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Small-Scale Renewable Energy for Rural Livelihood Development: A Water-Energy-Food Security (WEF) Nexus Approach

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1. Abstract

Water, energy, and food security are interdependent and crucial to supporting human welfare and livelihoods. The lack of clean and affordable energy is a major underpinning factor to energy, water, and food insecurity for the rural poor, further undermining access to basic services and opportunities. Latin America has some of the world's best renewable energy conditions. Still, 17 million people lack energy access due to living in rural off-grid locations in hard-to-reach areas, which further increase their water and food insecurity, and associated impoverishment. Therefore, this article aims to analyse small-scale rural renewable energy project's potential in rural areas through the Water-Energy-Food security (WEF) nexus. The Wayuu people, an indigenous tribe in La Guajira, Colombia, have shown a favourable attitude to renewable energy deployment in past research projects and will therefore be used as an example of rural communities that would benefit from small-scale rural renewable energy. This article argues that small-scale rural renewable energy projects can create energy security, which subsequently will lead to water and food security in La Guajira, with the potential to improve the livelihoods of poor rural communities, especially in areas with vast wind and solar potential.

2. Introduction

A major driver of rural impoverishment is the lack of opportunities and basic services in rural areas, undermining people's ability to support their livelihoods (Bebbington, 1999). The lack of clean and affordable energy is a major underpinning factor to such issues (Guta et al., 2019). Although Latin America has some of the world's best renewable energy conditions, 17 million people lack energy access due to living in rural off-grid locations in hard-to-reach areas and thus face energy, water, and food insecurity (IRENA; Eras-Almeida et al., 2019). These three resources – water, energy, and food – are crucial factors to consider when attempting to solve rural impoverishment and recognising their interdependence allows for a more holistic and inclusive approach to be adapted. Approaches that analyse water, energy, or food, without consideration of the interdependency between the resources, threatens to increase the vulnerability of communities and livelihoods since a change in one of the resources might create unintentional outcomes that can cause depletion in one of the other resources and thus impoverish livelihoods (Nhamo et al., 2020). Therefore, viewing energy-related issues through the Energy-Food security (WEF) nexus perspective can increase the chances that new projects ensure a holistic management approach. For example, increasing the energy access for rural communities can enhance their access to clean water, e.g., by powering water pumping systems, which can significantly improve people's health and reduce the time otherwise needed to gather water. Increased energy access and subsequently increased water access also leads to improved opportunities to secure a stable food supply through agricultural activities, e.g., using energy to power water pumping systems used to irrigate food crops (Guta et al., 2017). Besides being more prone to water and food insecurity, the lack of clean and reliable energy often leads rural households to withdraw their children from school and suffer health hazards such as indoor pollution (ibid; IEA, 2020), which can be mitigated by increasing energy, water, and food security.

Renewable energy can solve many of the issues associated with water, energy, and food (in)security. If renewable energy is managed through decentralised procedures and used where it is produced, it can provide increasing agency for rural people and counterbalance large centralised renewable energy projects that often does not benefit the local population where such large-scale projects take place (Buechler et al., 2020). One way of creating decentralised energy systems, especially for rural hard-to-reach areas, is through small-scale rural renewable energy. Small-scale rural renewable energy is a decentralised energy system, through mini-grids and stand-alone energy system, that can provide easily accessible energy to rural households (ibid.). Current estimations suggest that small-scale rural renewable energy systems can provide more than 50 per cent of the additional electricity needed to reach universal energy access without adding any additional Greenhouse Gas (GHG) emissions into the atmosphere (Madriz-Vargas, Bruce & Watt, 2018). Small-scale rural renewable energy systems can solve the lack of energy in rural off-grid locations. They could serve as a driving force for Latin American rural development by empowering communities to harvest the region's energy supply and create further agency for rural communities due to the non-need to be connected to larger power grids (Eras-Almeida et al., 2019).

Furthermore, renewable off-grid energy can provide a safety net for rural livelihoods in times of stress since it is independent of other energy grids and functions without outside support (Zaman et al., 2021). The WEF nexus approach can contribute to sustainable and inclusive planning that ensures the improvement of vulnerable communities' livelihoods. Thus, to support rural development and improve rural livelihoods, decentralised energy solutions, such as small-scale rural renewable energy, should be incorporated within a WEF nexus thinking (Guta et al., 2017; Grafton et al., 2016). Therefore, this article examines the potential for small-scale rural renewable energy projects to improve energy, water, and food security for poor rural households. To showcase the potential for small-scale rural renewable energy for poor rural communities in Latin America, the Wayuu Tribe in La Guajira, Colombia, will be used as a case study of a population that would benefit greatly by incorporating small-scale rural renewable energy systems.

