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Increasing the Resilience of Colombia's Indigenous Wayuu Communities Through Renewable Energy Technologies

"Barriers and enablers of small-scale renewable energy innovation diffusion in the Indigenous Wayuu communities in La Guajira Colombia and its impact on the Water-Energy-Food Security (WEF) Nexus and potential as a climate change adaptation tool."

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Abstract

Small scale renewable energy systems (SSRES) serve as a potential solution to decrease energy poverty, increase water and food security, and as a potential climate change adaptation (CCA) strategy. This thesis investigates the diffusion of such systems amongst indigenous Wayuu communities in La Guajira, Colombia, through Roger's Diffusion Theory. Subsequently, a Water-Energy-Food Security Nexus analysis examines the local impacts of SSRES diffusion and underpins an investigation of its suitability as a CCA strategy. To grasp the knowledge of La Guajira's indigenous peoples, semi-structured interviews, focus group discussions, and field observations serve as the primary research methodology for this thesis. The data shows that numerous enablers of SSRES innovation diffusion exist; however, the lack of financial capital significantly limits widespread diffusion, serving as a large barrier. The systems in place increase water and food security amongst users, showcasing strong synergies within the WEF Nexus. Still, with the increasing depletion of aquifers, exacerbating groundwater depletion is a significant long-term trade-off. This leads to whether SSRES is suitable for CCA. In the short term, SSRES serves as an efficient CCA strategy by increasing water and subsequent food security. However, decreasing groundwater levels compromise the CCA potential of SSRES in the long term.

Key words: Water-Energy-Food Security (WEF) Nexus, Renewable Energy, Energy Security, Water Security, Food Security, diffusion, innovation

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List of Abbreviations

GHG	Greenhouse Gas
SSRES	Small-Scale Renewable Energy System
CCA	Climate Change Adaptation
SDGs	Sustainable Development Goals
WEF	Water-Energy-Food Security
FGD	Focus Group Discussion
IGOs	Intergovernmental Organizations
NGOs	Non-Governmental Organizations
MNCs	Multinational Corporations
R	Respondent

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1. Introduction

In Latin America, seventeen million rural people lack access to a secure energy supply, while the region simultaneously has some of the world's most favourable wind and solar energy conditions (Eras-Almeida et al., 2019; Terrapon-Plaff et al., 2014). Several researchers propose small-scale renewable energy systems (SSRES), or microgrids , as a way to ensure reliable and clean energy to the regions rural population, allowing them to harvest their vast potential for wind and solar energy production independently from large power grids (Buechler et al., 2020; Eres-Almeida et al., 2019). This thesis follows the Wg6.22. 's definition of a microgrid as an "electricity distribution system containing loads and distributed energy resources that can be operated in a controlled, coordinated way either while connected to the main power network or while islanded." (Marnay et al., 2015: 140). According to current estimations, such microgrids can provide more than 50 percent of the additional energy needed to reach universal energy access without adding additional Greenhouse Gas (GHG) emissions into the atmosphere (Madriz-Vargas et al., 2018).

Even with great potential, diffusing SSRES innovations in energy-poor developing contexts face numerous obstacles (Rogers, 2010). Still, microgrid solutions serve as an important catch-up component in developing countries, with effective diffusion leading to large social and environmental changes (Zanello et al., 2016). This thesis follows Roger's (2010: 10) definition of diffusion as a "process by which an innovation is communicated through certain channels over time among members of a social system." Some of the large social and environmental changes recently emerging in the literature is using SSRES as a potential Climate Change Adaptation (CCA) strategy for the rural poor by increasing their access to water and food resources (Galindo Montero et al., 2017; Kelly-Pitou et al., 2017). While promising, in arid water-scarce regions, diffusing renewable energy innovations without considering their full impacts on water and food resources can undermine their long-term CCA potential, which is especially important to consider in regions suffering from increasing climate-change impacts (Closas & Rap, 2017; Roje et al., 2020).

To examine SSRES potential in rural arid hard-to-reach regions facing increasing climate change impacts, the indigenous Wayuu peoples in La Guajira, Colombia, serve as a case study for this thesis. The Wayuu people face extreme energy, water, and food insecurity where increasing water scarcity is one of the most pressing issues (Schwartz, 2021). The small amount of water communities has access to comes from groundwater wells, often far away from households or collected during the rainy season (Daza-Daza, Serna-Mendoza, & Carabalí-Angola, 2018). Climate change further exacerbates the dire situation by decreasing rainfall and increasing desertification and drought, making the dependency on rainfall and groundwater unreliable (Arrais Herrera, 2020; Ulloa, 2021).

A clean and reliable energy supply can significantly improve much of the water and food-related issues Wayuu communities face (Benavides-Castillo et al., 2021). While La Guajira's environmental conditions contribute to the Wayuu's harsh living conditions, paradoxically, the region has some of the best solar and wind conditions in Latin America (Rueda-Bayona et al., 2019; Gelves & Florez, 2020). In attempts to improve access to water and food and to harvest the region's renewable energy potential, SSRES diffusion exist on a small scale with the help of NGOs and IGOs operating in the area (FAO & WHP, 2019). These SSRES projects in La Guajira's Wayuu communities have shown great potential in increasing energy, water, and food security. Furthermore, researchers in the area speculate that they can serve as a great way of adapting to the increasing climate change impacts in the region (Galindo Montero et al., 2017; Franco Avendaño, 2017).

Even with great potential to improve the living conditions of Wayuu people in La Guajira, the diffusion of SSRES systems is low (Franco Avendaño, 2017). Furthermore, the research on the topic focuses on the immediate impacts of the innovation in the presence of outsiders, lacking an investigation of how SSRES impacts to water and food resources while community members use them independently for a longer period. According to Benavides-Castillo et al. (2021), implementing a new energy system within indigenous communities requires more than solely the finances to pay for the technology and the knowledge of how to set it up and must incorporate aspects of culture, integrity, worldviews, independence, rights, and trust for widespread acceptance. Therefore, investigating the enablers and barriers of SSRES diffusion through the views and needs of La Guajira's Wayuu communities is essential.

Moreover, in rural arid areas facing increasing water scarcity, over-usage of water resources due to increasing energy access can lead to the long-term depletion of local aquifers and hence risks worsening the already existing problem without adequate mitigating efforts (Closas & Rap, 2017). A holistic analysis of diffusing energy innovations is therefore essential to gain a comprehensive view of the issue, especially in La Guajira, where water is extremely scarce, malnutrition is widespread, and where climate change exacerbates the already dire situation (Guta et al., 2017; Ochoa Bustamante & Felipe, 2019).

Against this backdrop, this study aims to explore the barriers and enablers of SSRES innovations diffusion in rural indigenous Wayuu communities in La Guajira, Colombia, their impacts on water and food security and critically examine its potential as a CCA strategy.

In order to fulfil the aim, we will explore the following research questions:

1. *What are the enablers and barriers of diffusing SSRES innovations in La Guajira's Wayuu peoples social system?*

2. *How does SSRES innovations affect water, energy, and food security and the synergies and trade-offs within the WEF nexus?*

3. *What is the potential of using SSRES as a CCA strategy for rural Wayuu communities in La Guajira?*

2. Literature Review

To answer the research questions, reviewing the specific contextual factors of the Wayuu people of La Guajira is essential, especially when designing renewable energy solutions for indigenous communities with often unique social and cultural elements that relate to their local environment (Pratiwi & Juerges, 2022). This section will first present the context of this thesis, thereafter, review microgrid diffusion in developing regions and later review its impact on the Water-Energy-Food Security (WEF) Nexus.

The indigenous Wayuu community inhabits the La Guajira peninsula in Northern Colombia and Northwestern Venezuela and has over 270,000 members, making them the largest indigenous population in the country while constituting approximately half of the population in La Guajira (Aarón et al., 2018). Even with such a large population spread over two countries, the Wayuu people have extensive familiar networks and strong communal bonds, which their leaders play an essential part in maintaining (Alarcón, 2016). Women have a central leadership role within Wayuu societies due to the Wayuu's matrilineal heritage and have the strongest influence on the decision-making and ensuring cooperation between different communities (UNICEF, 2015; Bustamante et al., 2019).

Even with strong communal ties, the Wayuu people face many complex life-threatening issues relating to their local environment and political conditions. The extreme aridity of La Guajira makes access to water and food resources inherently more difficult compared to many other regions in Colombia (Becerra, Salamanca & Perez, 2020). This, in combination with governmental neglect and the lack of providing the regions inhabitants with basic public services, leads to very harsh living conditions, exacerbating rapidly the past years (Schwartz, 2021). The impacts of this have led the Interamerican Court to declare the Wayuu's situation as a humanitarian crisis due to their widespread thirst and malnutrition (Silva et al., 2020).

Widespread SSRES diffusion serves as a potential solution to many of the Wayuu people's interconnected issues (Galindo Montero et al., 2017). However, reviewing the existing literature on these topics is essential to understand SSRES innovation diffusion, its impact on water and food security, and CCA potential. This thesis follows Rogers's (2010; 12) definition of innovations as "an idea, practice, or object perceived as new by an individual or other unit of adoption." Diffusing renewable energy microgrid innovations in low-income developing countries face a combination of barriers such as low education and incomes, lack of adequate involvement of communities, coordination, and consultation, technical factors, and information about the technology, its costs, and benefits (Eder et al., 2015; Schmidt et al., 2013; Yadav, Davies & Palit, 2019).

Eder et al. (2015) take Roger's Diffusion Theory as a starting point and elaborates on microgrid diffusion's technical barriers. One of the most important aspects is that the provider's services must be reliable; if they are unreliable, it creates distrust and frustration leading to resistance in the early diffusion stages. This correlates with technical functionality; diffusion rates will be higher if the innovation functions better than previous energy systems. Another important aspect is technological awareness, where education about the benefits and potential impacts of the technology on the recipients is crucial. Eder et al. (2015) add that recipients often favour energy systems that sustainably use local energy sources since they preserve the local environment and are economically favourable. Let et al. (2020) mention another important factor: knowledge and skill in operating the SSRES; if recipients have the skills to maintain the system, it can be more effective than receiving energy from a national grid.

