Original Paper

Enhancing energy justice through solar power proliferation in Kenya's devolved units.

Insights from Makueni and Nyeri

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Received: 12 March 2024 | **Accepted:** 22 April 2024 | **Published:** 26 April 2024

Keywords: sustainable development; fairness; environmental pollution; equity; solar power proliferation; Kenya.

Abstract. *In response to escalating human needs and the worsening impacts of climate change attributed to fossil fuel use, the concept of energy justice, especially in relation to solar power, has emerged as a solution to ensure sustainable energy access, security, and affordability universally. Despite efforts to promote solar power in many developing countries, energy injustices persist, exacerbated by limited scientific information on promoting energy justice within the solar power context. Addressing this challenge in Kenya, this study aimed to explore Makueni and Nyeri counties better to understand strategies for universal energy provision through solar power. The study examined the socio-cultural, economic, and environmental contexts relevant to energy justice and solar power usage. Information was gathered from online sources through literature and official documents to analyze qualitatively for insights employing a case study research design and literature review. The examination revealed contrasting scenarios in Nyeri and Makueni counties: Makueni demonstrated robust leadership with community-driven projects and proactive financing, while Nyeri faced challenges with regulatory transparency. Nonetheless, both counties sought equitable solar distribution, with Nyeri prioritizing affordability and Makueni emphasizing public participation and long-term community involvement. The study underscores the influence of contextual factors and governance on energy justice outcomes in solar power expansion, urging solar power stakeholders to prioritize inclusive approaches and regulatory enhancements for sustainable energy justice initiatives.*

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1. Introduction

There is widespread concurrence that providing energy for all through the proliferation of renewable energy sources such as solar energy is one of the most feasible interventions for limiting global warming to 1.5^{o}c in efforts to avoid catastrophic climate change (IPCC, 2018; IEA, 2019; Sustainable Energy for All, 2024). This realization originates from the fact that traditional energy production and distribution systems based on fossil fuels have propagated energy injustice for a long time. Fossil fuel extraction pollutes the environment, demands substantial resources, and exploitation requires monopolized technology, which

may not be available for most developing countries. Promoting energy justice through solar photovoltaics (PV) has become cost-effective and accessible, challenging fossil fuels. In 2019, up to 119 GW of solar power installed capacity was achieved globally, reflecting its versatility across market segments. In addition, many governments actively pursue solar power exploitation in their quest for sustainable development (IEA, 2020; Aklin, 2018; UN, 2018). However, solar PV's affordability and modularity have not completely eradicated energy poverty, reflecting socio-material injustice where households struggle to access adequate energy services (Horta et al., 2019).

Consequently, the concept of energy justice in solar power proliferation has emerged to strive for fairness in social and economic involvement, addressing the disproportionate impacts on marginalized groups such as frontline, working class, and indigenous communities. Energy justice aims for accessible, affordable, clean, and democratically community-managed energy for all (Initiative for Energy Justice, 2024). However, existing literature reveals there are still gaps in clearly defining renewable energy and marginalized communities across various jurisdictions (Initiative for Energy Justice, 2023). Contrary to policy goals, this creates a substantial opportunity for energy sources backed by the fossil fuel industry to remain a part of the grid. Moreover, various approaches are used to define marginalized communities without carefully examining the perspective of outcomes and benefits for frontline communities. As a result, energy poverty tied to inadequate infrastructure for energy services can endure even with widespread infrastructure rooted in deep-seated inequalities. Energy access related to energy justice is integral to energy rights, citizenship, facilitating cleanliness, good health, political participation, and comfortable living temperatures (Day et al., 2016; Brand-Correa & Steinberger, 2017). However, the concept of a right to energy is intricate, with diverse interpretations and contestations over its implications necessitating the need for more context-specific studies in various jurisdictions (Sareen & Haarstad, 2018; Day et al., 2016). Nevertheless, enhancing energy justice in solar power exploitation requires new strategies that intertwine renewable energy justice, energy equity, and energy democracy to enhance benefits that can accrue to local populations through remedying injustices of the fossil-fuel energy system and extractive economy (Behrens et al., 2016; Mitchell, 2009).

In Kenya, solar energy is recognized through key policies such as the Energy Act No. 1 of 2019 as essential for achieving energy justice and sustainable development. This realization has seen massive government investment being channeled into promoting its proliferation. The Kenyan government has

removed import duty and zero-rated value-added tax (VAT) for renewable energy equipment and accessories. Furthermore, Kenya is devising and revising renewable energy plans to ensure dependable solar energy provision at optimal costs by creating a favorable atmosphere encouraging investments in energy infrastructure at national and county government levels. Despite these efforts, energy injustices are still prevalent in access to energy, energy costs, and energy governance, particularly in rural and underserved areas. Using a literature review through document content analysis with case study insights from Makueni and Nyeri counties, this study investigates the current status of solar energy justice in the two counties in Kenya and devises strategies for improving solar energy access for all. To respond to this study objective, two research questions were asked. First, from the perspective of energy justice and sustainable development, what is the current status of solar proliferation in Makueni and Nyeri counties? How can solar energy justice be improved for sustainable development in Nyeri and Makueni counties? To execute this study, the concept of energy justice in solar power proliferation was first reviewed from the theoretical and empirical background of sustainable development. Later, the findings were synthesized with results from the case studies in order to draw the policy implications of this paper.

