and herbs for healing, share stories, and garden. The idea for the women's center began as a result of conversations between women from Zayab-Ha and women who had Nahi Xix compost toilets in their homes. During routine maintenance inspections, stories of domestic abuse were shared with the women from Zayab-Ha. This informal social support network grew into the founding of an Indigenous, women-led organization, Kiimak'oo Ko'olel, A.C., and its associated women's center in Chemax, Tumbén Kuxtal. Both strive for social and gender equity in the town, reflect community ownership, incorporate sustainability and cultural restoration in their work, welcome diverse perspectives, and value traditional knowledge holders. For example, the women's center played an important role during the COVID-19 crisis in 2020 and 2021 by preparing and distributing traditional medicines to community members to help support their immune system and to treat symptoms of respiratory distress.

2.5. Ecohealth Village Case Study 2: People, Cities and Nature, Aotearoa New Zealand

People, Cities and Nature (PCaN; https://www.peoplecitiesnature.co.nz/, accessed on 28 April 2022) is a socio-ecological research program leading the study of urban restoration ecology in Aotearoa New Zealand. This large team with six themed projects has people working across 10 cities with the common goal of discovering and communicating the best means for "restoring indigenous biodiversity in urban environments" (Figure 3). The areas of research—*Restoration Plantings*, *Urban Lizards*, *Mammalian Predators*, *Māori Restoration Values*, *Green Space Benefits*, and *Cross-sector Alliances*—converge along the common principles of ecohealth, linking the restoration of biodiversity in urban environments to human health.

Māori are the Indigenous People of Aotearoa New Zealand who descended from some of the original Polynesian settlements. Their Traditional Ecological Knowledge recognizes a close relationship between humans and nature [36]. This connection is practiced through *kaitiakitanga*, or guardianship, in which people are part of the natural world and have responsibility towards its care. The PCaN team includes Māori research leads and also aims to engage with the wider Māori community to guide the program's restoration endeavors. *The Māori Restoration Values* research aim involves specifically surveying and interviewing Māori to better understand how they can implement *kaitiakitanga* values within the context of urban environments. In doing so, PCaN is incorporating traditional practices and cultural perspectives within the context of their research, two key components of an Ecohealth Village.

Additionally, their *Green Space Benefits* research is engaging people within cities to identify their knowledge and beliefs regarding biodiversity. They ask, "In what ways do people interact with their urban environment and how do they perceive the presence of green spaces?" In conducting interviews, they attempt to capture the perspectives of different ethnic groups within cities and encourage their participation in restoration. The *Restoration Plantings* research is directly focusing on ecological restoration projects already underway. The design entails surveying planted urban forests of different ages and linking these with the processes that would foster further ecosystem succession or development (e.g., canopy closure and native seedling regeneration) [39]. In three of their focal cities,

researchers are planting important native tree seedlings to enrich the forest ecosystem restoration process and observing the best conditions for their growth.

Figure 3. The People, Cities & Nature research program is located in Aotearoa New Zealand, with a primary hub in the city of Kirikiriroa Hamilton, (red pin). Other major cities are marked with white dots (accessed from Google Maps on 28 April 2022).

Parallel research with *Urban Lizards* is working to protect lizard populations through habitat enhancement such as the following: (1) complex vegetation planting and (2) planting along with constructed rock piles. Part of this endeavor includes understanding where urban lizards have been lost [40]. Another project surveys introduced invasive *Mammalian Predators* to gain an understanding of best practice control for improving biodiversity. These areas all connect under restoration activities in common urban environments, which could be further developed into Ecohealth Villages.

3. Discussion

Both case studies show activities that support an ecosystem approach to health. The People, Cities and Nature (PCaN) research program established holistic, ecological restoration activities at the core if its efforts, which could lead to the establishment of Ecohealth Villages. It incorporated traditional practices and cultural perspectives in its research, key

components to Ecohealth Villages, and values of both the Magnolia Ecohealth Framework and the Hobart Declaration. In Chemax, the work was not focused on research or ecological restoration but instead on projects that positively influenced community environmental health, with local leadership that embraced the values of the Magnolia Ecohealth Framework and the resulting key principles of an Ecohealth Village and that, similarly to PCaN, supported cultural restoration.