The affordability of SSRES is especially important in developing contexts, and the lack of financing opportunities and low economic capital severely constrain widespread microgrid diffusion (Schäfer, Kebir & Neumann, 2011). Renewable energy technologies often have a higher initial investment cost than other technologies; however, it is close to free to maintain. This initial investment cost by households is a significant economic barrier since diffusion cannot occur if the recipients cannot afford the technology in its initial stage (Eder et al., 2015). Furthermore, adequate and transparent information about the costs of SSRES closely relates to affordability, where recipients must be aware of the low costs of maintaining the systems and suitability for their context to encourage diffusion (Yadav, Malakar & Davies, 2019).

Entering a new context with an innovation requires careful consideration of the existing social system. According to Rogers (2010), viewing diffusion as a process rather than giving out innovations to communities without adequate follow-up is crucial. Still, microgrid diffusion receives very little social scientific focus, often ignoring the social factors of the technology and, according to Wolsink (2014: 37), "follows strong but highly questionable assumption of expected social acceptance of the basic principles and the crucial elements." The social acceptance of renewable energy innovations differs widely depending on the social context and cultural beliefs, which has led to the view that social acceptance is a crucial factor in determining successful microgrid diffusion, according to several scholars (Wolsink, 2014; Alam, 2014; Wu et al., 2022).

A further important diffusion component is the engagement of the recipients of SSRES innovations by incorporating their views and opinions where the neglection of these factors leads to a top-down approach to implementation (Bukari et al., 2021). In India, top-down SSRES implementation led potential recipients to claim they received fake energy and wanted real energy from the conventional grid, viewing SSRES as inefficient and incapable of addressing their energy needs (Sharma, 2020). To avoid similar scenarios like the one in India, effective coordination, consultation, and participation of the recipients by involving them in the early stages of microgrid implementation is essential to achieve acceptance

(Schmidt, 2013). To avoid a top-down diffusion of SSRES, the main goals and objectives of the system from the donor or development entity are key in promoting an adequate understanding of its usage (Ley, 2017). Transferring such understanding about SSRES is often most effective in developing contexts through word to mouth and direct observation. Rebane and Barham (2011) support this and states that familiarity with the system often leads to a higher willingness to adopt it and improves knowledge about its positive impacts.

In indigenous communities, involvement in the management of the systems and the planning process is especially important for effective diffusion to ensure long-term beneficial impacts (Ballesteros-Ballesteros, 2019). Indigenous communities might become resistant to renewable energy initiatives if it neglects their rights to decide over their communities' current and future needs, leading to severe challenges in implementing such projects, their long-term usage, and eventual or immediate failure of the projects (Benavides-Castillo et al., 2021). Amongst Wayuu communities, an important factor regarding renewable energy diffusion is their cultural worldview on natural resources such as sun, wind, and water. Their ancestral culture teaches different visions about the sun, wind, and water, which can impact their view about renewable energy technologies that use these resources to produce energy or change the way they use a resource such as water (ibid).

For rural development and reaching the SDGs, modern energy services are only one of the issues communities and households face since they often also experience water and food insecurity simultaneously (Guta et al., 2017). While the demand for water, energy, and food resources increases worldwide, these resources also face increasing depletion due to climate change, environmental degradation, soil erosion, drought, and numerous other impacts relating to climate change and biodiversity loss (Terrapon-Pfaff et al., 2018; Hanjra & Qureshi, 2010; Mancosu et al., 2015; Warner et al., 2010). Only a few empirical evaluations compare and analyse how SSRES impacts local living conditions, with even fewer studies considering the potential long-term impacts of using solar energy to achieve water and food security in arid regions suffering from increasing climate change impacts (Terrapon-Plaff et al., 2014).

Buechler et al. (2020) multi-disciplinary comparative qualitative study in rural and urban Arizona, United States, and Zacatecas, Mexico, focus on how SSRES impact local communities' water and food resources. In the communities, solar energy allows groundwater to be pumped for irrigation, increasing the ability to produce organic food cheaper, while community members simultaneously use it to power electric fences to keep animals away from food production, leading to further food security. In addition, the authors found that the implementation of solar energy technologies led to other sustainable behaviours, such as saving freshwater by using rainwater or greywater for irrigation.

Terrapon-Pfaff et al. (2018) examine 103 decentralised SSRES projects where almost half of the projects mainly focus on generating energy for food or water subsystems, showing that local energy developments significantly impact local water and food resources. Theoretically, this should increase access to water and food; however, the authors stress the lack of empirical project evaluation to determine the case fully. Such empirical evaluation was done by Ibrik (2020), examining two rural communities in Palestine after replacing their former diesel generators with solar microgrids. The solar energy led to increasing energy access and further access to potable water while stimulating their agro-food industries, leading to significantly reducing poverty levels in the two communities.

Roje et al. (2020) analyse the impacts of solar microgrids in rural parts of Southern Chile, suffering from 20-40 per cent less rainfall in recent years. The increasing energy access led to improving irrigation possibilities and increasing crop yields; however, the authors note potential side effects, such as long-term water depletion if overusing local water resources. Like Roje et al. (2020), Al-Saidi and Laham (2019) identify that in five Indian states, solar energy usage amongst rural farmers, both small and large-scale projects, increase access to groundwater, leading to further irrigation potential for the farmers and, therefore, increases food production, leading to further food security. However, extensive irrigation by the farmers causes stress to local groundwater resources, confirming the water-related worries Roje et al. (2020) raise. Similarly to Al-Saidi and Laham (2019), Gupta (2019) examines six districts where rural farmers adopt solar pump irrigation for crop production. The solar energy pumps led to increasing crop intensity in four districts and vegetable and fruit production in three districts, leading to further food security. However, increasing water access from the solar energy led to larger total water consumption, causing stress to groundwater resources in two districts, corresponding to the findings of Al-Saidi and Laham (2019).

Besides the few locally-based studies this section reviews, most research, discussions, and applications of the WEF nexus have been on national or global levels, focusing on large infrastructure developments, macro-drivers, and material flows which often overlooks that the major nexus challenges occur locally (Terrapon-Pfaff et al., 2018). Although SSRES have a largely positive impact on energy, water, and food security, leading to more sustainable rural livelihood development, this review identifies a major water-related trade-off. In rural arid regions, increasing access to local aquifers often leads to significantly increasing water usage and subsequently propose threats to long term water sustainability. Shedding light on this issue is crucial since improving knowledge and monitoring of resource use can mitigate potentially adverse impacts; if not, it can significantly threaten the long-term sustainability of SSRES use (Closas & Rap, 2017).

Regarding potential water depletion, an important factor of SSRES diffusion in arid regions and its impact on the WEF nexus is its CCA potential (Ley, 2017). The few studies on SSRES potential as a CCA strategy through the WEF nexus in rural arid regions are sparse. Galindo Montero et al. (2017) show that the systems can increase water security in rural arid regions where climate change makes water scarcity more present. Ley (2017) shows how SSRES can increase the number of livelihood opportunities and therefore reduce the dependency on scarce natural resources. However, the research on SSRES CCA suitability in regions experiencing increasing groundwater scarcity remains scarce. The existing ones do not fully account for how these systems will function when climate change decreases total water availability in arid regions.

3. Theoretical Framework

Reviewing the previous section's literature, diffusing renewable energy innovations in rural arid regions in developing countries requires incorporating numerous factors. This thesis combines two theoretical frameworks to adequately examine the diffusion of SSRES innovations and their impacts on water, energy, and food security to answer the research questions. Combining Roger’s diffusion theory, which the first subsection covers, with the WEF nexus, which the second subsection covers, gives a good understanding of the issues this thesis investigates.

3.1. Diffusion Theory

Even with many obvious advantages, diffusing innovations often face many obstacles that depend on many, often local-specific factors, such as culture, norms, beliefs, the local environment, politics, and economics. Roger's (2010) Diffusion Theory focuses on what makes an innovation's diffusion successful and covers four main elements: innovation, communication channels, time, and the social system, whereas this study focuses on the social system, innovation, and communication channels aspects.

The social system is a major element of diffusion theory, and it can refer to a group of individuals, informal groups, organisations, or subsystems and range from all families in a village, a certain group such as medical doctors in a hospital, or all consumers within a nation. The social structure of the social system impacts the diffusion of innovations in numerous ways (Rogers, 2010). Formal social structure can refer to hierarchical positions within a community. Within the Wayuu communities, women have the highest formal hierarchical positions due to their leadership role, while elders receive much respect; these two groups are therefore likely to have the strongest influence within their social system (Bustamante et al., 2019). Informal social structures involve interpersonal networks that link members of a social system, determine who interacts with whom and under what conditions, and influence communication within a social system, impacting when an individual adopts an innovation (Rogers, 2010).

Norms are another crucial aspect of diffusion theory's social system aspect, guiding individuals' behaviour and defining a tolerable behaviour range, often determining the acceptance of an innovation (Rogers, 2010). Certain individuals, the opinion leaders, strongly influence the norms by having technical competence, showcasing conformity to the system's norms, and possessing strong social influence. Depending on their view of an innovation and the system's norms, opinion leaders can either increase diffusion rates or serve as a significant barrier (Rogers, 2010). According to the literature, the strongest opinion leaders setting the norms within Wayuu societies are the community and territorial leaders and the elders and are the focus of this thesis's data gathering process and analysis (Bustamante et al., 2019).

Innovation refers to an object, practice, or idea that a unit of adoption or an individual perceives as new. According to the innovation element, several aspects determine successful diffusion, and Rogers divides these aspects into five main characteristics. Firstly, the degree to which an innovation is superior to the idea that it supersedes, including economic advantage, social prestige, satisfaction, and convenience: the greater the innovation's advantage, the greater the diffusion level (Rogers, 2010). In developing country contexts, the relative economic advantage is often the deciding factor determining the diffusion rate due to the low purchasing power of potential adopters (Hogarth, 2012). With past research showing a willingness to adopt renewable energy systems amongst rural Wayuu people but with low purchasing power, the economic advantage aspect is especially important to consider in the context of this thesis (Schwartz, 2021).

The degree to which an innovation is consistent with existing norms and values, the needs of potential adopters, and past experiences – its compatibility – is another essential factor; the diffusion of an innovation will likely not be successful if it goes against the values of the adopter. Whether it is difficult to understand or to use, an innovation's complexity is the third characteristic, whereas if the social system members can easily understand and use the innovation, it will diffuse quicker. Compatibility and complexity are especially important in developing indigenous contexts since outsiders often provide information about an innovation in which social systems members often have very different norms, cultures, and ways of learning (Benavides-Castillo et al., 2021). For solar energy innovations specifically, the lack of understanding of how a system operates amongst the recipients is often a significant barrier hindering widespread diffusion (Amuzu-Sefordzi, 2018).

