



From Policy to Practice: Evaluating Malaysia's Energy-Laws Framework for Supporting Organic Farming and Water Resource Sustainability

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ABSTRACT

Malaysia faces increasing water-related challenges associated with climate variability, pollution, and inefficient resource management, with agriculture being a major user of freshwater resources. Globally, agriculture accounts for more than 70% of freshwater withdrawals, highlighting the importance of sustainable agricultural practices in addressing water stress. Organic farming represents one potential approach to sustainable agricultural production through practices that promote soil health, water conservation, and reduced reliance on synthetic fertilisers and pesticides. However, the adoption of sustainable farming practices also requires reliable and affordable energy, particularly in rural areas where electricity is needed for irrigation, storage, and other agricultural activities. This study examines whether Malaysia's existing energy-law and policy framework adequately supports the integration of decentralised renewable energy into organic farming as part of a broader response to water-related challenges. A qualitative doctrinal legal research method is adopted to analyse relevant Malaysian legislation, national policies, and academic literature concerning renewable energy, sustainable agriculture, water management, and energy justice. The findings reveal a gap between Malaysia's sustainability policy objectives and their implementation at the farm level. Although existing frameworks promote renewable energy and sustainable agricultural development, they provide limited legal and institutional support for decentralised renewable-energy applications in small-scale and rural farming, including solar-powered irrigation and on-farm renewable-energy systems. The analysis further identifies limitations in financial incentives, technical assistance, and accessible implementation mechanisms for rural farmers. From an energy-justice perspective, these gaps raise concerns regarding equitable access to renewable energy and the participation of rural agricultural communities in the energy transition. The study therefore proposes a more integrated legal and policy framework that connects energy, agriculture, and water governance, supported by targeted financial incentives, simplified regulatory mechanisms, technical assistance, and decentralised renewable-energy initiatives to strengthen the sustainability and resilience of organic farming in Malaysia.

Keywords: Water crisis, energy law, organic farming, sustainable agriculture, energy justice

INTRODUCTION

The global water issue has become a legal and moral problem, not only focusing on the environment, thus, it urges all countries around the world to legislate laws that are equitable in how they are made and enforced. As energy justice became the centre of idea for this paper, this paper discusses in depth on how fair access and treatment to the advantages of energy and distribution of environmental cost should be practiced in order to really develop a new Malaysia in exercising renewable energy as our main energy sources. Energy justice



in agriculture means that legal systems must make sure that all communities, especially farmers in rural areas that depend on resources, can use renewable energy technology that helps with sustainable practices like organic farming. Additionally, according to McCauley and Heffron (2018), the protection against the environment for a long-term usage of natural resources while energy development is being evolved is also part of energy justice. It is found that there are two issues which are actually important to tackle, the issue of energy law corresponds with the needs to support organic farming and water conservation efforts which seems to be inadequately discussed and solved by the legislation.

It is not new to humankind that the water crisis is not a small issue. This problem has become a world-wide issue which really has a bigger impact on food security, environment, sustainability and the economy with 70% of all freshwater withdrawals worldwide, making it a major part of this challenge (Ritchie & Roser, 2024). It is not arguable that among the main causes to this effect is actually traditional farming which uses a lot of chemical pesticides, leading to water pollution around the world. Other than that, much evidence has been given and shown on how many rivers, lakes and groundwater around the world are polluted because of practices. Not only that, due to climate change which happened in the blink of an eye is putting much pressure on this weak system which can be seen through sturdy changes in more frequent abnormal rain. (Joint Research Centre, 2024).

Additionally, as environmental concerns grow, organic farming has become a more sustainable option than conventional agriculture. It relies on natural techniques such as composting, crop rotation, and cover crops rather than using synthetic pesticides. These methods improve soil health, prevent erosion, enhance water retention and reduce overall water usage. Consequently, by avoiding harmful chemicals, organic farming helps preserve water quality and contributes to both environmental protection and public health (Çerçioğlu, Udawatta, et al., 2025).