2. Energy Justice, Solar Power, and Sustainable Development

2.1. Theoretical analysis

Energy justice addresses inequalities in the energy sector by advocating for a global energy system that distributes benefits and costs fairly. It emphasizes representative and impartial decision-making, applying principles of justice to availability, affordability, sustainability, and due process (Sovacool & Dworkin, 2014). This approach aims to integrate justice and ethics into energy sector decisions, recognizing the potential impact on citizens' lives while ensuring fairness among paying consumers (Heffron & McCauley, 2017; Heffron, 2022). Energy justice addresses the ethical distribution of energy resources, aligning with sustainable development principles and the Rio Declaration's equity standards. Prioritizing affordability, sustainability, and availability, it fosters human and economic development through distributional, recognition, and procedural justice principles (Jenkins et al., 2016). Distributional justice tackles energy access disparities, recognizing uneven resource distribution. Recognition justice rectifies overlooked populations. Procedural justice ensures inclusive decision-making, employing methods like public participation and EIAs. Implementing these

principles in energy policies enhances availability, affordability, sustainability, and due process, fostering acceptance, conservation, and development (Jenkins et al., 2016). The concept of energy justice holds significant importance for Kenya as it navigates defining its energy future, including the future of solar power. Kenya is confronted with the task of facilitating a 'just transition' to a lower carbon economy, balancing poverty reduction and climate change resilience objectives.

2.2. Empirical studies

The global recognition of energy's importance is underscored by the dimensions of Sustainable Development, which aims to ensure access to affordable, reliable, sustainable, and modern energy for all (Muigua, 2020; Heffron & Heffron, 2021). Renewable energy sources, especially solar power is increasingly being promoted as the preferred modern energy for all. Consequently, there is an emerging body of knowledge that seeks to explore energy justice and find ways in how to improve the proliferation of solar power (Chapman et al., 2018). Energy justice literature has gained substantial academic and practical traction, yet lacks systematic reflection on its scope and contributions. A review of 155 articles from 2008 to 2019 reveals gaps in author diversity and research design. While conceptual frameworks are expanding, there's a need for more diverse research methods. Energy justice serves as a powerful tool, encouraging researchers to remain normative and proactive in identifying injustices while fostering new research methods and themes (Jenkins et al., 2021).

In Australia, a study that delved into the equitable distribution of energy production benefits and costs explored the tension between urban consolidation and solar photovoltaic (PV) promotion in Australia's capital cities. Using dynamic panel data analysis from 2001 to 2015, it finds that denser built environments initially impede solar PV installations, mitigated by feed-in tariffs (FiTs) (Poruschi & Ambrey, 2019).

In two Western Indian states, a study explored the political-economic dynamics influencing solar energy development, focusing on Rajasthan and Gujarat. It investigated how regional factors and path dependence shaped solar growth, often diverging from expectations. Energy justice was introduced to assess alignment with climate justice, economic development, and social equity goals. Through a political economy lens, the study contributed to understanding solar power's intersection with development. Another study in India indicated that large-scale deployment of solar photovoltaic (PV) systems might overshadow social and environmental justice concerns. It examined procedural justice in solar energy implementation, using the Charanaka Solar Park case study. It highlighted

impacts on rural communities and marginalized groups due to procedural justice failures, suggesting policy and governance improvements (Yeneti & Day, 2015). Yeneti et al. (2016) delved into spatial justice aspects concerning land acquisition for large-scale solar energy projects within India's developmental framework, focusing on the Charanka Solar Park in Gujarat, one of the world's largest solar park projects. It exposes discrepancies between official rhetoric and ground realities. Despite claims of inclusive renewable energy initiatives, the research uncovers contentious land and power dynamics. Vulnerable communities face increased precariousness, risking livelihoods due to common land enclosure and questionable land acquisition practices. This case illustrates how mega solar projects may perpetuate a regime of accumulation, benefiting coalitions of interests while disenfranchising vulnerable social groups from their vital assets.

Bedi (2019) studied solar energy as an alternative to fossil fuels to meet India's energy needs, particularly in Kerala. It examined the Kasaragod solar park project and the associated green corridor transmission line, promoted as climate-friendly infrastructure development. While government officials touted benefits, including development for local stakeholders, indigenous Adivasis and others without land titles opposed land acquisition. Local political opposition reduced the solar park's size, but some Adivasis lost land and livelihoods. The case highlighted how achieving renewable energy goals must address socio-environmental injustices and recognize historical land disparities, underscoring the importance of local political power in shaping large-scale projects.

Other studies show that renewable energy, including wind and solar power, is vital for sustainable development. However, challenges like unequal benefits distribution, cultural disrespect, and limited participation in decision-making persist. Addressing these issues is crucial for integrating energy justice into policies and ensuring an equitable transition to sustainable energy systems (Villavicencio Calzadilla & Mauger, 2018). Heffron et al. (2021) found that global solar energy development is crucial for meeting energy and climate goals, leveraging untapped solar potential. It transforms energy mixes, aligning with Paris Agreement targets. Research highlights solar's overlooked benefits and justice implications. Analyzing legislation across 72 countries emphasizes the need for robust legal frameworks to ensure investment certainty and flexibility. Combining law and economics, flexible justice can enhance economic welfare through market reforms, accommodating technological advancements, cost changes, and ownership structures in solar energy systems (Heffron et al., 2021).

In the African context, access to clean and affordable energy remains a significant challenge due to economic constraints and inadequate institutional support

(Njiru & Letema, 2018). However, renewable energy adoption policy is advancing in Africa with the hope of exploiting the benefits of energy justice. Comparative mapping of renewable energy policies in 34 African countries reveals varying policy frameworks' contributions to energy justice (Müller et al., 2021).

In summary, scholarly reviews emphasize global efforts to promote solar energy justice for Sustainable Development. Studies across the world highlight disparities in contextual practicalities, while in Africa, there is still low energy access despite solar power adoption. This calls for comparative solar energy policy mapping, integrating socio-ecological justice and development goals.