Trialability and observability are the two final innovation elements. An innovation diffuses faster if individuals can see how it works and if people can try out the innovation, or if potential recipients can observe how the innovation functions and its impacts (Rogers, 2010). These aspects of innovation diffusion are very relevant for the Wayuu people since, with strong communal ties and networks, many Wayuu people are likely able to observe other communities using SSRES and see how it works in such communities.

Underpinning and facilitating the diffusion of an innovation are the communication channels, how information about the innovation by someone who knows of it and someone without experience if the innovation spreads. This can be from mass media channels or interpersonal channels involving face-to-face exchanges. Most people depend on a subjective evaluation of innovation, and the subjective evaluation comes from other people like themselves that use the innovation. When two individuals with and without the innovation share common meanings, the same language, and similar personal and social characteristics, communicating the acceptance of an innovation is likely to lead to higher diffusion rates (Rogers, 2010). In developing contexts such as La Guajira, interpersonal channels are likely the largest and most important communications channel (Rebane & Barham, 2011). Therefore, this thesis focuses on the interpersonal communication channels present in Wayuu communities.

3.2. Water-Energy Food security (WEF) Nexus

As seen in the previous section, the acceptance of an innovation depends on its relative advantage and must fulfil numerous additional socio-economic and cultural aspects. Since energy often has a large impact on water and food resources, this thesis uses the Water-Energy-Food security (WEF) Nexus Framework to gain a deeper understanding of the impacts of SSRES and to help answer the final two research questions.

The WEF nexus refers to studying the connections between water, energy, and food resources and aims to determine the synergies and trade-offs between management practices and decisions regarding these three resources (Simpson & Jewitt, 2019). The WEF nexus evaluates and examines how water, energy, and food interact and operate by explicitly acknowledging the interdependence of these resources and, by doing so, establishes the potential for maximising synergies and minimising trade-offs (Albrecht, Crootof and Scott, 2018). To illustrate the WEF nexus framework, agricultural production needs energy for effective irrigation, water pumping, transportation, and other aspects relating to food production. Food production often has substantial water and energy footprints, while energy and food production often compete for land and water resources (Guta et al., 2017).

The WEF nexus serves as a decision support tool to improve rural livelihoods through integrated resource management, planning, and distribution approaches and targets SDGs 2, 3, 6, and 7 (Madhaudhi et al., 2019). Policy and management decisions that acknowledge that a change in one of the three resources will impact and alter the others are thus important to mitigate potential trade-offs and enhance potential synergies. Therefore, improving the understanding of SSRES within the WEF Nexus can provide more comprehensive and innovative insights into what role modern energy services have within development while accounting for the potential synergies or trade-offs with water and food security and thus create a more comprehensive view of how to achieve the SDGs (Guta et al., 2017). These factors are especially important to examine in the Wayuu context, where past studies have shown a strong correlation between increased energy security from SSRES and increasing water and food security, while a potential future lack of water might severely undermine such effectiveness (FAO & WHP, 2019; Galindo Montero et al., 2017).

4. Methodology

4.1. Research Methodology Justification, Strategy, and Design

Despite the increasing attention towards a WEF nexus approach to support the efficient implementation of the SDGs, the role renewable energies have in addressing trade-offs and realising synergies are scarce. Over one billion people lack access to modern energy services, while a billion people lack access to safe drinking water. The same people often lack access to these services and natural resources simultaneously and usually depend primarily on agriculture to sustain their livelihoods. Directing WEF Nexus research towards rural communities facing nexus challenges is therefore crucial (Terrapon-Pfaff et al., 2018). The European Commission's WEF Nexus report accordingly recommends that future WEF Nexus focus on decentralised and local solutions on a local level, including social aspects (Mayor et al., 2015). To answer the calls of more localised WEF Nexus research, this thesis uses the views and opinions of the local Wayuu people in La Guajira as its main data source.

To do so, this thesis uses a qualitative comparative case study methodology which is especially useful in situations that copes with a technically distinctive situation with many variables, that relies on multiple sources of evidence which need data triangulation, and where prior theories guide the data collection and analysis (Yin, 2009). A case study methodology therefore allows for an investigation of the complex interactions between SSRES innovation diffusion, the WEF Nexus, and its suitability for CCA in the distinctive Wayuu context. A semi-structured interview approach, focus group discussions (FGDs), observatory research and additional literature support the data-gathering process (Bryman, 2015). This study is explanatory as it seeks to analyse the enablers and barriers to SSRES diffusion amongst Wayuu communities in La Guajira, the impacts of the systems on the WEF, and its potential as a CCA tool. Such an approach follows Saunders et al.'s (2009) explanatory research design as a tool to determine how causal relationships explain a situation.

The semi-structured interviews follow a set of predetermined questions, as seen in the interview guide (Appendix 1) that helps direct and create a fluid conversation around the research topic. This allows for amending questions throughout the interview to address important responses while keeping the participants' focus on the research topic (Hammett, Twyman & Graham, 2014). The respondents might have differing abilities to provide relevant data to answer the main research questions, while some information might come about by letting the participants elaborate on certain aspects themselves. The use of the semi-structured interview approach allows for the incorporation of potentially varying knowledge and views amongst the respondents about how SSRES impact Wayuu communities (Bryman, 2015). The FGDs depart from topics and discussion questions but supplement the semi-structured interviews by allowing a more informal discussion about the research topic to take place. This was chosen as an additional research methodology since it facilitates the ability for the participants to express views collectively and discuss the topic in a greater depth, which is especially relevant for this study due to the Wayuu communities' strong communal ties (O. Nyumba et al., 2018; Alarcón, 2016).

Moreover, the knowledge of indigenous peoples is important to include in any research that involves or impacts them (Nilsson, 2008). The flexibility of a semi-structured interview approach and FGDs leaves more room for such knowledge to be included during the data gathering process and for new insights and spontaneous dialogues to emerge (Bryman, 2015; Huntington, 2000). In addition, it can increase the possibility of drawing on the participant's values and perceptions of water, energy, food security and CCA from their values and beliefs (Wolf, Allice & Bell, 2013).

4.2. Practical Preparations

Before arriving at the research site, the researcher had been in touch with several people in La Guajira regarding practical considerations, cultural context, and safety. The researcher had three zoom discussions with academics and development practitioners in the area about how to best conduct research amongst the indigenous Wayuu people and cultural factors to consider. Three weeks before arriving, the researcher was in touch with a local cultural mentor who elaborated upon these explanations and helped set up the connections to a local guide, transport, and approval from the territorial leaders.

When arriving at Riohacha, one of the major cities in La Guajira, the researcher was briefed about the cultural context, safety issues, and other practical matters in person by a cultural guide. On January 28, the first meeting with the territory leader occurred, including formal greetings, a briefing about the researcher, the research study, and information about the cultural context.

4.3. Sampling and Methodology

The rural Manaure municipality in La Guajira, Colombia, was purposively selected as a case study due to the presence of communities with and without SSRES innovations. Most of the semi-structured interviews, all FGDs, and observatory research took place there. Additional semi-structured phone interviews were conducted in the neighbouring rural Maicao municipality in La Guajira, Colombia. Both locations selected are extremely arid and represent the hardships many Wayuu communities face in La Guajira.

The exact number of communities residing in the Manaure area is unknown, but approximately 60 communities live in the study area and each community has 20-40 households with differing numbers of people living in each household. The Maicao territory consists of approximately 35 communities with an unknown number of households. Most of the women in both territories work either with creating handbags or hammocks, while the men often work with any available odd-job. Due to the extreme aridity of the area, many of the communities lack access to clean and safe drinking water, forcing them to access water from groundwater wells subject to pollution and insecure water supplies. Some people in the area work with subsistence farming, which is becoming harder due to the increasing lack of water.

This thesis relies on several different research methodologies. Secondary data was used for the literature review, the theoretical and conceptual aspects of the research, and to critically reflect on the research findings. A mixed qualitative research method was used as primary data consisting of individual semi-structured interviews, FGDs, and observations in the field. Hence, enabling methodological triangulation and different points of intersection and comparisons (Denzin, 1989). Using different qualitative data gathering methods aided in revealing a more in-depth understanding of the study phenomenon.

Five rural communities from two different Wayuu territories participate in this research. Seventeen community members aged 18 to 79 participated in the semi-structured interviews, ten women and seven men, consisting of 12 in-person and five phone interviews. These took place between January 29, 2022 – February 10, 2022, and lasted between 20 to 50 minutes. A translator was always present during the in-person interviews to help with potential language barriers since all participants did not speak Spanish. All participants in the phone interviews spoke Spanish fluently; therefore, the presence of a translator was not needed. One elderly person from each community participated in the research since they are often wisdom keepers within indigenous communities, possessing essential information (Levac et al., 2018). This was further encouraged by the community members themselves, expressing the importance of elders participating due to their vast knowledge about their community's history and their local area.

This study adopted a purposive and convenience sampling procedure to select participants (Bryman, 2015). The main criteria for participating in this study was that at least one community had access to SSRES innovations, and one had no access to SSRES. Once relevant communities were identified to ensure that both people without and with SSRES participated in the study, the semi-structured interviews were conveniently sampled once arriving at the respective communities by asking which community members were willing to participate in the research. This was done to respect each community member's time and ensure that their participation was voluntary and not forced.

During some of the interviews, participants claiming not to have access to any energy revealed that they used a small-scale windmill groundwater pumping system. These interviews were still conducted and included in this study since they provided additional important information and the possibility for further comparison between different SSRES impacts. Five additional semi-structured interviews were done through WhatsApp phone calls with rural Wayuu communities from the Maicao municipality in La Guajira, Colombia, to get a fuller view of people without any energy access.

The FGD's also followed a purposeful and convenience sampling approach. Relevant communities were purposefully sampled to ensure people with and without SSRES participated. After arriving in the respective communities, community members were asked to participate in FGDs voluntarily. Fifteen people participated in the FGDs, seven men and eight women and took place on January 29, 2022.

The first FGD involved community members using a solar microgrid groundwater pumping system and a water filtration tank with three women and one man participating. The second FGD involved five men and two women. Initially, the participants claimed not to have any energy. However, some participants had access to a solar groundwater pumping system, which was revealed during the FGD. Hence, this FGD compromised a mix of people where three had access to SSRES, and four did not have any energy access. Although the initial thought was to compare the differences between answers from the FGDs, the participants in the mixed group were able to discuss their differences in how SSRES access impacted them, which provided additionally unique data.