In order for organic farming to expand, communities must have access to renewable energy, especially in rural areas where reliable electricity is needed for storage, composting, and irrigation. Expanding organic practices depends on energy laws that support the adoption of renewable technologies like solar, wind, and biogas. When energy laws are aligned with sustainability goals, farms are able to reduce their reliance on fossil fuels, improve productivity, and achieve more sustainable environmental outcomes. Drip irrigation systems that run on solar power, for instance, have been demonstrated to reduce greenhouse gas emissions and increase water efficiency (Schnetzler & Pluschke, 2017).

However, it is important to understand that all energy generation methods, whether they come from renewable or fossil fuels, have an impact on the environment. It is commonly known that using fossil fuels degrades the environment and contributes significantly to air pollution, greenhouse gas emissions, and global warming (International Energy Agency, 2021). However, even though switching to renewable energy is crucial to meeting climate goals, there are certain ecological and societal drawbacks. Even if they produce less pollution when in use, technologies like solar, hydroelectric, and wind energy still need a lot of land, interfere with water systems, destroy biodiversity, and depend on the mining of rare earth materials. Significant ethical and environmental issues are brought up by these procedures (Dunlap & Sovacool, 2020; Sovacool et al., 2020).

Sustainability must be viewed as a balance rather than a presumption of harm-free energy sources in light of these complications. It is crucial to evaluate the environmental effects of all energy sources in comparison. The main issue is not whether harm exists, but rather how well it can be reduced by innovation, legislation, and careful planning. Creating energy frameworks that promote efficiency, long-term sustainability, and environmental preservation is the aim from a legal and political standpoint, especially for energy-dependent and environmentally vulnerable industries like agriculture.

Supportive energy laws as well as agricultural policies are necessary for the broad adoption of organic farming. For important farming activities, especially in rural areas, economical and dependable renewable energy is crucial. The implementation of targeted legal frameworks and financial support mechanisms plays a critical role in accelerating the adoption of solar and biogas technologies, thereby mitigating fossil fuel dependency (Codogni, 2026; Marciniuk-Kluska & Kluska, 2023). The growth of organic techniques is constrained by the difficulty of access to these advances for many small and medium-sized farms in the absence of such



frameworks.

Despite the growing national water crisis in Malaysia, driven by climate change, pollution, and wasteful resource use, there remains limited connection between the country's energy laws and sustainable agricultural practices, such as organic farming, which could be extremely important for conserving water. Existing legal frameworks primarily focus on the production and use of energy, with minimal integration of agricultural sustainability goals. The lack of unified legislative backing for organic farming raises serious questions about whether current energy regulations can support the widespread adoption of organic practices, given that organic farming primarily depends on water-efficient techniques and renewable energy sources. This lack of regulatory alignment highlights a gap that weakens efforts to address water-related issues through sustainable farming practices. Consequently, it is crucial to analyse the extent to which Malaysia's energy laws support the adoption of organic farming as a sustainable measure to address the national water crisis.

This paper evaluates the gaps between policy and practice and assesses how Malaysia's existing energy laws encourage organic farming as a means of lessening agriculture's influence on the water problem.

In addressing the water crisis through organic farming initiatives, it is crucial to recognise the role of energy laws in supporting sustainable agricultural practices. This study aligns with the broader discourse on intergenerational justice (Dworkin, 1981; Barry, 1999; Weiss, 1989), which emphasises the moral obligation to preserve environmental and energy resources for future generations. The theme of posterity underpins this research, focusing on how today's energy policies can impact environmental resources, including water. This study supports the philosophical underpinnings that emphasise intergenerational justice and sustainable resource management by establishing a connection between energy consumption, farming methods, and water conservation (Barry, 1999; Weiss, 1989).