2.3. Solar energy and just transition in Kenya

Kenya has seen remarkable strides in energy transition, with 89% of electricity sourced from renewables in 2021, including a 1% contribution from solar power. The country's solar potential, estimated at 15,000 MW, is promising due to its equatorial location and ample sunshine hours. Major solar projects like the Garissa Solar power (55 MW), Malindi solar plant (52 MW), and others aim to mitigate carbon emissions and provide energy access. Corporate giants like East African Breweries Limited (EABL) and Bamburi Cement are investing significantly in solar energy to reduce costs and reliance on the national grid, signaling a broader trend toward sustainability and clean energy adoption in Kenya. Additionally, local companies such as the London Distillers Kenya (LDK) has successfully cut power costs by 50% through solar power utilization, demonstrating the economic and environmental benefits of renewable energy integration (KIPPRA Website, 2024). Kenya faces significant challenges regarding the cost, source, and quality of electricity. Compared to neighboring countries, Kenyan manufacturers pay up to four times more for electricity, impacting their competitiveness. Solar energy presents a cost-effective solution, with costs decreasing globally by 86% since 2009. However, solar energy usage remains low in Kenya, despite its abundant potential and environmental benefits. The country heavily relies on hydroelectric and geothermal power, leading to power outages and losses for manufacturing firms. Drought exacerbates electricity generation issues, prompting increased reliance on costly diesel generators. Efforts to improve energy access and reduce costs include tariff reductions and subsidies by the government. Plans for renewable energy expansion and initiatives like the National Energy Efficiency and Conservation Strategy aim to enhance energy supply and promote solar energy utilization. Recent interventions, such as VAT exemptions on solar equipment and solar

electrification programs for schools and health facilities, demonstrate progress in solar energy adoption (KIPPRA, 2024).

Despite these efforts, Challenges persist in the solar market due to substandard products, necessitating regulatory measures and consumer awareness for quality and affordability assurance. Policy recommendations include subsidies for commercial projects, restructuring Feed-In Tariffs, promoting mini-grids, net metering, domestic manufacturing, and quality control measures (KIPPRA, 2024). Solar energy systems benefit manufacturers by stabilizing power bills, improving energy reliability, and reducing grid dependency. Collaboration between the solar industry and regulators ensures quality standards enforcement (KIPPRA, 2024).

Moreover, Kenya has experienced rapid growth in electrification, reaching 75% of the population with access to electricity by 2018 (International Energy Agency [IEA], 2019). The National Electrification Strategy aims for universal access by 2022, emphasizing renewable energy deployment. Despite progress, a significant urban-rural disparity persists, with 84% of rural populations lacking electricity. Nairobi households are 36 times more likely to have electricity compared to those in Turkana or Tana River Counties, raising concerns about energy justice (Muigua, 2020). Such disparities underscore the need for equitable energy access, especially for vulnerable populations. Ensuring fairness in energy provision is essential, given its fundamental importance as a human need (Moner-Girona et al., 2019).

Energy costs encompass both connection expenses and energy consumption fees. Sub-Saharan African countries face significant affordability challenges due to high power costs relative to income levels. In Kenya, electricity prices surpass global averages, with households paying $0.224 per kWh and businesses $0.192 per kWh. Alternative sources like kerosene, influenced by international prices, are unpredictable and unreliable for low-income households (Avila et al., 2017). The Constitution of Kenya 2010 guarantees access to information, but some energy providers withhold crucial details, hindering informed decisions on tariffs, pollution, and affordability. Additionally, stakeholders often disregard public participation principles during energy projects, undermining democratic decision-making and potentially neglecting the interests of affected communities (Muigua et al., 2015). In summary, even though adoption rates are still low due to a myriad of challenges, Kenya has made significant strides in energy transition, with renewables contributing 89% of electricity, including a 1% share from solar power.

3. Materials and Methods

3.1. Case study research design

The case study research design for the study on Enhancing Solar Energy Justice in Devolved Units in Kenya, which focused on Makueni and Nyeri Counties, involved an in-depth investigation into the unique contexts, challenges, and opportunities surrounding solar energy access and distribution within these regions. By examining specific cases within Makueni and Nyeri Counties, researchers identified best practices, barriers, and potential interventions to promote equitable solar energy access and address underlying socio-economic and environmental concerns. The case study approach enabled a comprehensive examination of real-world experiences, providing insights that informed policy formulation, community engagement strategies, and sustainable energy development initiatives at both local and national levels.

3.2. Case studies

3.2.1. Nyeri County

Nyeri County, located in Kenya, boasts a diverse landscape characterized by its administrative boundaries, topographical features, hydrological networks, vegetation, national parks, human settlements, transportation corridors, and social infrastructural facilities. Covering an area of 3337 km^2, the county comprises eight sub-counties and 30 wards. Its topographical diversity ranges from the majestic heights of Mount Kenya, the highest point at 5199m above sea level, to the lowlands of Mukurweini Central ward along the Sagana River, which sits at 1192m above sea level. Slopes within the county vary from 2% to 90%. Hydrologically, rivers, wetlands, and dams cover 0.05% of the total land area, with the River Sagana boasting the highest average discharge of 13m^3/s. Nyeri County's rich vegetation includes forests covering 38% of the land area, notably the Mount Kenya Forest and Aberdare Forest. The county is also home to significant conservation areas, including Mount Kenya National Park (107 km^2) and Aberdare National Park (466 km^2). Human settlements are marked by two principal towns—Nyeri and Karatina—along with four urban centers and numerous market and rural centers. The transportation infrastructure is well-developed, with a road network spanning 3092 km, a rail network of 77.7 km, and four airstrips. The county has an extensive network of social infrastructural facilities, including 440 public ECDs, 352 public primary schools, 195 public secondary schools, colleges, TVETS, vocational training institutes, polytechnics,

and universities, along with various levels of health facilities catering to the diverse needs of its population.