Nonetheless, to create a more comprehensive view of people lacking energy, an FGD was conducted with people who lack energy access involving three women and two men. However, during the FGD, the participants in this focus group revealed that they had access to a small-scale groundwater windmill pumping system that they could access groundwater through. Due to the time limitations of the participants during the study visit, an FGD could not be conducted with people who lacked access to SSRES. However, an FGD with people using the windmill system allowed for a more thorough comparison between the solar energy, windmill energy, and no energy groups.

The lack of an FGD with a group that completely lacked any energy source that could increase their access to water was mitigated by conducting additional semi-structured phone interviews with participants from another territory that lacks access to any energy, where the use of SSRES is sparser, mentioned in previous paragraphs.

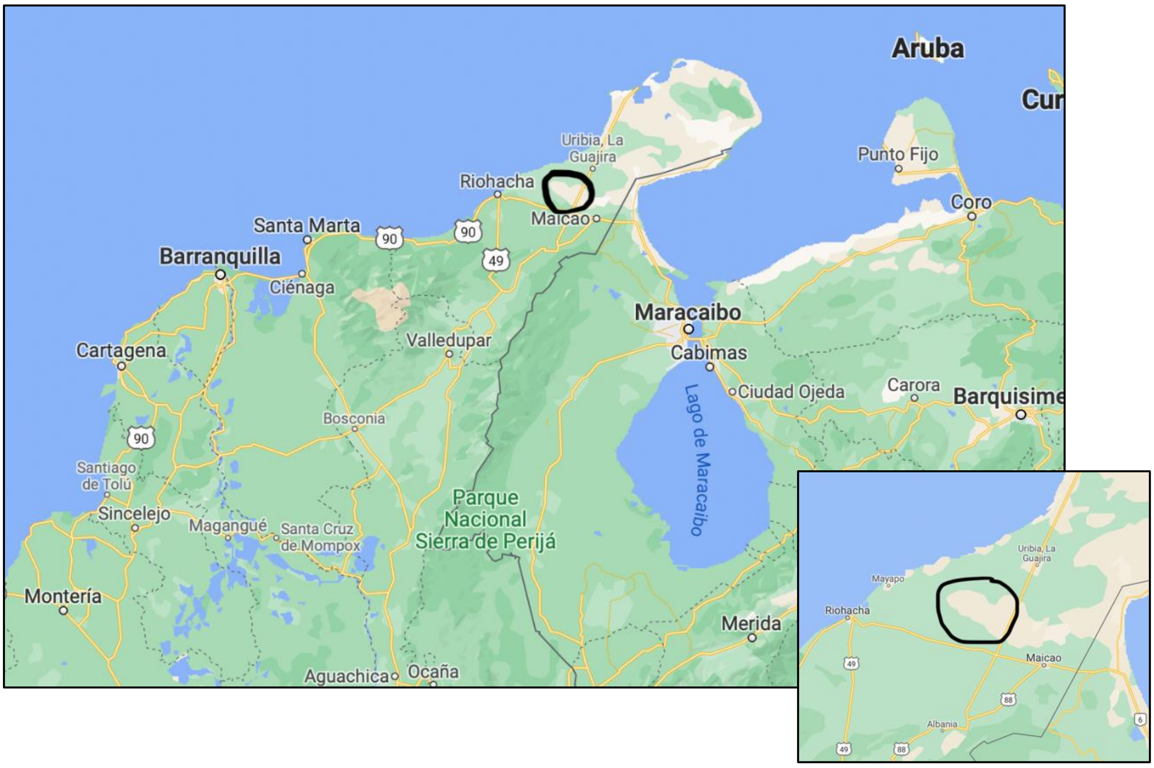
Wayuu societies are built on a matriarchal lineage. Therefore, women are the territorial leaders and often have much power in their communities. This was present during the research collection process since many women were often very talkative and willing to participate in the interviews. During the semi-structured interviews, the men often talked less than the women, while more women participated. This was mitigated by asking the cultural mentor and guide whether more men would be willing to participate and having one of the FGDs mainly consisting of men. The impact of this led to closer participation of men and women while the men were more willing to provide further information during the FGDs.

The Manaure area served as the field site for the observational research, as seen in Figure 1, since it has SSRES innovations and people without access to any energy. The community members and leaders invited the researcher to look at the different types of energy they used. In cases where no energy was available, the researcher was invited to look at how the communities could access water. Several community members accompanied the researcher at each field site, where they showed and explained what the energy systems were used for. In the field site without energy, community members showed how far they had to walk to get water and how they had to carry it back to their homes. The observational study took place on January 29, 2022, approximately a two-hour car-drive from Riohacha into rural Wayuu territory. The researcher was accompanied by the territorial leader, the driver, the cultural guide, and a local guide during this time.

The research adopted a purposive and convincing sampling procedure to select observation sites (Bryman, 2015). The criteria for the site were to see at least one site with an SSRES innovation and one without any energy source. In the end, five different sites in the Manaure were visited to gather the observatory data. The first field site had several solar panels which were used to give energy to a groundwater pump and also powered a water filtration system that provided clean and safe drinking water. The second field site involved solar panels that powered a groundwater abstraction system. A windmill groundwater pumping system on the third field site was originally used for irrigation, but parts were lacking since they were broken or stolen. Therefore, the windmill did not currently power any irrigation system. The fourth site was the largest and had several solar panels which powered an irrigation system for agriculture and drinking/domestic usage water. Several people from other communities visited this site to gain access to drinking water, showing the strong communal ties between the people living in the area. A groundwater well where people manually had to throw down buckets and hoist them up was visited during the end of the field visit with several members from different communities present. The water was collected in tanks holding approximately five to thirty litres and was afterwards transported with either a donkey or human power to their respective households.

Viewing the different energy systems, or lack of, and their impact on the WEF nexus helped create further understanding to how the WEF nexus relates to different energy sources. For example, in the interviews, many communities that used the windmill system complained about how it only works when the wind works, which was seen several times during the observational research, allowing the researcher to see with their own eyes how it impacts water access. When no energy was available, community members showed how far they had to walk to reach a well and the need to manually use a bucket by the well attached to a rope to throw down and then lift to access water.

Figure 1. Location of Observatory Research



4.4. Data Analysis and Presentation

To analyse the data gathered in the Wayuu communities, this study adopts a qualitative content analysis approach which allows for a controlled analysis of texts where the researcher develops specific categories that are revised and refined in an interactive, feedback-loop process to ensure credibility and usefulness (Drisko & Maschi, 2016). NVIVO was used to analyse the data by coding recurrent themes and patterns related to the theoretical frameworks. Participants are referred to as respondent (R) followed by a numerical number in the Chapter 5 of this thesis. The theoretical frameworks were evaluated deductively; however, since the Wayuu's situation in La Guajira is very context-specific, new, and emerging theories from the data patterns were evaluated inductively (Bryman, 2015; Creswell, 2013). This was especially relevant to answer the third research question regarding the suitability of SSRES as a CCA strategy. Accordingly, the research analysis follows a retroductive approach, combining inductive and deductive elements, allowing for potential diverging ideas and voices to be included and provide richer research findings (Ragin & Amoroso, 2011).

While creating themes and codes, a large focus was on recognising the researchers' own biases and perspectives that might influence the interpretation of the results, themes, and codes since the process of writing up a research project are subject to the researcher's own subjective experiences, academic training, and past contexts (Scheyvens, 2014; Weston et al., 2001). Only the quotes included in the analysis section were translated from Spanish to English.

4.5. Ethical considerations

This research study follows standard ethical procedures (Bryman, 2015). According to Lund University Guidelines, consent forms were prepared and explained to the participants by the researcher and the translator. Due to the general lack of reading and writing skills among the participants, verbal consent was asked and given by all participants. All interviews were recorded since the participants felt comfortable with such a method. The participants were briefed about the purpose of the research and what actors the research will be shared with before the interviews. Interviewees were allowed to choose the interview's location and time.

Before starting the recording, the participants were informed that the interview would be recorded, transcribed and be used for academic purposes. The participants were ensured that their participation is voluntary and that they can withdraw their contribution to the research at any time during the interview process or research process without any explanation and refuse to answer any questions without explanation, following the United Nations Declaration on the Rights of Indigenous Peoples – free, prior, and informed consent (Kwaymullina, 2016).

When working with indigenous communities, it is important to allow them to participate on their terms. In research projects, Harris (2021) views this as indigenous peoples being able to express themselves in their languages which aligns with the importance of ensuring that the interviewees can express themselves freely and without the foreign language constraint when conducting multilingual research (Littig & Pöchhacker, 2014). Some of the participants in this study spoke fluent Spanish, while some only the indigenous language Wayuu-naike. Therefore, a local guide, speaking both Spanish and Wayuu-naike, was present during the in person semi-structured interviews and FGDs to ensure the participants could express themselves in their preferred language.

4.6. Research Validity and Study Limitations and delimitations

It is hard to generalise the research to other areas since it is very context-specific and limited geographically. Nonetheless, in Colombia and Venezuela, most rural Wayuu communities in La Guajira live under similar conditions, constituting a population of several hundred thousand. Therefore, this study can be used to indicate how Wayuu people in La Guajira view SSRES and its impact on the WEF nexus. This research aims not to present results that can be generalised to the whole Colombian population or other communities in the world that face similar natural conditions. Instead, this study aims to shed light on the importance of a local-specific approach to solve local-specific challenges. Therefore, the sample used in this study can only indicate the broader picture of the research phenomena for Wayuu people in La Guajira, both in Colombia and Venezuela and help future research directions.

To ensure the consistency of the data and the internal validity, the researcher used varied data collection techniques, incorporating several communities and people from a wide age range, and checked divergence or consistency of data with previous literature on the topic and theory.

Several research limitations can be identified. Qualitative research methods depend on theory, where language often plays a crucial part in constructing social realities (Talja, 1999). Using a translator to interpret Wayuu-naike and translate it to Spanish propose challenges common in multilingual research. The translator is at risk of becoming a co-interviewer instead of serving as a translator while certain meanings can be lost in translation (Littig & Pöchhacker, 2014). The researcher mitigated this by briefing the translator of the importance of the researcher to guide the interview, ensuring there was enough time for unique Wayuu concepts to be explained for the researcher by the translator during and after the interviews, and reviewed the research questions with the cultural guide before starting the research process. In addition, the observatory research allowed the researcher to gain a fuller view of the research questions in their local-specific context without the need for translation.