LITERATURE REVIEW

A clear grasp of energy laws is essential to understand how they contribute to sustainable farming and water resource management in Malaysia. These laws refer to the legal frameworks that regulate the production, distribution, and use of energy across various sectors. Moreover, in addition to ensuring that the energy system is safe and environmentally friendly, it incorporates both fossil fuels and renewable energy sources and seeks to maintain equity between the government, energy providers, and consumers (ESADE, 2023). These rules are important when considering how energy laws might support sectors like farming, especially organic farming, which requires clean and easily accessible energy.

Agriculture is a key sector in the transition towards a more sustainable future. Today, farmers play a crucial role not only as food producers but also as emerging energy producers, making them integral to both farming and energy systems. According to Hahn et al., (2025), farmers play a central role in the transition toward sustainable agriculture and clean energy. As a result, energy laws ought to provide assistance and support to farmers in both sectors.

Apart from that, this governmental initiative closely aligns with Malaysia's commitment in advancing green technology and enabling sustainable development across different sectors and organisations in the country (Malaysian Green Technology and Climate Change Corporation, 2023). In the agriculture context, such alignment allows energy laws to play an important role in advancing organic farming mainly by helping rural areas get better access to clean energy.

Following this, it is important to define what organic farming is and discuss its significance in protecting the environment. One form of sustainable agriculture is organic farming, which uses natural methods to control pests and fertilise the soil. It mainly relies on animal and plant waste, along with specific crops that naturally add nitrogen to the soil (Britannica, 2025). By reducing the use of synthetic chemicals, it produces food that is generally safer and more nutritious. Additionally, organic practices support biodiversity, protect soil health, reduce water pollution, and contribute to climate change mitigation (Malik et al., 2023).

One way to understand how energy laws support sustainable agriculture is by looking at how different farming

methods impact the environment and water use. Traditional farming often depends on synthetic fertilisers and chemical pesticides, which can damage soil health, contaminate water sources, and reduce biodiversity. On the other hand, organic farming leans on natural approaches like composting and mulching. These methods improve soil quality, help prevent erosion, and allow the land to retain water more effectively. They also lower the need for constant irrigation, making organic farming a more sustainable option in the long run. By moving away from heavy chemical use, organic agriculture offers a more environmentally conscious way of farming that fits with broader efforts to protect water resources (Uyir Organic, 2024).

These environmentally conscious practices not only protect ecosystems but also offer a more sustainable approach to water management. Although most Malaysians have access to tap water, water scarcity is still a serious problem. Rahman (2021) notes that in 2017, Malaysia drew about 18.375 billion litres of raw water each day, but a lot was wasted across households, farming, and industries. With each person using around 210 litres daily and wasting about 50 litres, the low cost or free supply of water often leads people to be careless. If this continues, it could make future water shortages worse. As agriculture consumes a significant amount of water, moving towards organic farming can reduce water runoff and make water use more efficient particularly when energy laws support the use of eco-friendly, water-saving technologies in rural communities.

Addressing the water crisis means understanding how closely water, energy, and farming are connected, a relationship known as the water-energy-agriculture (WEA) nexus. Farming relies on both water and energy, while producing energy also requires water. For instance, water is used to cool power stations, and energy is needed to run irrigation systems and process crops. Problems in one area can affect the others. Because of this, efforts to support sustainable farming should be based on policies that consider all three areas together. Studies show that applying the WEA nexus approach, especially in irrigation, can help use resources more wisely and improve long-term food and water security (Cuthbert Taguta et al., 2022). Therefore, to make sustainable farming truly effective, it must be supported by well-designed national policies something Malaysia has already begun to address through various initiatives.

This connection between policy and practice is not entirely new in Malaysia. Early efforts to integrate organic farming into national strategies began in 1998 with the introduction of regulatory rules for organic production. Through agroforestry, composting, and organic farming, the Third National Agriculture Policy (NAP3, 1998–2010) sought to boost productivity while guaranteeing sustainable use of natural resources (Ilani Zuhairah et al., 2016). By 2010, it aimed to have 20,000 hectares of organic farmland, but this target was not reached. In order to support smallholders and encourage conservation, organic farming was nevertheless included in subsequent Malaysia Plans and the National Agrofood Policy 2011–2020 (Ilani Zuhairah et al., 2016).