3. La Guajira and the Wayuu People

La Guajira is a coastal department located in the north of Colombia. Approximately half of the population in La Guajira belongs to the Wayuu indigenous tribe. Colombia recognizes the Wayuu people and their territory as an autonomous region within Colombia but without full political autonomy (Becerra, Salamanca & Perez, 2020; Silva et al., 2020). Above 53 per cent of La Guajira's population, mainly Wayuu people, live in poverty and suffers from food scarcity, water insecurity, and the lack of basic services (Schwartz, 2021). Furthermore, despite a recent boom in electrification in Colombia, 85 per cent of the Wayuu households lack a connection to the electricity grid (ibid.). Despite having substantial amounts of natural resources, Wayuu territory suffers from very poor socio-economic and health conditions and increasing desertification (Carvajal-Romo et al., 2019). Before the Covid-19 pandemic started, the Interamerican Court declared Wayuu's situation to be a humanitarian crisis due to malnutrition, thirst, and lack of livelihood opportunities (Silva et al., 2020).

Policies to alleviate poverty and improve rural areas' livelihoods must consider local-specific needs and opportunities. One important aspect is to enable rural areas to exploit their available comparative advantage (Ruben & Pender, 2004). The La Guajira department has some of Colombia's and the world's best conditions for wind and solar energy, which has led to a growing interest in large-scale renewable energy farms from the Colombian Government and Multinational Corporations (MNCs) in recent years (Rueda-Bayona et al., 2019; Gelves & Florez, 2020). However, the Wayuu people emphasize the need to meet their local energy needs first through renewable energy to reduce their water and food insecurities while creating educational possibilities for their children (Schwartz, 2021). According to Ruben and Pender (2004: 304), less-favoured-areas comparative advantage is often found in 'resource management strategies that optimize the returns to scarce factors, improve local governance structures and reduce transaction costs. In La Guajira, small-scale rural renewable energy serves as an opportunity for communities in the region to use their comparative resource advantage, i.e., wind and sun, and use it for their rural development.

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4. Small-Scale Rural Renewable Energy's Potential to Ensure Energy, Water, Food Security and Livelihood Opportunities

4.1 Energy Security

Energy security refers to a reliable and accessible energy supply and remains a challenge for the Wayuu people's, severely undermining their livelihoods (Staupe-Delgado, 2019; Camargo et al., 2016). A main reason for the Wayuu people's widespread lack of electricity is their communities' dispersed and off-grid location, making it hard to connect them to the national electrical grid (Camargo et al., 2016). Currently, the main electricity source is diesel generation, which is an unreliable, costly energy source for the Wayuu people. Besides the financial costs of diesel-generated electricity, it has high environmental costs, leading to local water and soil pollution, threatening the long-term sustainability of maintaining and creating livelihood opportunities based on the local environment (Spiegel-Feld et al., 2017). An alternative to the diesel energy sources used by the Wayuu people is to implement small-scale renewable energy projects for the Wayuu communities in La Guajira. Small-scale rural renewable energy projects create a bottom-up economic model for farmers and rural people due to its favourable economics at a local level compared to other energy sources. Once renewable energy systems are built, they have low running costs, high reliability and does not cause pollution or soil contamination (Al-Saidi & Lahham, 2019). In Colombia, small-scale rural renewable energy projects have proven to be a cost-effective alternative to the common diesel electrification (Herran & Nakata, 2012). Incorporating small-scale rural renewable energy usage would therefore serve as an emissions-free way of creating reliable, easy-to-access, and affordable energy for Wayuu people and serve as a non-polluting alternative to the current diesel dependent energy system.

Another issue Wayuu people face is that their current energy supply is highly unreliable and subject to national and international price fluctuations. Small-scale rural renewable energy systems offer a solution to the unsustainable international and national energy supply since it can be produced and supplied within a community, and therefore reduce the reliance on large national and international markets to gain access to energy (Camargo et al., 2016). The impact of this would allow the Wayuu people to control their own energy sources and create energy security for people in their communities.