Cross-cultural qualitative research can impact the type of data accessed positively and negatively. Everything from age, ethnicity, gender, culture, and the researcher's clothing can play significant roles in accessing data and conducting research in the field (Ryen & Torhell, 2004). The Wayuu people in La Guajira have suffered from marginalisation from outsiders for decades. This has made many distrustful of strangers, and accessing their areas, especially asking them questions, is only possible with help from someone inside. This was mitigated by the cultural guide, who also belongs to the Wayuu people, briefing the participants beforehand about the aim of the study.

Upon arrival, all community members showed great interest in the study due to their willingness to make their harsh living conditions known to the world. Such an intimate relationship can serve to get more reliable information and increase the validity of the information since being an outsider would serve as a hindrance (Funder, 2005). Another aspect that increased the participants' openness was the researcher's willingness to come to the field and spend time with the people living there. Several participants expressed their content that the researcher was interested in listening to their situation, which they all explained were very harsh and the need for more people to find out how the Wayuu people in La Guajira live.

Regarding translation, the translator works for a local NGO in the area. Since the translator is well known in the communities, it is possible that she also faced some aspects of positionality bias. The translator's presence in the interviews that took place in person might have influenced the openness and responses of the interviewees and thus the data quality. This was mitigated by ensuring that the NGO worker and the NGO she works on does not work with SSRES to avoid any potential conflict of interest during the interviews.

Furthermore, the presence of SSRES in La Guajira is very sparse, and the access to communities with this technology reflects a broader issue within the development – that some groups receive more attention than others by NGOs. This can lead to the exclusion of certain individuals and groups, and in this case, especially those that completely lack any energy, and was mitigated by conducting additional phone interviews with communities that lack energy access in another territory.

5. Data Analysis

This chapter analyses the data based on the information received from the Wayuu communities in La Guajira. The first subsection examines the Wayuu's social system, the five main dimensions of the innovation aspect of Roger's (2010) Diffusion Theory, and the interpersonal communication channels to explain the enablers and barriers of solar microgrid diffusion. To ensure the amendment of Diffusion Theory to the developing context amongst the rural Wayuu communities in La Guajira, a focus lays on incorporating the financial possibility (Eder et al., 2015), technological factors (Chatterjee et al., 2019), and social acceptance (Sharma, 2020).

The second subsection deploys the WEF Nexus Framework to examine the impact of SSRES on water and food security within the communities participating in this research. Particularly, the focus is to identify the synergies and trade-offs when diffusing an energy innovation in an arid developing region by comparing communities with access to solar microgrids, windmill systems and communities without access to energy. Since the WEF Nexus analysis departs from SSRES – Energy – this study follows a slightly modified version placing energy first, thus following an Energy-Water-Food Security Nexus approach. The WEF Nexus analysis underpins an examination of the suitability of SSRES as a CCA strategy from a short-term and long-term perspective as elaborated on in the third subsection.

5.1. Diffusion of Innovation

The Wayuu people's matrilineal kinship with women as their leaders underpins their social system (UNICEF, 2015; Bustamante et al., 2019). The leaders often forge strong connections with other communities and receive much respect as authority figures. Another important authority figure is the elders within each community. The view of elders as possessing great wisdom is common within indigenous societies (González-Padrón, 2019; Levac, 2018). The

Wayuu communities participating in this research confirmed this by showing much respect for their elders. These findings strongly indicate that leaders and elders are the strongest opinion leaders within Wayuu's social system.

The Wayuu's opinion leaders' impact on the views of SSRES innovations was strongly present throughout the data-gathering process. In a semi-structured interview, one of the leaders (R4) mentioned that she had tried, and continues to try, to get more solar microgrids to the communities due to the positive impacts she had seen it create for other communities. An elder (R2) agreed with this notion and mentioned that she had experienced natural environmental changes during her lifetime, making it difficult to access food and water but that solar energy has reduced this difficulty. Another leader elaborated on this and explained that she had seen *"solar energy changing the living conditions in different communities (R15)."* The opinion leaders' positive views of solar microgrids are likely to have contributed to the favourable norms regarding solar energy within Wayuu communities. All participants further supported this and mentioned that they viewed solar energy microgrids as positive, while 28 out of 33 of the respondents expressed strong urges to adopt such systems.

The strong support from the opinion leaders within the Wayuu social system is likely to have created the favourability towards solar microgrid diffusion. However, while the opinion leaders' views can be a determining factor impacting the willingness to adopt innovations, one of the most important aspects of diffusion, underpinning both the opinion leaders' views and the views of the rest of the community members, is whether the innovation is superior to what it replaces (Rogers, 2010). The previous ways of accessing water for the community members using solar microgrids were either a windmill groundwater pumping system or manually accessing water from a well. All solar energy usage respondents emphasized the relative advantage of solar microgrids, responding that the system's most significant impact is its ability to increase their water access, making its relative advantage strong. As expressed by a respondent with solar energy: *"It has made a difference that I did not see before. The water is available faster with the submersible pump, it works daily and there is water. There is a lot of change (R3)."*

As shown in the previous quote, the innovation has increased access to water which all respondents with solar microgrids stated had improved their lives. The older windmill system also increased water access leading to further improvements. However, according to five out of eight participants with wind energy, the systems are highly dependent on strong winds, and with mediocre or weaker winds, it does not pump any water. This was seen during the observatory research when the wind was blowing modestly, but the windmill did not function. Comparably, five of the respondents in this study had replaced their windmill system with a solar microgrid and they all reported that solar energy worked better than their previous wind system, hence supporting the view of solar innovations as having a great relative advantage compared to previous ways of accessing water within Wayuu's social system.

The convenience of an innovation is another important factor determining the diffusion rate and relating to the innovation's relative advantage (Rogers, 2010). A crucial convenience aspect amongst solar microgrid users was the time saved with the new system. All respondents with solar energy mentioned that they save time in at least one of two major aspects. Firstly, compared to manually accessing water using a bucket via a well, one respondent mentioned that: *"it has changed a lot because previously we had to do a lot of work, because we had to grind. So, grinding that took us about 15 minutes to get a tube of water. But not anymore, because now that we have solar energy, you put in your water tank, and it fills up in a moment (R6)."* Hence, such convenience of accessing water easier serves as another relative advantage of solar microgrids within Wayuu communities. This was further supported by all other solar microgrid users who agreed that the system saves them time since they can press a button that pumps up water for them within seconds compared to the time it takes manually. Another time-saving factor amongst the respondents was the distance they had to walk to access water. Before using solar energy, the respondents had to walk one to two hours to access water from a groundwater well. With the microgrid closer to home, access to water becomes more convenient and serves as another strong relative advantage amongst the solar energy participants in this research.

As seen in the previous paragraphs, the relative advantage of innovations greatly impacts the views of the systems leading to a high level of satisfaction, which is crucial for whether members of a social system accept an innovation (Rogers, 2010). The overwhelming majority of respondents expressed strong positive views about solar microgrids. However, two respondents (R1 & R9) mentioned that the solar system works less well when it is cloudy, and when the sun disappears, the system stops working optimally. Nonetheless, respondent nine also added that it works better than their community's previous windmill system, which was significantly more unreliable since the sun is often stronger in the area than the wind. Therefore, although slight dissatisfaction existed amongst two respondents, the satisfaction part of the relative advantage of solar microgrids compared to previous systems is strong.

While straightforward relative advantage factors are important for diffusing innovations, the social prestige underpinned by the relative advantage it holds amongst members of a social system is another important factor for effective diffusion (Rogers, 2010). The social prestige of having a solar microgrid was present amongst all its users. During the observatory research, all people with such systems proudly showcased how it works, what they use them for, and how it helps them improve their lives. Simultaneously, all the members of households and communities interviewed with either windmill systems or no energy expressed willingness to adopt solar microgrids. Elders and leaders alike were strong promoters of solar energy and is likely to positively impact the high prestige of using solar energy. Within the communities that participated in this research, the social prestige of using solar energy was therefore particularly strongly reflected due to its high relative advantage.

Thus far, from the data analysis, the relative advantage of solar microgrids has been overwhelmingly positive and showcase several strong enablers of SSRES innovation diffusion. Easier access to water, time-saving, and overall satisfaction are shown to be strong enablers of solar innovation diffusion in rural Wayuu communities. Therefore, these factors can explain the positive views about solar energy amongst the participants in this research and why solar microgrids have been successfully diffused amongst the current users and why the potential for diffusion is great amongst the participants. However, one of the most important factors determining whether individuals adopt innovations is the innovation's economic relative advantage (Rogers, 2010). In developing country contexts, low incomes, the relatively high cost of an innovation and lack of financing opportunities often serve as some of the most significant barriers to diffusing SSRES innovations (Eder et al., 2015; Yadav, Davies & Palit, 2019; Schäfer, Kebir & Neumann, 2011).

The lack of financial capital to buy a solar microgrid was mentioned by all participants in this study as the largest barrier to widespread SSRES diffusion amongst La Guajira's Wayuu communities. As expressed by one respondent without any access to energy: "*I need more money. I just wish I had it, if you have more money, you want to buy one of those systems (R20)*." This quote was reflected by all participants without energy who mentioned that the little money they had must be used to buy food to survive and that saving up enough to buy a solar energy system was too hard. This notion was further supported by all people with solar energy, who all had received their system as a donation from either the government, MNC operating in the area, or NGOs or IGOs, expressing that they would not have the system if it were not for the donation. In the FGD consisting of people with and without solar microgrids, one respondent (R15) mentioned that they used to have solar energy, which they had bought themselves on a lease agreement. However, they had to return it eventually due to its high costs. Therefore, even though solar microgrids have strong relative advantages compared to previous ways of accessing water, the low incomes combined with high initial costs serve as the greatest barrier to widespread SSRES innovations diffusion amongst the Wayuu peoples' participating in this study.