Building on these agricultural initiatives and against the backdrop of Malaysia's growing water stress, to address Malaysia's growing water scarcity, it's crucial to examine how the country's energy legislation can support organic farmers to set up clean-energy solutions that improve irrigation efficiency and conserve water.

Malaysia's National Renewable Energy Policy and Action Plan (NREPAP) 2022 - 2040 aims to diversify the national energy mix through solar, biomass, biogas, and mini-hydro, yet its focus remains overwhelmingly on electricity generation, particularly in grid-connected contexts. Although it acknowledges agricultural biomass such as palm oil residues and livestock manure as energy feedstocks, NREPAP does not provide mechanisms to empower organic or small-scale farmers to adopt renewable technologies like solar-powered irrigation or on-farm biogas systems (NREPAP 2022 - 2040). This limited remit reflects findings from a systems-modelling study in Perak, which identified inefficient electricity use in agriculture principally for water pumping as a barrier to sustainable production, yet noted that no policies targeted this on-the-ground issue (Qi & Haslinda, 2022).

Grid-connected renewables such as solar, biomass, and mini-hydro are the main focus of the National Renewable Energy Policy and Action Plan (NREPAP) 2022–2040. Agricultural biomass is mentioned, however, there are no procedures for organic or small-scale farms to use on-site technology like methane digesters or solar-powered irrigation (NREPAP, 2022–2040; Qi & Haslinda, 2022). Research indicates that without focused assistance, such as easily accessible funding, expedited approvals, and technical training, smallholders are unlikely to embrace such technology (Omar et al., 2024). In order to adopt those focuses in

this policy, it definitely cost much in expenditure especially upfront expenditure, thus the lack of regulation, hampered the adequacy of practice on this policy (Afrina Arfa, 2025; Kardooni et al., 2015). It is understood that because of this it has led to the continued inadequate implementation of the agriculture-water-energy nexus in Malaysia.

Besides that, National Agrofood Policy 2021 - 2030 (NAP 2.0) is also known as another major policy in Malaysia. This policy outlines the target for agricultural sustainability which includes food security, smart farming technology and agroecological practices in Malaysia in which improving irrigation systems, reducing chemical inputs, and strengthening agro-ecological practices (UNEP-FAOLEX, 2021). Nonetheless, this policy, like the NREPAP, is also to seem detached from the renewable energy systems. the problem with this policy is also same with above policy i which it offers no legal provisions, funding incentives or technical assistance to the farmers especially in rural areas for incorporating solar-powered irrigation, biogas digesters, agrivoltaics, or community microgrids into organic farming operations (Noor Fadzlina et al., 2023; Kong, 2002). Despite having sustainability objectives, NAP 2.0 does not have any particular financial or legal tools to support the use of renewable energy in organic farming (Othman et al., 2023)

In addressing the gap found in the National Renewable Energy Policy and Action Plan and the National Agrofood Policy 2021 - 2030, the government has come out with one policy which seems adequate to offer a broader vision in energy law in Malaysia. The Green Technology Master Plan (GTMP) 2017-2030 includes energy-efficient irrigation, solar-powered agricultural and biomass utilisation (Malaysian Green Transition, 2024). However, according to Othman et al. (2018), in her article journal, this master plan is still inadequate in statutory authority to really exercise the meaning of the master plan and there are no meaningful incentives for organic farms. In addition, the Green Technology Master Plan still focuses on the strategy to remain consultive. Meanwhile, with legislative tools or budgetary collections, it will help plan a new Malaysia in supporting organic farming by energy law (Othman et al., 2018). As a result, GTMP still falls short of overcoming many problems like inadequate funding, pure rural infrastructure and no policy mandates (Tan et al., 2018).