Hydropower stands as Nyeri's primary grid electricity source, contributing 677 MW to the national grid and comprising over 57% of the country's electricity output. In Nyeri County, Sagana River holds hydropower potential, as indicated by studies from Sogreah Engineering Firm. While wind speeds are generally low, wards in Kieni East display moderate potential for small-scale power generation. The region's cool climate, influenced by Aberdare Ranges and Mt. Kenya, contrasts with hotter, drier areas in Kieni East and West, where solar energy potential thrives due to high insolation, particularly during dry seasons. These renewable resources offer promising energy alternatives in the county (Two Ems Associates, 2019).

Up to 68% of residents rely on electricity for lighting, with over 80.78% of households connected to the national grid as of August 2018. Firewood serves as the primary cooking fuel for 61% of households, particularly in Rugi and Gikondi wards, highlighting the demand for alternative energy sources like solar power, especially in Kieni East and West sub-counties.

The Nyeri solar PV plant in Kenya is poised to become the country's first privately owned project of its kind to achieve commercial operation, following a significant US$355,000 equity investment from the Renewable Energy Performance Platform (REPP, 2024). Developer Marco Borero anticipates reaching financial close on the 1.5MW project in Nyeri County imminently, targeting commercial operation by year-end. REPP's equity injection has facilitated completion of the financing required for the project, complementing earlier senior debt offers. Astonfield Solar, the sub-Saharan Africa solar EPC contractor, is set to accelerate construction with REPP's support. The project's location just north of Nyeri town aims to harness natural solar energy, contributing to Kenya's clean energy goals and reducing reliance on fossil fuels (REPP, 2024).

The Kiamariga solar project, initially envisioned as a remedy to the energy poverty plaguing Kagati, Mathira Constituency, encountered formidable obstacles that ultimately led to its downfall. Primarily, the absence of comprehensive community consultation regarding land use profoundly undermined the project's legitimacy, fostering skepticism and resistance, particularly among figures like James Kabarita (Standard Newspaper, 2020). Moreover, the opaque process of awarding the project to Kumar and Associates triggered concerns regarding transparency and potential misappropriation of

public funds, voiced notably by members of the Nyeri County Assembly. Regulatory challenges, including the failure to secure a Power Purchase Agreement with Kenya Power, compounded the project's difficulties, while doubts about Kumar and Associates' expertise in solar energy development further eroded confidence in its feasibility. Environmental apprehensions and disputes over land usage rights added to the project's complexities, prompting appeals to the National Land Commission. Despite these setbacks, the county government remains intent on revitalizing the project, highlighting the need to address community grievances, enhance transparency in procurement, and navigate regulatory frameworks meticulously to ensure its potential success upon revival (Standard Newspaper, 2020).

3.2.2. Makueni County

Makueni County, spanning 8,034.7 sq km, is home to over 0.9 million people. It shares borders with Kajiado, Taita Taveta, Kitui, and Machakos Counties, lying within Kenya's arid and semi-arid Eastern region. Notable physical features include the Volcanic Chyulu hills, Mbooni hills, and Kilungu hills. The county comprises six sub-counties: Makueni, Mbooni, Kaiti, Kibwezi East, Kibwezi West, and Kilome. Renowned for horticulture, Makueni boasts water management projects like dams and irrigation schemes, bolstering agriculture and prosperity. With a focus on service delivery and continuous investment, the county emphasizes transparency through web portals, social media, and maps, aiming to serve as a model for development locally and nationally. Makueni County, located in Kenya's arid and semi-arid southeastern region, confronts significant climate challenges, notably frequent droughts. Its population, primarily dependent on rain-fed agriculture and estimated at 987,653 in 2019, faces heightened vulnerability to climate change due to limited adaptation resources (GoK, 2019c). In response, Makueni County has enacted the Makueni County Climate Change Act of 2022, a robust framework for climate resilience and adaptation. This legislation establishes the County Climate Change Fund (CCCF), mandating 1% of the annual county development budget for climate change initiatives. Operationalized in 2015, the CCCF, with investments totaling KES 28.9 million by April 2017, aims to enhance the adaptive capacity of local communities (GoK, 2015c; BRACED, 2020).

Energy consumption in the county is rising, yet the adoption of renewable energy sources beyond hydro-electricity remains limited. Most residents depend on charcoal and firewood, undermining environmental conservation efforts in the county (Makueni County Environment and Climate Change Policy, 2021). In Makueni County, strategies are being pursued to promote the adoption of

renewable sources of energy and identify mechanisms for subsidizing alternative energy sources as a way of reducing environmental pollution. The county and REREC have signed a collaboration to enhance rural electricity accessibility, renewable energy, and clean cooking (Makueni County Government Website, 2024). With a Kshs. 30 Million matching grants from the County Government, the initiative aims to benefit approximately 624 households, promising improved living standards and economic growth. The Department of Infrastructure, Transport, Public Works, Housing, and Energy, in collaboration with Strathmore University and WRI, organized a 3-day County Energy Plan Validation workshop focused on Energy Access to affordable, sustainable, and clean energy, productive use of energy, clean cooking technologies, and sustainable bioenergy (Makueni County Government, 2024).