With financial capital serving as the greatest barrier to diffusing SSRES innovations amongst Wayuu communities in this study, numerous other enablers still exist. An innovation's compatibility with existing norms and values, needs of the potential adopters, and past experiences are other essential aspects of diffusing an innovation (Rogers, 2010). For effective diffusion, especially for SSRES diffusion in developing contexts, such social aspects are often considered one of the most important parts of diffusion (Alam, 2014; Eder et al., 2015). These aspects are especially important within indigenous social systems where development interventions that fail to consider indigenous knowledge systems and beliefs often fail due to the lack of adequate consideration of local-specific norms, needs, and cultures (Rogers, 2010). Working with the Wayuu people, it is therefore important to respect their worldview that underpins their view of nature and natural resources like the sun and water, especially when designing water and energy solutions. Wayuu ancestral teachings contain different visions about the sun and water, with past research showing that Wayuu communities are positive to renewable energy if it means they will be able to access clean water and energy themselves (Benavides-Castillo et al., 2021). In the semi-structured interviews, this was confirmed by all participants who mentioned that the sun had given them a lot and that they were used to working with the sun as mentioned by one respondent saying that: *"we are a culture that is accustomed to doing everything under the sun (R8)."* This quote was further supported during the FGDs, where 14 out of 16 participants expressed the importance of the sun in their culture and how it served as a motivation to use the sun to access other natural resources since they wanted to continue receiving the gift of the sun.

Thus, based on the Wayuu's people participating in this study, solar microgrids are compatible with their norms and beliefs.

While compatibility with indigenous norms and beliefs is important, effective SSRES diffusion must also meet the needs of the recipients while simultaneously be supported by past experiences (Sharma, 2020; Rogers, 2010). Within the Wayuu communities participating in this study, the past experiences and needs were shown to have strongly shaped the social acceptance of solar energy. Amongst the participants with solar microgrids, 12 out of 14 respondents mentioned their past experiences of not having access to the energy source and the difficulties they faced because of it. One respondent mentioned that: "*previously when there was no solar energy we had a lot of work, but now that we have it, we have benefited from it, and we have not suffered so much from the water problem (R7)*." Another respondent mentioned how it helps her household and community to fulfil their needs: "*it is a good technology, and I am happy that I can use it for water supply, for food, for agriculture, for livestock and animals (R11)*." Therefore, solar energy is highly compatible with the rural Wayuu communities participating in this study based on their past experiences and current needs, serving as a strong enabler of diffusion. This was further expressed by the group lacking energy, they all mentioned the difficulties they faced due to lack of energy and how a secure energy supply could secure many of their needs based on what they had witnessed in other communities with solar microgrids.

Another aspect of diffusing innovations that impacts the ability to meet the users' needs and significantly impacts the social acceptance is the innovation's complexity. If an innovation is easy to understand and use, it is likelier to be accepted within a social system (Rogers, 2010). In developing contexts, SSRES requires adequate knowledge and skills that are often received by the development agents (Ley et al., 2020; Chatterjee et al., 2019). The solar energy users reported that they had received adequate information about using and maintaining the system, and this significantly impacted the complexity of the innovation within the Wayuu communities. All respondents reported that the system is easy to maintain and had not faced any difficulties. Only one respondent (R21) mentioned that they had faced an issue with the solar system. However, the issue was resolved quickly by someone with expertise who were easy to access for the community member. Therefore, the solar microgrids used by Wayuu communities do not seem to face any significant complexities.

This is likely contributing positively to the large willingness of the participants to adopt the innovation.

To determine an innovation's complexity, potential recipients must either be able to try it out first or observe how it is used and its impacts. Trialability, the degree to which an innovation can be tried on a partial basis, allows members of a social system to determine if the innovation is worth adapting (Rogers, 2010). The solar microgrids' trialability rate can be viewed from two points. One point of view is that people should be able to make up their own opinion about the system, not only from what they hear from the neighbours with access to solar energy. Only one respondent said they had been able to try out a system but *"gave that back because we have to be paying (R16)."* Therefore, the largest barrier to diffusing SSRES innovations in this study, financial aspects, does constitute a barrier in itself and an underpinning barrier that hinders social aspects of diffusion innovation such as trialability from being fully embraced. Nonetheless, another point of view is that all the solar energy systems used by the participants in this study had been provided for free by either the government, MNCs, IGOs or NGOs and can therefore be viewed as trials. From this point of view, the microgrids in place are tried on a partial basis by some of the Wayuu people. The impact of this seems to have contributed to the willingness to adopt solar microgrids amongst Wayuu communities since everyone showed very positive views towards the systems based on their experiences of witnessing such systems function well.

The last trialability point of view is closely related to Roger's theory's final innovation diffusion aspect, its observability. For an innovation to be adopted quicker within a social system, it helps if the result of an innovation and how to use it is observable to non-adopters (Rogers, 2010). This is strongly reflected within the Wayuu people's social system due to their communal ties underpinned by openness and willingness to share experiences and resources with neighbours. As one respondent mentioned when talking about the water accessed through solar microgrids: "*we cannot deny water to the neighbours that are around us, where there are many communities that are in need (R11).*" This quote shows that even amongst the communities and households without any solar energy, people with the systems show a strong inclination for sharing the benefits of the energy. This was further supported during the observatory research where, by many solar energy systems, people with donkeys and wheelbarrows from other communities had travelled to collect water. Therefore, due to the strong communal ties, the participants without solar microgrids can observe how solar energy works and how it has impacted other communities and households.

This observability of how SSRES works and impacts its users are likely contributing to the positive views on solar energy amongst people with it and without it alike. As a result, all participants without any access to energy expressed that they wanted solar energy systems, often due to how they had been able to "*see many communities that use it. For water, for agriculture. It is good energy (R17)*." Others had observed how "*it changes the way of life in the communities (R19)*" and expressed strong willingness to adopt it, stating that "*we dream about that, that someday we will be in a solar energy project here for us, for every house, because honestly it is needed quite a lot (R28)*." This was further expressed by participants with windmill systems who all mentioned that they would prefer to have solar energy since it seemed to be more reliable to use from what they had observed from their neighbours. Hence, the observability of solar microgrids serves as a further strong enabler of diffusion within Wayuu communities.

Thus far, the major barrier to SSRES innovation diffusion is the lack of financial capital. Due to the strong enablers found in this study, SSRES diffusion would likely occur on a greater scale if the financial aspect were solved. Underpinning these enablers and barriers to innovation diffusion is the communication channels within the Wayuu's social system. Such communication about an innovation between people within a social system is essential (Rogers, 2010). In developing contexts, especially with little or no energy access, interpersonal communication channels involving face-to-face exchanges and direct observation is often the primary way of communicating about an innovation (Rebane & Barham, 2011), as seen in the Wayuu context. If this occurs between individuals that show similarities, such as a common language and characteristics, the communication is likely to be more accepted (Rogers, 2010). As shown through the strong observability of solar microgrids, interpersonal communication channels are the most prevalent way Wayuu peoples receive information about the innovation. All participants mentioned positive aspects of solar energy and its importance for their local development. This communication was further supported by the opinion leaders, who several times during the observatory research and semi-structured interviews mentioned how important it is for their community members to understand the difference solar energy can bring to their communities. Based on the data analysed in this thesis, interpersonal communication can therefore be determined to be favourable towards solar energy innovation diffusion and as an important enabler driving these positive views.

However, as many of the communities without solar energy mentioned, the lack of outside communication serves as a significant barrier to the diffusion of solar energy innovations in Wayuu communities. As mentioned by one respondent: "*we have not been invited to a project development, we are not taught either, we do not have the basis, either for an academic training or in respect to where many of us could learn soon, to know (R32).*" As this quote shows, the lack of communication from outsiders with the local communities about SSRES innovations benefits serves as a barrier to diffusion. Four other respondents reported that they had been offered solar energy systems, but it had never been followed up. This lack of communication had led some of the respondents without solar energy to distrust whether people who offer them solar energy systems will be able to fulfil their promises.

5.2. Energy-Water-Food Security Nexus Analysis

Thus far, this thesis has shown that the only significant barriers to widespread solar microgrid groundwater pumping systems are lack of finances, ability to try out the systems, and effective outside communication. Without adequate financial support, the probability of widespread diffusion is deemed particularly low. This lack of energy creates severe challenges for the Wayuu people, contributing to their high water and food insecurity (Benavides-Castillo et al., 2021). With SSRES proposed as a way of ensuring water, energy, and food security, while serving as a possible way of adapting to climate change, it is important to analyse how SSRES impacts these factors. This is especially important to examine within rural Wayuu communities in La Guajira, who experience contemporary climate change impacts adversely impact their water and food security situation (FAO & WHP, 2019; Galindo Montero et al., 2017).

The lack of energy, and the way it drives water and food insecurity, was strongly present in the group without any energy. All participants lacking energy in this study expressed strong concerns over water insecurity, mentioning how scarce water is within their communities and the adverse impacts on their lives. Many had to walk large distances to access water, often needing to walk *"half an hour there and half an hour back, with a water trip of only 20 litres (20),"* which often is often used one household for all domestic usage and the animals. In comparison, the indicated daily minimum water quantity of safe water is 20 litres per person per day (Chenoweth, Malcolm & Pedley, 2013). Furthermore, as seen through the observatory research, the water accessed through the manual groundwater well is visibly unclean and does not go through any filtration before consumption. Therefore, the no energy group did not only lack sufficient water, but the water they were able to access was unclean, proposing severe health risks.

The lack of energy, leading to subsequently higher water insecurity, had significant impacts on food security within the no energy group. As mentioned by one respondent: "*right now, we have an artesian well for consumption only. It is not possible to plant. We cannot guarantee food because the well we have is not enough (R21),*" and further elaborated on by another respondent: "*we are affected by everything, food is more affected because we do not have water and energy, we are affected (R24)*." As reflected by these quotes and further confirmed by the rest of the interviewees without energy, the time needed to walk back and forth to the well, and the manual labour required to access the water from the well made it impossible for them to use the water from the well for agricultural production. Besides undermining agricultural production, livestock production was undermined through two aspects. Firstly, seven out of 11 of the respondents without energy mentioned that they had to travel far to the closest towns to buy food with the little money they had, often needing to sell their animals to afford food, therefore undermining the possibility to expand livestock production. Secondly, eight out of 11 of the participants without energy mentioned that the animals could not get sufficient water and were barely producing any milk due to the high-water scarcity, resulting in overall lower quality of livestock production and an inability to further expand the practice due to lack of water.