In reducing environmental degradation and water stress, nations are urged to implement clean energy technologies in all sectors, including agriculture, in order to meet the Sustainable Development Goals (SDGs) of the UN, especially Goal 7 (Affordable and Clean Energy) and Goal 6 (Clean Water and Sanitation) (United Nations, 2015). In a similar vein, the Food and Agriculture Organization of the United Nations has promoted solar-powered irrigation as a means of improving water-use efficiency and reducing greenhouse gas emissions (Schnitzer & Pluschke, 2017).

Many countries are integrating renewable energy into agriculture. In the European Union, the Renewable Energy Directive II (RED II) provides a framework for promoting renewable energy, while the Farm to Fork Strategy supports the transition to more sustainable food systems and organic farming (European Parliament & Council of the European Union, 2018; European Commission, 2020). Under the European Agricultural Fund for Rural Development (EAFRD), national and regional Rural Development Programmes (RDPs) may co-finance farm investments in renewable-energy production and use, energy efficiency, and water-saving irrigation infrastructure (European Parliament & Council of the European Union, 2013, 2020). While the Netherlands, according to Nazarov (2024), has shown successful use of biomass heating systems in high-tech agriculture, India's PM-KUSUM Scheme (Kisan Urja Suraksha evam Utthaan Mahabhiyan) is a scheme which provides smallholders with subsidies for solar pumps. These examples show how specific energy regulations can improve water efficiency and sustainable farming.

In this context, the energy justice framework provides a lens to critique these policy gaps. As defined by Sovacool and Dworkin, energy justice envisions “a global energy system that fairly distributes both the benefits and costs of energy services, and one that features representative and impartial energy decision-making” (Feenstra & Özerol, 2021). Its aim is to ensure fairness in the social and economic involvement in energy systems while addressing related health, environmental, and economic inequalities (Initiative for Energy Justice, n.d.). The framework is grounded in four main dimensions which are distributive, procedural, recognition, and restorative justice and each dimension address a different aspect of systemic inequity (Agbaitoro, Hulme, & Wewerinke-Singh, 2024).

Distributive energy justice refers to the fair allocation of the benefits and burdens of energy systems, regardless of socioeconomic background or geography. This principle is critical when examining national electricity-access statistics. Malaysia's rural electricity coverage increased from 97.4% of housing units in 2020 to 97.8% in 2022 and 98.3% in 2023 (Ministry of Finance Malaysia, 2024). However, national figures can obscure regional disparities. Sabah contains eight of Malaysia's ten poorest districts, illustrating the concentration of socioeconomic disadvantage in its rural and interior areas (Ramli, 2024). In Sarawak, the Rural Power Master Plan was formulated to connect remaining rural households and achieve full electrification by 2025 (Sarawak Energy Berhad, n.d.). Nevertheless, aggregate coverage rates and policy targets can conceal the "last-mile" challenge faced by remote communities. This uneven distribution of reliable electricity access demonstrates the need for region-specific solutions (SabahRE2 Consortium, 2023).

Procedural justice addresses who gets to participate in energy-related decision-making. It demands inclusive, transparent processes where all affected groups, especially marginalised or Indigenous communities, have a meaningful voice. Procedural justice promotes the integration of local knowledge, access to complete information, and equitable representation in institutions. In Malaysia, these elements are often missing. For example, island communities in Sabah rely on unreliable grid links or diesel generators that operate only a few hours per day (University of Waterloo, 2025). Their exclusion from planning processes perpetuates a cycle where their needs are sidelined and decisions made without them fail to solve their energy problems.

In contrast, recognition justice focuses on acknowledging the unique experiences and identities of groups historically excluded from energy policies. It requires recognising who suffers most from energy injustice and understanding the historical roots of this inequality. It involves accurately identifying marginalized groups, like Sabah's smallholder farmers, and adapting policies to accommodate their needs. These farmers are unable to implement modern agricultural technologies due to high capital expenses, unstable infrastructure, and limited digital connectivity (SabahRE2 Consortium, 2023). Due to its emphasis on systemic neglect, some academics see recognition as a component of procedural justice, while others see it as a stand-alone notion (Ren et al., 2023). In any case, the rural poor in Malaysia suffer greatly when it is not included in energy planning.