Moreover, allowing the Wayuu people to control the energy resources themselves through small-scale rural renewable energy systems would increase their agency and empowerment and limit the extraction of resources in the region at the local's expense (Eras-Almeida et al., 2019). However, designing solutions for Wayuu communities requires an integrated approach to community life, incorporating local views, customs, and world beliefs (Benavides-Castillo et al., 2021). Small-scale rural renewable energy projects have been shown to increase rural people's autonomy by increasing their ability to support their livelihoods and improve community participation in the energy-generation process (Buechler et al., 2020). Community participation is a crucial factor that reduces transaction costs and bureaucracy and have shown to be able to incorporate local knowledge which makes renewable energy projects sustainable in the long-term (Pansera, 2012). Small-scale rural renewable energy often has to engage with communities to a large extent and thus empower local actors through participation and allows local communities to be in control of the management and monitoring of their energy resources (Guta et al., 2017). Small-scale rural renewable energy projects would therefore allow for an integrated approach to take place regarding Wayuu people's community life and be able to incorporate their local views and customs of how to manage their renewable energy resources.

4.2 Water Security

Water security concerns having sufficient clean water quantities to support human welfare and livelihoods within a region, state, or nation (Staupe-Delgado, 2019). The Wayuu people lack access to a clean and reliable water supply, often suffering from long periods without drinking water (Silva et al., 2020). Wayuu people often collect water from groundwater wells or ditches far away or collect it during the rainy seasons in tanks. Such water-collecting requires significant human resources, takes considerable amounts of time, and often requires one or several household members to make water-collection their daily priority task (Daza-Daza et al., 2018). For farmers who require significantly more water than non-farming households, water-collecting is often insufficient to sustain food crop irrigation. Therefore, farmers with crop-irrigation issues often resort to unstable diesel power generation, leading to high costs, maintenance, and high pollution, which further undermines the long-term clean water sustainability in the region (Benavides-Castillo & Colmenares-Quintero, 2020). One solution to water scarcity is the usage of desalination plants. Although desalination plants exist amongst Wayuu communities, they are not in operation due to a lack of a reliable electricity supply. Therefore, due to the lack of a reliable and clean energy supply, water scarcity, and lack of access to water in La Guajira's Wayuu communities severely undermines the population's ability to support their health, welfare, and livelihoods (Daza-Daza et al., 2018).

As seen, a major hindrance to water security for the Wayuu people is the lack of clean, reliable, and affordable energy. Small-scale renewable energy systems have the potential to solve many of the most pressing water scarcity issues. Renewable energy, such as wind and solar power, are some of the most efficient energy systems when counting litres per MWh. In places that rely on gas and oil, such as in Wayuu communities, wind and solar energy can provide a low-emission, water-saving alternative that would increase water access and create a more efficient water usage system compared to diesel-generated energy while not polluting local water reservoirs (Al-Saidi & Lahham, 2019). For farmers and non-farmers, that have to travel far to access water or resort to diesel-generated energy systems to increase their water access, renewable energy powered water pumps can provide a reliable, environmentally friendly, and economically viable option in rural areas compared to diesel generator pumps (Chel & Kaushik, 2011).

Furthermore, small-scale renewable energy systems could power desalination plants for Wayuu communities and thus provide further access to clean, drinkable water without relying on an excessive abstraction of local freshwater supplies (Burbano, 2014). With climate change impacts changing territories water accessibility, increasing droughts and desertification, improving water security is more pressing than ever. Small-scale renewable energy systems would ensure that the energy-related aspects of water insecurity are mitigated and serve as an adaptation method to climate-change-induced impacts in rural areas by increasing water accessibility (Chel & Kaushik, 2011).

4.3 Food Security

Food security involves having enough nutritional food to feed all people within a territory or a nation (Staupe-Delgado, 2019). To ensure food security, small-scale farmers in developing countries must overcome their low-production capacities and supply constraints (Agarwal, 2014). For the Wayuu people, two of the major root causes of food insecurity is the lack of a secure energy supply and limited access to water resources (Silva et al., 2020). The issue is further limited by the Colombian government's mining and energy extraction in the Wayuu areas during the 19th and 20th centuries, which has limited the agricultural potential in the region (ibid.). Further exacerbating the issue, current water resources and irrigation systems suitable for agriculture are undermined due to the impacts of climate change, such as droughts, increasing desertification, and decreased rainfall (Battisti & Naylor, 2009; Carvajal-Romo et al., 2019). The impacts of droughts, desertification, and less rainfall have further limited the Wayuu people's agricultural possibilities, creating vast food and nutritional insecurity in the region (WFP, 2014; Minambiente, 2015).