Making the water scarcity situation worse, the Wayuu people in La Guajira are extremely vulnerable to climate change. Within Colombia, La Guajira is one of the most affected areas by climate change, with increasingly long and intense periods of drought and spreading desertification. The impact of this is leading to diminishing water resources (Ulload, 2020). The impact of droughts on agriculture leads to lower quality and quantity, directly influencing food and water insecurity (Ospina-Noreña et al., 2017). The no energy group showed to be particularly subject to such climate change impacts. According to the three elders interviewed, three decades ago, they used to have approximately two harvests a year from agricultural production that was irrigated through natural rainfall. However, with increasing climate change impacts such as less rainfall and increasing periods of droughts, this was no longer possible as reflected by one respondent: "*there is no rain, because of this phenomenon. There is this climate change that has affected us since 2010. In La Guajira, today, it is not raining as it was raining before (R5)*," and further elaborated on by another stating that: "*and then to have a vegetable garden, without rain, with this temperature, it is quite difficult because there is no water, the sun is quite hot, so the plants die (R27."* The suffering due to the increasing water scarcity was particularly explained by a further respondent: *"so right now, we are suffering, suffering for water. We are suffering for water, and we have not been able to feed ourselves because there is no way to plant (R10)."* As shown by these quotes, the lack of rain further increased water insecurity, leading to the impossibility of agricultural production and further food insecurity. Other participants without energy reinforced this and mentioned that they could not continue having agriculture or engage in livestock production without the rain like before.

Comparably, the windmill groundwater pumping group, identified in this research as a middle group[1] between having SSRES and not having SSRES, showed higher water and food security due to their access to wind energy. All the participants in the windmill group reported that they had higher water security than when they had no access to energy as one respondent said, *"now the water resource situation has improved because of this windmill that has improved compared to before (R13)."* This quote was further supported by two other respondents (R14 & R16) who mentioned that they have sufficient water throughout the day. Seven out of eight participants mentioned that the increased access to water from the windmill system was used for cooking, agriculture, and livestock production. The increased agricultural possibilities have led to further food security through growing and harvesting foods such as beans, melons, corn, and yuca. Furthermore, the ability to engage in livestock production has led to further food security through being able to eat their livestock when in need or selling their livestock and buying food for the income.

[1] The windmill group is identified as a middle group since the windmills used by the communities are used to generate mechanical power to perform a specific task – pump groundwater. The systems only worked if there was sufficient wind. As seen during the observatory research, the windmills stopped several times due to lack of sufficient wind, which hindered the ability to access the water, and were expressed by the community members as a less effective way of accessing water compared to solar microgrids, but better than having no access to any type of energy at all.

However, in the wind group FGD, three out of five respondents raised the issue of increasing groundwater scarcity. As two respondents mentioned: "*There is no alternative source of water, we need another source of water (R14)*" and "*the well does not store water well anymore (R15)*." Increasing access to groundwater often leads to long-term groundwater scarcity and is a major trade-off within the WEF nexus, especially in rural arid regions (Closas & Rap, 2017). Amongst the participants raising the issue of increasing groundwater scarcity, they all had used their windmill systems for decades. According to the respondents, this led to the depletion of the aquifer used by the windmill's groundwater pumping system and served as a severe trade-off within the WEF nexus when diffusing energy systems that increase access to groundwater in La Guajira.

Similarly, to the windmill group, the solar microgrid group had experienced increased water and food security because of the innovation. The solar group however reported higher water and food security than both previous groups with all respondents stating that the solar microgrids had significantly increased their access to water. Most of the participants mentioned how the solar energy allowed them to access water quickly and that they now had sufficient water to meet their needs, as mentioned by one respondent: *"right now, there is a difference, you can fill a 500 litre tank with that, because with the submersible pump it is faster, you don't have to work or the animals, you can fill it for our animals and to supply as well (R11)."*

Like the windmill group, the increased water access had positive impacts on food security. All respondents mentioned that they use the water access from the solar system for cooking and for their animals thus showing two synergies within the WEF nexus. Firstly, the ability to cook with the water access increase the individual's way of accessing nutritious food by being able to cook products such as beans and rice that otherwise would be uneatable as stated by several participants. Secondly, by being able to give their animals water, households could engage in livestock production even with many of their natural water sources such as the rain significantly decreasing, as mentioned by one respondent: *"as we have animal husbandry, they are not suffering as much anymore, they need a lot of water (R7)."*

Moreover, the strongest synergy was mentioned by four participants from the semi-structured interviews that reported that they used the increased water access from the solar system for agricultural production, as mentioned by one respondent; *"it has changed in terms of* *agriculture because we have almost permanent water and irrigation system connected to it (R6)."* However, as this quote shows, fulfilling the food security aspect of the WEF nexus through increasing energy and water access to increase agricultural production also depends on the right infrastructure. As mentioned in the solar group FGD, the participants could not engage in agriculture yet even though the system provided them with an abundance of water. The water was also attached to a large-scale water filtration system, providing them with clean drinking water suitable for human consumption. However, the water was not used for agriculture due to the lack of irrigation infrastructure, tools, seeds, and wires for agricultural plotland. The participants in the FGD stated that they were waiting to receive these agricultural inputs to be able to use solar energy and increase water access for agricultural production.

From the two FGDs, everyone agreed that solar microgrids had increased their access to clean water. The impact of this has led to less salination in the water people are drinking and improved the taste and nutrition of their food. However, in the FGD with people with solar energy and without any energy, the participants with solar energy mentioned that they have started to experience increasing water unreliability. Before they had access to solar energy, they used a windmill system using the same aquifer for over three decades. They all mentioned how solar energy had increased their access to water. However, the water they could obtain through the system was only sufficient to use for domestic purposes and for their animals and *"the problem is that there is almost no water in the well; it stops sometimes (R12)*. This was reflected by all other participants in the mixed FGD, where the participants mentioned that the well they were using was drying up, and they were all worried that it soon would not be possible to continue its use. Hence, similar to the windmill group, using the same aquifer for decades had eventually started to deplete the aquifer leading long-term water insecurity, showcasing a significant trade-off within the WEF Nexus when using SSRES in arid regions.

5.3. Small-Scale Renewable Energy Systems Potential as a Climate Change Adaptation Strategy

As shown in the previous subsection, SSRES innovations have increased water and food security, leading to improved living conditions, amongst the Wayuu people. In the short term, SSRES diffusion was shown to have strong synergies within the WEF nexus which shows how SSRES can effectively be used as a CCA strategy in the short term. Amongst the two groups with SSRES, the microgrids increased access to water, leading to further food security, even amidst increasing climate change impacts. Therefore, SSRES can serve as an effective CCA strategy for Wayuu communities in La Guajira due to the increased water and food security it enables. Comparably, all respondents expect for one from the group without energy mentioned how climate change makes it harder for them to sustain their lives due to the increasing water scarcity leading to the inability to engage in agriculture due to increasing drought and lack of rainfall which makes agriculture dependent on rainfall an impossibility amongst Wayuu communities.

However, as the previous subsection show, a major trade-off when diffusing SSRES's technologies in arid regions experiencing increasing climate change impacts is the long-term impacts on groundwater resources. This trade-off is starting to become a reality within Wayuu communities and can be explained by two factors; (1) Increasing climate change impacts such as less rainfall and increasing desertification; and (2) overuse of groundwater resources. Climate change is one of the drivers of increasing groundwater scarcity (Ojeda Olivares et al., 2019). In arid and semi-arid regions, many groundwater resources contain fossil groundwater and are therefore non-renewable since the groundwater removed was recharged during wetter periods under paleoclimate conditions (Green, 2016). In La Guajira, this is especially prevalent since groundwater scarcity will continue to increase because of climate change (Ospina-Noreña et al., 2017). Unsustainable management and overuse of groundwater resources are other drivers of groundwater scarcity (Khair et al., 2019). In combination with increasing climate change impacts such as decreasing rainfall, increasing salination of groundwater resources, and less overall water availability, depending on groundwater resources serves as a high risk of potential long-term water depletion in La Guajira.

Nontheless, people aware of climate change impacts on groundwater resources are more likely to adopt water-saving techniques (Leroy, 2017). Furthermore, the crops present in the study area was on a very small scale. The major player in the region engaging with large-scale water extraction is the Cerrejón mining operations, using 14,000 cubic meters of water per day only to water down the dirt towards its heavy machinery creates and has 18 groundwater wells (Banks, 2017). Therefore, the major driver of the increasing groundwater depletion experienced by the Wayuu communities participating in this study is likely not due to the Wayuu communities themselves. Many participants further support this claim that they do not waste any water since they know its value and have seen many other communities' wells dry up, aligning with Leroy's (2017) findings.

Although the usage of groundwater by Wayuu people might not be the driver of groundwater scarcity in the region, the small-scale water extraction from local communities, in combination with climate change impacts, serves as a potential threat to long-term water availability for Wayuu communities. Therefore, relying on SSRES and groundwater abstraction to meet the Wayuu's water needs might not be a possibility in the long-term with increasing climate change impacts. If an increasing amount of groundwater resources are depleted, the ability of SSRES to work as an adaptation strategy against climate change decreases substantially due to its inability to extract water if the region's water scarcity further exacerbates. Therefore, the suitability of SSRES as a CCA strategy proposes high risks from a long-term perspective and might only be a possibility in the short term while awaiting more long-term solutions.

6. Concluding Remarks

This thesis attempts to grasp the enablers and barriers of SSRES innovations within La Guajira's indigenous Wayuu communities, its impact on the WEF nexus, and its potential as a CCA strategy. Through analysing the data through Roger's (2010) Diffusion Theory, numerous enablers for SSRES diffusion exist. Through intra-personal communication channels, the Wayuu people observe how SSRES have positively impacted their neighbouring communities, leading to strong observability of how the systems work. The opinion leaders – elders and tribal leaders – further these positive opinions, especially for the newer solar microgrids. The systems' relative advantage, compatibility, and low complexity further support these communication networks. The impacts of these factors serve as strong enablers of SSRES diffusion, and all respondents in this study show a strong willingness to adopt the systems.

Furthermore, many respondents' express willingness to adopt SSRES since they want to continue receiving the benefits of the sun. Decentralised microgrids seem to be especially favourable amongst the Wayuu people because such systems allow them to be in control over the systems and the natural resources access themselves. Comparably, larger renewable energy projects in La Guajira often neglect to provide the indigenous people with energy, and therefore, the Wayuu's often views such large-scale projects with suspicion (Schwartz, 2021). SSRES can there be a more suitable solution for the Wayuu people to ensure that their agency and rights are respected by allowing them to choose how they use their natural resources.