The County Government of Makueni (GoM) emphasizes power and resource redistribution through robust Public Participation (Gathii and Otieno, 2018; Wesangula, 2018; Omolo et al., 2018). Public participation involves five layers: village, cluster, sub-ward, ward, and county levels, fostering community decision-making and civic education on governance and household involvement. The policy acknowledges the interconnectedness of institutions, systems, and individuals. An interview conducted in the county in a region that had been installed with solar power the benefit of public participation in the county (Acts, 2024). All 32 interviewees concurred that public participation is pivotal for the success of solar initiatives, including mini-grids, home systems, or grid-connected projects. They emphasized that excluding stakeholders from the process undermines a project's sustainability and effectiveness in the long run. The prevalence of non-state actors in Makueni has facilitated the government's introduction of a robust policy of public participation, creating an environment conducive to the adoption of solar technologies at the household level. Community groups, such as the women's group selling M-KOPA solar products, play a significant role in promoting and distributing these solutions through various channels like churches, markets, and community gatherings. Their partnership with M-KOPA, incentivized by bonus payments, underscores the effectiveness of organized groups as a value chain for solar products. This collaborative approach not only fosters solar uptake but also empowers women economically and socially, granting them decision-making authority over products that directly impact their lives and community. Thus, Makueni's emphasis on public participation not only supports the private sector in solar production but also fosters socio-economic empowerment at the grassroots level (Acts, 2024). The study recommended that the deployment of solar energy should be integrated into broader decision-making frameworks within any given

context. Inclusive decision-making processes are essential for the successful uptake of solar energy, necessitating targeted efforts to include historically marginalized groups such as women and young people. Moreover, solar power initiatives should align with broader efforts aimed at empowering citizens both at the individual and collective levels. This holistic approach ensures that solar energy projects contribute not only to sustainable energy access but also to broader societal empowerment and inclusion agendas (Acts, 2024). The map (Figure 1) shows the geographical location of Nyeri and Makueni counties in Kenya.

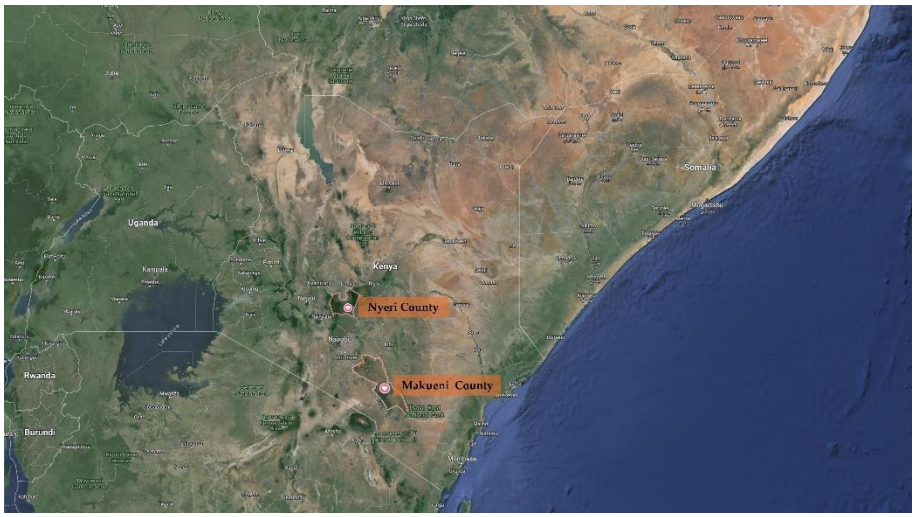

Figure 1. Location of the study sites

3.3. Data sources and collection process

In conducting the study, a meticulous approach to data collection via textual analysis was adopted. Initially, inclusion and exclusion criteria were established to ensure the relevance of the gathered literature, focusing on solar energy justice, devolution in Kenya, and studies specific to Makueni and Nyeri Counties. Keywords such as "solar energy justice," "devolution," "Kenya," "Makueni County," and "Nyeri County" were defined to facilitate comprehensive searches across academic databases like PubMed, Google Scholar, JSTOR, and Scopus.

Through systematic screening, texts were evaluated based on their alignment with the research objectives, and only those meeting the inclusion criteria were selected for detailed analysis. These selected texts underwent thorough textual scrutiny, concentrating on identifying key themes regarding solar energy justice, devolution policies, challenges, and opportunities within the context of the two counties. Pertinent data points were extracted from the analyzed texts to inform the study's conclusions and recommendations. Ultimately, through synthesis and interpretation, the findings derived from the textual analysis aimed to offer meaningful insights into solar energy justice within the framework of devolved governance in Makueni and Nyeri Counties, thus contributing to informed decision-making and policy formulation in the region.

Document	**Key findings**	**Source**
Government of Makueni County Vision 2025	Provides for the need of clean energy sources, including solar power for sustainable development in the county.	Website
Makueni County Environment and Climate Change Policy 2021	Promotes the use of renewable energy sources including solar power as a way of curbing environmental pollution	Website
Makueni County Forest and Landscape Restoration Implementation Plan (FOLAREP), 2023-2030	Identifies solar power fencing as one of the ways of promoting innovative community-based and cost-efficient approaches for protection of restored and/ or areas under restoration	Website
Nyeri County Spatial Development Plan, (2019- 2029)	Identifies the potential for solar energy in the county in the drier and hotter areas of Kieni East and West sub-counties due to the high insolation, especially during dry seasons.	Website
Nyeri County Integrated Development Plan, (2023-2027)	Emphasizes the need to tap solar energy resources in the county	Website
Kareithi, (2017)	The study examined factors influencing the implementation of rural electrification programs in Kieni East Sub County, Nyeri County, Kenya. It employed a descriptive survey research design targeting 4289 households and 10 Rural Electrification Authority Team members. The findings highlighted funding, electricity costs, alternative power sources, and demand as critical factors affecting program implementation, suggesting the need for subsidies and policy adjustments to enhance success.	Google Scholar
Nyaga et al., (2020)	Explored the fuel preferences and reasons among households in urban areas of Nyeri town, Kenya, aiming to understand domestic energy transition. It	Google Scholar