Hard to reach areas that suffer from adverse climate change impacts that limits their agricultural capabilities can benefit widely from small-scale irrigation (Ruben & Pender, 2004). Renewable energy can create a cheap energy source that does not create water, soil, or air pollution, and therefore increase the agricultural activities and food production capacities, especially in impoverished rural areas (Al Saidi & Lahham, 2019). Small-scale rural renewable energy systems can support rural livelihoods and ensure food security by creating power for refrigeration, reducing food waste, creating power for feed and product grinding, compressors and pumps, and livestock feeders (Chel & Kaushik, 2011). For the Wayuu people, many of their food and nutritional scarcity issues can be solved through better electricity access. It would increase their ability to use water from more distant places, which would, in turn, be able to be used for improving agricultural productivity through better irrigation and agricultural production by ensuring a continuous water supply (Ojeda, Candelo & Silva, 2016).

4.4 Livelihood Opportunities

Due to the increasing climate change impacts experienced in Wayuu communities, soma places in La Guajira might become non-suitable for agricultural activities. Wayuu people are already deeply versatile economically, showcasing strong adaptability regarding employment and work opportunities, as well as entrepreneurial capabilities (Schwartz, 2021). To improve Wayuu people's ability to change their income-sources amidst climate change induced impacts, education is a fundamental part that allows for such employment adaptation to occur (Ferrero Botero, 2015). Small-scale renewable energy systems offer a way for Wayuu people to engage in non-agricultural employment while at the same time gain access to educational activities (Zaman et al., 2021). Amidst the Covid-19 pandemic, education is increasingly available online; however, it requires a sustainable electricity supply to function. Increasing the access to renewable energy in off-grid communities would ensure that education opportunities spread out to hard-to-reach areas and creates long-term solutions to areas that might be over-dependent on agriculture to support their livelihoods (Zaman et al., 2021). Such efforts would provide long-term opportunities for Wayuu people who find that their past agricultural lands might not be suitable for food crops and thus need other means of supporting their livelihoods.

One major trade-off within the WEF nexus that expanding energy access can create is increasing the pressure on local water reservoirs through extensive water-pumping irrigation for agriculture (Closas & Rap, 2017). However, the threat increased energy access can create to water security – e.g., overuse of local water resources to irrigate food crops – can be mitigated by increasing education about water depletion and its impact on future water and food security. Studies have shown that increased awareness about climate change and water scarcity issues lead farmers towards an openness to try more water-efficient ways of producing food (Sharma et al., 2016). Therefore, small-scale renewable energy systems could create power for online education and information about the causes of water scarcity issues and potential ways of making agriculture more efficient. Thus, reducing the potential stresses on local water reservoirs the increased energy access might create.

Furthermore, another solution to ensure long-term water and food security in areas experiencing stresses to local water reservoirs, examining other livelihood opportunities are important. Small-scale renewable energy programs allow rural communities to use their comparative advantage, renewable energy, and sell the excess energy on the market and diversify their livelihoods away from over-reliance on agriculture. Small-scale renewable energy farming creates a bottom-up way for rural communities to engage in the marketplace according to their conditions since they are the owner of the energy source (Al-Saidi & Lahham, 2019).

5. Conclusion

Through a WEF nexus approach, this article has examined the potential to reduce energy, water, and food insecurities if small-scale renewable energy projects were to be deployed in rural Wayuu areas of La Guajira, Colombia. Due to La Guajira's favourable wind and sun, small-scale renewable energy systems have the potential to create a non-polluting, reliable energy supply for the Wayuu people. Since many Wayuu households live off-grid in hard-to-reach areas for the national electricity grid, small-scale renewable energy systems serve as a cost-effective way of expanding energy access to these parts without expanding the national electricity grid. The impact of creating further energy access to Wayuu people will allow their communities and households to gain further access to water, mainly through powering water-pumping systems and already existing desalination plants, which currently cannot or have a hard time operating due to lack of energy. The increased energy and water access could increase food security by ensuring more reliable irrigation for agricultural activities. Furthermore, increasing access to energy through small-scale renewable energy projects can increase access to education for the Wayuu people and help with further economic diversification attempts in the region. Small-scale renewable energy projects, therefore, serve as a way of ensuring energy, water, and food security while at the same time having the ability for communities to diversify their livelihoods and increase their educational access.

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