Moreover, the goal of restorative justice is to repair the harm that unequal energy systems have created. It encourages direct, challenging discussions that question the status quo rather than offering quick fixes. In addition, acknowledgment alone is insufficient; meaningful justice requires listening to opposing viewpoints and making a concrete commitment to structural change (Heffron, 2022; McCauley & Heffron, 2018). In Malaysia, this can entail establishing experimental projects or localized funding models that actively address past energy injustices. This includes direct collaboration with marginalized people, particularly in Sabah and Sarawak. Thus, in the absence of restorative measures, current policies do not address historical injustices; rather, they serve to perpetuate them.

Furthermore, environmental justice and energy justice are closely related, especially when considering pollution and climate danger. Polluting energy infrastructure is often found in less developed areas, risking both human's health and the environment. To address this, renewable energy policies should be implemented to reduce emission and promote equity in access to clean energy. This is closely related to agriculture, where energy shortages can undermine both food security and rural livelihoods. For example, it has been shown that

solar-powered irrigation systems in sub-Saharan Africa increase output while cutting greenhouse gas emissions (Falchetta et al., 2023). This example shows that renewable energy is more than just a technical fix. It can also help people and the economy grow. Therefore, Malaysia's energy governance should prioritise justice to ensure fair outcomes. Failing to do so may undermine the country's progress towards the 12th Malaysia Plan's rural and environmental targets

METHODOLOGY

This study adopts a doctrinal legal research method, supported by a juridical-normative approach, as it focuses on analysing existing statutes, policies and legal principles relevant to energy law and sustainable agriculture in Malaysia. The research critically examines primary sources such as the National Renewable Energy Policy

and Action Plan (NREPAP), the National Agrofood Policy (NAP 2.0) and the Green Technology Master Plan (GTMP), alongside secondary sources including legal journals, scholarly commentaries and international guidelines. This method is appropriate as it allows the identification of legal gaps, inconsistencies and the extent to which current policies support organic farming to mitigate water crises. By grounding the analysis in legal doctrine and normative principles of energy justice and sustainability, this methodology contributes meaningfully to the discourse on environmental governance and agricultural reform.

The legal and policy materials were selected based on their relevance to renewable energy, sustainable agriculture, water management and rural development in Malaysia. Primary legal and policy sources were examined to identify their objectives, scope and provisions relating to renewable-energy development and agricultural sustainability. Secondary sources were used to support the interpretation of the legal and policy framework and to provide relevant academic perspectives. The study focuses particularly on the Renewable Energy Act 2011, NREPAP 2022–2040, NAP 2021–2030, GTMP 2017–2030 and other relevant environmental and energy-related instruments.

The analysis examined whether the existing legal and policy framework provides sufficient support for the adoption of decentralised renewable-energy technologies in agriculture, particularly for small-scale and rural farmers. Attention was given to the availability of financial incentives, technical support, regulatory mechanisms and institutional coordination. The findings were then considered through the energy justice framework, particularly the distributive, procedural, recognition and restorative dimensions, to assess whether the existing framework adequately addresses the needs and participation of rural agricultural communities. The study also considers the relationship between energy, agriculture and water resources to identify areas where greater legal and policy integration may be required.

FINDINGS

A doctrinal analysis of Malaysia's legal framework reveals a consistent gap between the country's policy objectives and their legal implementation in supporting organic farming as a strategy to address the water crisis. Although Malaysia has introduced several policy initiatives aimed at promoting sustainability, including the National Renewable Energy Policy and Action Plan (NREPAP) 2022–2040, the National Agrofood Policy (NAP) 2021–2030 and the Green Technology Master Plan (GTMP) 2017–2030, these remain large aspirational and lack effective legal backing.