It remains to be seen how health benefits from an ecohealth approach will be measured in Ecohealth Villages. The implementation of a thoughtfully designed monitoring and evaluation plan would help. This would begin by establishing goals and actions that an Ecohealth Village intends to achieve. Then, in order to develop effective indicators or ways of measuring success, evaluators would question elements of these goals. Some example questions that may inform indicator selection based on the overarching goals and principles of Ecohealth Villages include the following:

(1) To what extent was the local community involved in the restoration efforts (from design to implementation and ongoing maintenance and monitoring of sites)?
(2) To what extent have the ecological health of the Village's ecosystems changed since the start of the project?
(3) Did the project involve environmentally sustainable practices as intended?
(4) To what degree has the health of the community (and/or its members) changed since implementation compared to before implementation?
(5) How have the attitudes of community members changed with regards to the importance of ecological restoration since implementation?
(6) How does the community define "ecohealth"? How does this definition change after the project when compared to before the project?
(7) How well do the community members know/how familiar are community members with ecohealth principles?
(8) Did the Village accomplish what it intended and in the manner in which it intended? Were there unexpected accomplishments?

The political economist Albert O. Hirschman observed that unintended consequences are ever present in development projects and can have negative and positive effects, noting that "All projects have their Trojan Horse quality, because they always bring many unexpected changes beyond their immediate and expected physical and production accomplishments" [41].

Projects will benefit from the gathering of public health and ecosystem information before any strategic planning or on-the-ground actions. This information can serve as the benchmark from which to measure progress on ecohealth goals. Participation from community members can improve data collection and inspire participants to be engaged in on-going public health and ecological restoration activities [42–44].

Public health information that can effectively guide actions and policy often incorporates an important concept: health indicators. Health indicators are quantifiable characteristics of a community or population that are supported by reliable, valid data. Examples include life expectancy and infant mortality rate. It is important to choose the right indicators to fit a given situation. Some can be irrelevant to community concerns and fail to reflect cultural circumstances. They can have distinct historical, social, and cultural context, for example, in Indigenous communities [45]. Even the definition of health differs among cultures.

An example of how research and reporting on health indicators can guide public policy can be found in the Indian government's subsidies for liquid petroleum gas (LPG) stoves. To combat indoor air pollution and the associated health risks, the government of India offered subsidies for LPG stoves to rural households who primarily utilize biomass for cooking [46]. More than 75 million households received these stoves as part of the plan. However, research showed this rapid growth was not matched by LPG sales, indicating

that households were still using polluting fuels like firewood and that additional incentives were needed for people to switch to using only LPG [47].

Health indicators can guide the collection of data based on what the project is hoping to achieve. They can be procedure-based, monitoring how well the actions are being taken; on the other hand, they can be goal oriented, measuring if an initiative achieved what it had hoped. When considering how ecohealth factors into this, health indicators become an important method of linking ecosystem changes to public health. A straightforward link, which is something directly measurable, could be, for example, using creatinine levels to measure kidney function in agricultural workers or fecal samples for microbiome tests. Other health indicators could be related to mental health, such as depression or anxiety experienced in areas with varying amounts of green space [18].

4. Conclusions

Alongside One Health and planetary health, ecohealth functions as a necessary approach to improving both human health and ecosystem health. It is distinguished by its focus on ecological restoration as an effort to improve this symbiotic relationship. Ecohealth can be a unifying principle, with measurable metrics, to help identify Ecohealth Villages. Broadly defined, an Ecohealth Village is a settlement that recognizes the interactions between an ecosystem and the health of people who live, work, learn, and play in it. Each Ecohealth Village ensures that the community is at the heart of its ecological restoration efforts, including its most vulnerable and marginalized members. The key principles of an Ecohealth Village are as follows: community ownership, ecological restoration, sustainability, social and gender equity, integrated perspectives, and traditional practices and knowledge. Two case studies from Mexico and Aotearoa New Zealand help show these key principles in action with the hope that their examples can generate interest in increasing the number of Ecohealth Villages worldwide.

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