Document	Key findings	Source
	was established that factors such as convenience, affordability, accessibility, and cultural beliefs significantly influence fuel choices among urban residents.	
Mwangi, (2013)	The study investigated energy consumption patterns in rural households in Mukaro location, Nyeri County, focusing on wood fuel usage and its influencing factors. Findings emphasized the significance of wood fuel, household income, and distance traveled in fuel consumption, proposing recommendations for policy recognition and support for alternative energy sources.	Google Scholar
Waita & Aduda, (2017)	The study established that unclear module specifications, poorly matched batteries, and undersized cables, emphasizing the need for training in PV system design and maintenance.	Google Scholar
MacEwen & Evensen, (2021)	The study demonstrated that processes of women's empowerment contribute to democratizing energy structures in the Makueni county. It emphasizes the importance of examining winners and losers in the energy transition and proposes integrating feminist epistemologies into energy democracy theorizing to analyze self-constructions and social hierarchies.	Google Scholar
Kazungu, (2020)	The study revealed that in Machakos county, firewood was extensively used for cooking across all schools, followed by charcoal, LPG gas, and paraffin. Electricity was seldom used due to its high cost and unreliability. Lighting mainly relied on electricity and solar energy. Energy-saving stoves, solar power, and energy-saving bulbs were preferred due to their affordability and environmental benefits. Challenges included the scarcity of firewood and charcoal, the high installation cost of solar power, and electricity's unreliability. The study recommended government interventions to make modern energy technologies more accessible, establishment of school-based woodlots, and increased adoption of solar power to mitigate overreliance on firewood.	Google Scholar
Ngetha, (2015)	The paper examined energy source trends in Kenya's central highlands rural community over three decades, from firewood to solar home systems. While industries and urban areas rely on petroleum and hydroelectric power, rural areas mainly use firewood. This reliance impacts ecosystems and nutrient cycling, especially considering over 80% of Kenya's regions are arid or semi-arid.	Google Scholar
Standard Newspaper, (2020)	The Newspaper reported that an existing solar power project, the Kiamariga solar project in Kagati, Mathira Constituency in Nyeri county, initially proposed as a	Website

Document	Key findings	Source
	solution to the energy poverty in the region, faced significant challenges and ultimately floundered. The failure of the Kiamariga solar project stemmed from: insufficient community consultation leading to skepticism and resistance, transparency concerns, regulatory hurdles, doubts over developer expertise, and environmental and land use issues.	
Nation Newspaper, (2020)	Reported that Nyeri residents opposed a Kshs. 6 billion solar power plant funded by international investors, citing irregularities in the contract. The residents complained that they had not been consulted. They noted that the public participation conducted over the handling over of their 134 Ha community land to the investor was biased. The plant was aimed at producing 40 megawatts to be fed to the national grid.	Website

Table 1. Documents reviewed

3.4. Data analysis

This study sought to explore ways of enhancing solar energy justice in Kenya's devolved units by using the lens of energy justice as an analytical framework. Energy justice encapsulates the foundational principles of equitable distribution, affordability, and universal access to clean and reliable energy sources for all individuals and communities. It serves as a conceptual framework for advancing solar energy justice, ensuring that the benefits of renewable energy technologies are shared equitably among diverse populations. Equitable distribution emphasizes the fair allocation of solar energy resources across regions, demographics, and socio-economic groups, striving to address historical disparities in energy access and promote inclusive development. Affordability is paramount within the realm of energy justice, as it entails making solar power financially accessible to households, businesses, and institutions, regardless of their income levels or economic status. By reducing barriers to entry and implementing innovative financing mechanisms, such as subsidies and microfinance initiatives, affordability can be enhanced, enabling more individuals to transition to clean energy solutions. Access to clean and reliable energy sources is foundational to achieving energy justice, as it underpins various aspects of human well-being, including health, education, and economic productivity. By prioritizing equitable distribution, affordability, and access to clean energy,

stakeholders can foster a more sustainable and inclusive energy transition, empowering communities and advancing social equity on a global scale.

4. Results

4.1. Current status of solar power in Nyeri and Makueni counties

Nyeri County lacks research on solar power and energy justice, contrasting with Makueni's thriving community solar projects driven by public participation and collaborations. Makueni's proactive financing, including partnerships with REREC and academia, showcases commitment to solar development. Challenges persist in Nyeri, marked by regulatory hurdles and transparency issues despite investments (Table 2).

Thematic Area	Makueni	Nyeri
Community solar projects	Community solar projects in Makueni County reflect a concerted effort towards sustainable energy adoption. Leveraging public participation initiatives, including multi-layered engagement from village to county levels, Makueni promotes solar energy uptake. Collaborations with non-state actors, exemplified by women's groups selling M-KOPA solar products, demonstrate effective community-driven distribution networks. This holistic approach empowers marginalized groups, aligning with broader socio-economic and environmental goals.	Community solar projects in Nyeri County face significant challenges despite its diverse landscape and rich renewable energy potential. The Nyeri solar PV plant represents a promising initiative, with substantial investment from REPP aiming to achieve commercial operation soon. However, the failure of the Kiamariga solar project underscores the importance of comprehensive community consultation and transparency in procurement processes. Regulatory hurdles and environmental concerns further complicate solar energy initiatives in the region.
Policy environment	Makueni County fosters sustainable energy through community-driven solar projects. Public participation initiatives, collaborations with non-state actors, and multi-layered engagement promote solar energy uptake, empowering marginalized groups and aligning	Nyeri County faces challenges in its solar power policy environment. The Nyeri solar PV plant represents progress, attracting substantial investment for commercial operation. However, the failed Kiamariga solar project highlights transparency and regulatory hurdles that impede solar energy initiatives.