Nonetheless, the diffusion of SSRES innovations is very slow in Wayuu communities. Finding participants with solar microgrids was very hard, and many reported that they wished they had them but that it was not possible for them. The main barrier to diffusing SSRES innovations aligns with the literature on the topic, mainly the lack of financial capital, likely due to the high governmental neglect, and increasing climate change that adversely impact livelihood opportunities, such as agriculture and livestock production. The very few SSRES projects from philanthropic organisations in the area, despite their promising potential, serve as another barrier. Before embarking on the field research for this thesis, many people familiar with the area expressed that the Wayuu people generally do not want SSRES systems and do not use the ones that have been implemented. Such views are likely to impact the willingness to distribute microgrids amongst Wayuu communities by philanthropic organisations and probably serve as a further barrier to widespread diffusion. On the contrary, as this thesis shows, all the Wayuu participants in this study show willingness to adopt such systems based on a thorough analysis of numerous socio-economic factors.

With strong enablers of solar microgrid diffusion, the WEF nexus analysis allows for a deeper understanding of how SSRES impacts the Wayuu communities. SSRES innovations significantly increase access to energy, leading to further water and energy security for the participants in this study. When comparing the different groups, the participants without any energy system reported higher water and food insecurity due to the lack of energy and increasing climate change impacts. Comparably, solar and wind energy users' higher energy access increases water access, leading to further food security amongst Wayuu communities – from cooking more nutritious and better food to engaging in animal husbandry and agriculture.

Nonetheless, several solar and wind energy group participants cannot engage in agricultural production, which is one of the most important synergies within the WEF Nexus for rural communities. Two major factors limit the ability to fully realise the potential synergies within the WEF Nexus that SSRES can create – the lack of infrastructure and increasing groundwater depletion. As the participants in the solar FGD mentioned, they can only use their water for drinking purposes since they are still waiting for other agricultural inputs. The people who provided them with the SSRES will supposedly provide them with these agricultural inputs, but the respondents are unsure when this will happen. Several participants in the wind energy group express similar issues; the lack of infrastructure to enable irrigation undermines their ability to engage in agriculture and also express the need for help from outsiders to gain access to such agricultural inputs. These factors indicate that the Wayuu people are dependent on outsiders to realise the synergies SSRES innovations can create within the WEF Nexus, similarly to the dependency on outside actors to adopt such solar energy innovations.

While agricultural inputs are needed to realise the synergies with the WEF Nexus fully, the increasing groundwater depletion in La Guajira serves as a significant trade-off within the Nexus. The participants with access to the same groundwater source for at least two decades experience increasing depletion of the aquifer they are using. This impact on the WEF Nexus leads to unreliable access to water regardless of the type of SSRES in use. However, although the SSRES in place for at least two decades show this phenomenon, SSRES in themselves are not likely to be the major cause for such groundwater depletion in La Guajira. Instead, with increasing desertification and climate change impacts leading to further groundwater insecurity, these factors are likely to be the main causes for future water insecurity. In addition, the vast water abstraction from large corporations in the area is likely to undermine further the ability to access water for the Wayuu communities. Nonetheless, no matter the main reason for the increasing groundwater depletion, it serves as a significant trade-off within the WEF Nexus, undermining the ability to fully realise SSRES potential for improving the living conditions of La Guajira's rural indigenous population.

Moreover, increasing water access from SSRES, and the decreasing availability of groundwater resources, serve as a paradox regarding the suitability of the systems as a CCA strategy. SSRES serve as a great way of adapting to climate change in the short term due to the strong synergies it shows within the WEF nexus. By increasing access to water and food, Wayuu communities can increase their resilience, improve their living conditions, and decrease their dependence on rainfall to meet their water needs. In addition, with the positive views of solar microgrid diffusion amongst Wayuu communities, the ability to diffuse SSRES and use it as a CCA strategy is high. However, with increasing climate change impacts in La Guajira, future groundwater depletion serves as a potential severe trade-off that can hinder the ability of SSRES to function as a long-term CCA solution. The system's ability to increase water access and serve as a CCA strategy depends on a reliable local water supply, which further water depletion of local aquifers undermine. Several participants in this study are highly aware of this issue, especially the elders who have witnessed how their ancestral lands have changed and become increasingly water-scarce and dry in the past decade. Therefore, before proclaiming that SSRES is an adequate CCA strategy, a careful investigation of the water availability in local aquifers intended for groundwater abstraction is needed before investing in groundwater pumping systems as a CCA strategy. In addition, examining how much groundwater communities can use before it completely depletes aquifers is another important aspect to consider before diffusing SSRES innovations in rural La Guajira to use it as a CCA strategy.

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Appendix A: Research Questions and Semi Structured Interview Guide

Background information about participant

What is your name?

How old are you?

What gender do you identify with?

Which community do you belong to?

What do you do for a living?

How long have you lived where you are currently living?

For households/communities with SSRES

Potential follow up questions highlighted in cursive.

Energy

What kind of energy source are you using?

For how long have you used your current energy source?

Does anyone you know personally use the same energy source?

Is your current energy source reliable?

Do you have access to energy whenever you need it?

How did you acquire the energy system?

Did you buy it yourself?

Did someone give it to you?

- If yes, were you involved during the implementation phase of the SSRES?
- If yes, was it unexpected?
    - If yes, did you want to have the energy system before it was given to you?

How does your culture/religion/worldview view the energy source you are using?

Did the person you received/buy the energy system from adequately consider your cultural worldview on resources such as wind and sun?

What is your current opinion about the energy system?

How come you believe that?

Have you had any issues with the energy system, before and/or after it was implemented?

- If yes, how does that impact your opinion about the system?

Did you receive any information about the energy system before and/or after it was implemented?

How to use it?

What to use it for?

The benefits of the system?

What do to do if something breaks?

If you had access to energy before, is the new energy system allowing you to access energy differently?

- If had access to energy before, which energy system do you find more reliable?
- If had access to energy before, which energy system is cheaper for you to maintain?

What do you usually use the energy for?

Water

Since the energy system was implemented have the way you access or use water changed?

Water for irrigation?

Water for sanitation?

Drinking water?

Potable water systems?

Water heating?

Water for cooking?

How does your culture/religion/worldview view water?

Do you know how much water you/your nearby community can use before it might impact to availability of water at local water reservoirs?

- If yes, how did you find that out?

Is there any way of knowing how much water left you have available in your local water reservoirs?

- *If yes, how do you know that?*

Are you aware of how climate change might impact local water reservoirs in your area?

- Is yes, who provided you with this information?

<u>(If SSRES is used to access water)</u>

Compared to before the energy system was implemented, has the amount of water you use changed?

Compared to before the energy system was implemented, has the amount of water wasted changed?

Did you receive any information from the people you bought/received the energy system from about how local water resources might be impacted when more people start using more water?

Food

Since the energy system was implemented, have the way you access, produce, or use food changed?

Energy to irrigate food crops?

Energy to boil/cook food?

Energy to store food?

How does your culture/religion/worldview view food production, access, or usage?

Are you aware of how climate change might impact local food production/usage/access in your area?

- Is yes, who provided you with this information?

(If energy system is used to access, produce, or use food differently)

How is food produced, accessed, or used differently?

What has changed regarding your food situation now compared to before you had access to the energy system?

(If energy system is used to access more water and subsequently differing food usages)

Have the increased access to water impacted the way you access, produce, or use food?

How much of the water used is for food related usages?

Is more water used for food usages?

Is more water wasted because of greater access to water for food usages?

<u>For households/communities without SSRES</u>

Energy

What kind of energy source are you using?

For how long have you used your current energy source?

Does anyone you know personally use the same energy source?

Is your current energy source reliable?

Do you have access to energy whenever you need it?

How do you acquire your energy source?

Have you ever considered, or want to, use any other energy source?

- If yes, why have you not acquired that energy source/system?

How does your culture/religion/worldview view the energy source you are using?

What is your opinion about the energy source you are using?

How come you believe that?

How been you offered to receive or buy any other energy system?

- If yes, why did you not accept the offer/why are you still not using the alternative energy source?
- If no, would you be open to use any other source of energy?

What do you usually use the energy for?

Water

For people without SSRES: Do you ever use your energy source for any water-related purposes?

Water for irrigation?
Water for sanitation?
Drinking water?
Potable water systems?
Water heating?
Water for cooking?

How does your culture/religion/worldview view water?

Do you know how much water you/your nearby community can use before it might impact to availability of water at local water reservoirs?

- If yes, how did you find that out?

Is there any way of knowing how much water left you have available in your local water reservoirs?

- *If yes, how do you know that?*

Are you aware of how climate change might impact local water reservoirs in your area?

- Is yes, who provided you with this information?

<u>(If energy is used to access water)</u>

Have you received any information about how local water resources might be impacted by your energy usage?

Food

Do you ever use your energy source to access, produce, or use food?

Energy to use to irrigate food crops?

Energy to use to boil/cook food?
Energy to store food?

How much of your total water use are you approximately using for food related purposes?

How does your culture/religion/worldview view food production, access, or usage?

Are you aware of how climate change might impact local food production/usage/access in your area?

- Is yes, who provided you with this information?

Appendix B – Informed Consent Forms

You have been invited to partake in this study on *"Increasing the Resilience of Colombia's Indigenous Wayuu Communities Through Renewable Energy Technologies*: *Barriers and enablers of small-scale renewable energy innovation diffusion in the Indigenous Wayuu communities in La Guajira Colombia and its impact on the Water-Energy-Food Security (WEF) Nexus and potential as a climate change adaptation tool"*. Your views are important since you live in La Guajira and have knowledge about what energy is used for. They study involves understanding your perceptions of renewable energy adoption and whether the energy source you are using impacts water and food and if so, how it impacts these resources. The study is in partial fulfilment of the master's degree in International Development and management and a final report will be presented to Lund University in May 2018.

Upon agreement to partake in the study, your views will be recorded and transcribed to form part of data analysis. This study has no foreseeable risks or political connotations. Your views will be held in confidence and treated anonymously to remove all possibilities of traceability of respondents. The interview is expected to take between 20-40 minutes. The interview is voluntary. You can withdraw at any time during the interview or inform us after the interview if you wish to withdraw the interview you are currently participating in from the research process. Your contribution to this research will be anonymous. Your name will be anonymized during the interview transcription, and the recording will be destroyed after that.

The researchers are in charge of recordings and transcription. Do you agree to participate in this interview?