Thematic Area	Makueni	Nyeri
	with socio-economic and environmental objectives.	
Financing initiatives and investments	In Makueni, financing initiatives and investments for solar power are gaining momentum as the county prioritizes sustainable energy solutions. The collaboration between the county government and the Rural Electrification and Renewable Energy Corporation exemplifies this commitment, aiming to enhance rural electricity accessibility and promote clean cooking through renewable energy sources. With a significant matching grant from the County Government, initiatives seek to benefit hundreds of households, promising improved living standards and economic growth. Additionally, partnerships with academic institutions like Strathmore University and organizations such as the World Resources Institute (WRI) underscore Makueni's proactive stance toward securing financing and investments for solar power. These efforts signify a pivotal shift towards leveraging financial resources to drive solar energy adoption and bolster the county's sustainable development agenda.	In Nyeri County, solar power initiatives receive substantial financing and investments, exemplified by the Nyeri solar PV plant. With a significant equity injection from the Renewable Energy Performance Platform, the project aims to achieve commercial operation soon, contributing to Kenya's clean energy goals.

Table 2. Status of solar power

4.2. Status of solar power justice

Both Nyeri and Makueni counties prioritize equitable distribution of solar power. Nyeri promotes affordability through initiatives like Solibrium, while Makueni's Public Participation policy and 40 MW solar project enhance energy access for off-grid communities. Makueni's structured governance approach suggests a

more comprehensive commitment to inclusive and sustainable energy distribution (Table 3).

Energy Justice Thematic Area	Nyeri	Makueni
equitable distribution	Solibrium, provides solar panels, solar systems, and solar lamps to communities through women's groups, offering loans or a subsidized price system. Residents have access to the solar systems and can pay in installments	The County Government of Makueni is committed to a redistribution of power and resources through a strong policy of Public Participation and investment in development projects. One such project is the 40 MW solar project. that aims to provide cheap, reliable, and clean energy to power public installations and later markets and villages not connected to the national power grid. The project is expected to bridge the energy supply gap in the county and contribute to Kenya's Nationally Determined Contribution (NDC) by reducing the country's greenhouse gas emissions by 30% by 2030.
affordability	Solar power is becoming increasingly affordable in Nyeri County, Kenya. The County Government of Nyeri has been committed to promoting the use of solar power to provide affordable and sustainable energy to the region.	The 40 MW solar project that aims to provide cheap, reliable, and clean energy to power public installations and later markets and villages not connected to the national power grid
access to clean and reliable energy sources	The county government of Kenya is prioritizing access to clean and reliable solar energy, particularly through solar-powered boreholes. Davis and Shirtliff Limited has been contracted to install solar power to 16 boreholes within six months, aiming for completion by March next year. Additionally, various solar energy companies in Kenya, such as Sunraserg Energy Experts and Eco Renewables Felicity Solar Energy Company, offer diverse solar products and services, including power generation and backup solutions.	The County Government of Makueni has a policy of Public Participation that subdivides the county into five layers of governance: (1) village level, (2) cluster level, made up of 5 villages grouped together, (3) the sub-ward level, (4) ward level, made up of 7 geographical regions that divide that county, and finally (5) the county level.

Table 3. Solar power justice

4.3. Strategies for promoting solar justice

Both Nyeri and Makueni counties employ innovative strategies to enhance energy justice through solar power. In Nyeri, geospatial tools identify areas

lacking electricity access, informing prioritized electrification and renewable energy strategies. Integrated energy access plans combine grid expansion and off-grid solar systems, aligning with Kenya's successful National Electrification Strategy. Meanwhile, Makueni emphasizes public participation and community empowerment, recognizing their role in achieving Sustainable Development Goals. Leveraging geospatial tools aids in identifying electricity-deprived areas, optimizing grid extension, and renewable energy strategies. Integrated energy access plans prioritize grid expansion and off-grid solar systems, reflecting a comprehensive approach to increase electricity access and foster sustainable development. Solar companies' contributions further bolster Kenya's transition to sustainable energy solutions, promoting economic growth in both counties.

5. Discussion

Energy is a fundamental driver of human development, yet global energy sectors face significant disparities in access, costs, and decision-making processes (Behrens et al., 2016). The imperative to address climate change has underscored the urgency of transitioning away from fossil fuels toward renewable energy sources (IPCC, 2018; IEA, 2019). Energy justice has emerged as a critical framework to tackle these disparities by advocating for distributional, recognition, and procedural fairness in energy provision (Sovacool & Dworkin 2014; Heffron & McCauley 2017; Heffron 2022; Jenkins et al., 2016).

In Kenya, achieving the country's development goals through the proliferation of solar power is closely linked to energy justice. Kenya's energy transition has made notable progress, with renewables contributing 89% of electricity in 2021, including a 1% share from solar power. Major solar projects aim to mitigate carbon emissions and improve energy access, highlighting the potential for collaboration among stakeholders to drive sustainable progress in the energy sector and broader development efforts (KIPPRA, 2024). Corporate entities like East African Breweries Limited (EABL) and Bamburi Cement are actively investing in solar energy to reduce costs and dependency on the national grid, reflecting Kenya's growing sustainability trend. Local firms like London Distillers Kenya (LDK) have also embraced solar energy, reducing power costs by 50% and demonstrating the economic and environmental benefits of solar adoption. However, Kenya still faces challenges related to electricity costs, sources, and quality, despite the significant potential and declining global costs of solar energy (KIPPRA, 2024).

Analyzing the application of energy justice principles to solar power proliferation in Nyeri and Makueni counties reveals contrasting realities. Makueni County has shown strong leadership in implementing community-driven solar projects through robust public participation and partnerships with non-state actors, supported by proactive financing initiatives. In contrast, Nyeri County faces challenges related to regulatory transparency and policy environments, despite investments in solar projects (Table 2). The comparison between Nyeri and Makueni counties underscores the implications for sustainable development. Makueni's proactive approach and community engagement highlight the potential for successful solar projects through transparent governance structures. Conversely, Nyeri's challenges underscore the need for improvements to foster equitable access to solar energy. The disparity between the counties emphasizes the importance of comprehensive frameworks and collaborative efforts to address barriers and promote energy justice.

Efforts to ensure equitable distribution of solar power are underway in both Nyeri and Makueni counties. While Nyeri focuses on affordability initiatives like Solibrium, Makueni's Public Participation policy stands out for facilitating access through large-scale solar projects. However, Makueni's structured governance approach suggests a more enduring commitment to community involvement, potentially leading to more inclusive and sustainable energy distribution over time compared to Nyeri (Table 3). Various documents and studies highlight the importance of promoting energy justice through solar power across Kenyan counties, advocating for clean energy sources to ensure sustainable development and environmental preservation. The Energy Act of 2019 defines renewable energy comprehensively, underlining its significance in guaranteeing energy security, a fundamental aspect of energy justice. Despite the prevalence of biomass, promoting other renewable sources is crucial for enhancing energy security and advancing energy justice in Kenya.

Studies from other regions, such as Australia and India, provide insights into the political-economic dynamics and procedural justice involved in solar energy development, highlighting disparities and obstacles in land acquisition and community involvement (Poruschi & Ambrey, 2019). In Africa, energy poverty remains a challenge, despite gradual progress in renewable energy uptake. Comparative analysis of policies underscores the necessity of justice considerations to ensure fair and sustainable energy transitions, emphasizing comprehensive strategies aligned with socio-ecological justice and development objectives. Several countries have made significant strides in implementing fair and sustainable energy transitions in solar power, aligning comprehensive

strategies with socio-ecological justice and development objectives to achieve sustainable outcomes. One notable example is India, where the government has launched ambitious solar energy programs like the Jawaharlal Nehru National Solar Mission. Through policy incentives, subsidies, and capacity-building initiatives, India has rapidly expanded its solar power capacity, making significant contributions to energy access and environmental sustainability while fostering socio-economic development. Another example is Rwanda, which has implemented innovative policies and partnerships to promote solar energy adoption, particularly in rural areas (Bedi, 2019). Through the Scaling Solar program, Rwanda has facilitated private sector investment in solar projects, improving energy access, creating jobs, and reducing carbon emissions. Additionally, countries such as Chile and Morocco have capitalized on their abundant solar resources to drive sustainable energy transitions. Chile has leveraged solar power to diversify its energy mix and reduce dependence on fossil fuels. At the same time, Morocco has invested in large-scale solar projects such as the Noor Ouarzazate Solar Complex, contributing to energy security and economic growth. These examples highlight the importance of comprehensive approaches that integrate social, economic, and environmental considerations to achieve sustainable outcomes in solar power deployment, advancing socio-ecological justice and development objectives on a global scale (Sustainable Energy for All, 2024).

In summary, promoting inclusive approaches ensures equitable access to clean energy. Kenya's Nyeri and Makueni counties exemplify collaborative efforts toward energy justice through solar power expansion. Partnerships between government, private sector, communities, and NGOs drive solutions, including community-driven projects, financing options, public awareness, and innovative technologies, fostering social equity and environmental sustainability.

6. Conclusion and Recommendations

Globally, energy disparities persist, magnifying the urgency of transitioning away from fossil fuels to renewable sources. Kenya's commendable progress in renewable energy, particularly solar power, reflects a commitment to mitigate climate change and enhance energy access. The quest for energy justice through solar power proliferation in devolved units in Kenya, exemplified by the case of Makueni and Nyeri counties, underscores the pivotal role of collaborative and innovative efforts in driving equitable and sustainable energy transitions. However, disparities between counties such as Makueni and Nyeri highlight the

need for comprehensive frameworks and collaborative strategies to address regulatory challenges and foster transparent governance. Makueni's proactive approach, marked by community engagement and partnerships, demonstrates a promising model for successful solar projects and enduring energy justice. Conversely, Nyeri's struggles underscore the imperative of improving policy environments to ensure equitable access to solar energy. The global discourse on energy justice underscores the significance of considering socio-ecological justice and development objectives in sustainable energy transitions. Examples from India, Rwanda, Chile, and Morocco illustrate the transformative potential of comprehensive strategies aligned with energy justice principles, driving socio-economic development while mitigating environmental impacts. Collaboration among government, private sector, and communities is crucial for overcoming solar energy barriers, improving financing, and raising awareness. Equitable access through innovation and inclusive policies fosters social and environmental sustainability, demanding commitment and collective action. The study's limitations include the focus on only two counties, which may not fully represent Kenya's diverse energy landscape. Additionally, the analysis primarily examines policy frameworks, potentially overlooking grassroots perspectives and implementation challenges. Future studies could explore broader geographical areas in Kenya to capture the diversity of energy justice initiatives and enrich the understanding of solar power proliferation and energy justice.

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Funds

This work was supported by the Ministry of Education of the Republic of Korea and the National Research Foundation of Korea (NRF-2020S1A5C2A01092978).

Competing Interests

The authors hereby state that there are no financial or non-financial competing interests.

Citation

Chisika, S.N. & Yeom, C. (2024). Enhancing energy justice through solar power proliferation in Kenya's devolved units. Insights from Makueni and Nyeri. *Visions for Sustainability*, 21, 9985, 171-197. http://dx.doi.org/10.13135/2384-8677/9985