The primary statutory instrument in this field is the Renewable Energy Act 2011, which introduced the Feed-in-Tariff system to promote electricity generation from renewable sources including solar photovoltaic, biomass, biogas and small-scale hydropower. While the Act has contributed significantly to increasing renewable energy capacity, particularly in grid-connected environments, its scope remains limited. The legal framework predominantly supports last-scale producers and urban application while failing to cater for off-grid solutions such as solar-powered irrigation or biogas digesters which are essential for small-scale and organic farms. As such, the Act advances national targets; it does not reflect the distinct need of agricultural stakeholders or their potential contribution to sustainable water use and energy independence (Abd Halim, 2012; Azreen, 2024).

Since its founding under the Sustainability Energy Development Authority Act 2011, the sustainability energy development authority has been instrumental in advancing green technology and energy efficiency as well as the implementation of Malaysia's Feed-in Tariff (FiT) programme in urban and industrial environments, rooftop solar photovoltaic (PV) systems have become increasingly popular due to the FiT mechanism which was later supplemented by the Net Energy Metering (NEM) scheme (Firdaus et al., 2014). Even with these successes, SEDA's efforts are still primarily focused on the grid. The development of decentralised or off-grid renewable was constrained by early FiT projects that required excess energy to be exported to the national grid through Tenaga Nasional Berhad (TNB) (Kartina et al., 2014). Despite the development of NEM 2.0 AND 3.0, the core architecture of these schemes remains dependent on grid connectivity with consumers using net metering to offset electricity bills instead of storing power for later use (MIDA, 2023). This ongoing on grid-based solar deployment draws attention to the death of frameworks or incentives that encourage off-grid



or rural renewable energy applications, especially in the agricultural and organic farming industries.

Despite evidence that solar-powered irrigation pumps, on-farm biogas digesters and agrivoltaic arrays can improve water resilience and energy self-sufficiency on organic and small-scale farms there are no specialised grant programmes, technical assistance programmes or simplified permitting procedures for farm-level installation (Ahmat et al., 2015; Eeyad et al., 2020). The relationship between agriculture, water and energy is weakened by this policy blind hole, which effectively denies rural farmers the benefits of decentralised renewables.

The Environmental Quality Act 1974 serves as a cornerstone regulation in the agriculture sector, regulating environmental contamination and guaranteeing sustainable practices. However, the Act still fails as it does not include any legal provisions that support, not only promoting or encouraging, the transition to renewable energy in agriculture, while relevant to organic farming through its environmental protection objectives, the Act does not facilitate the adoption of clean energy technologies that could improve irrigation efficiency and reduce chemical inputs (Ong et al., 2023). Despite the need for integrated legal procedures that support holistic and sustainable farming methods, this legal gap furthers the fragmented nature of Malaysia's policy landscape in which agriculture, water management and energy all function in silos.

In conclusion, in these findings, it is clear that Malaysia's legal framework remains focused on centralised energy models and does not provide the legislative infrastructure to support decentralised renewable energy use in agriculture. This absence, coupled with lack of financial and regulatory incentives, restricts the practical adoption of organic farming practices that could alleviate the national water crises.

DISCUSSION

In Malaysia's energy laws and policies, there is an apparent focus on solutions that connect to the grid, particularly in industrial and urban areas. However, there seems to be a lack of attention to the off-grid, decentralised energy requirements in the agricultural sector. The emphasis on urban legal issues continues, even though there are official statements advocating for sustainability and the growth of rural areas. The Renewable Energy Act 2011 brought in initiatives such as the Feed-in Tariff (FiT) and Net Energy Metering (NEM). However, both of these frameworks rely on access to the national grid and are primarily designed for commercial and residential use (Net Energy Metering (NEM) 3.0 by Sustainable Energy Development Authority (SEDA) Malaysia, n.d.; Abd Aziz et al., 2024). This raises the fundamental question of why does Malaysia continue to create energy policies that exclude the communities that rely heavily on land, water, and energy to survive, particularly rural farmers?

Additionally, the law tends to favor grid-based infrastructures, which can lead to an outdated approach to energy deployment. This does not align with the actual conditions faced in agricultural regions, especially in places like Sabah, Sarawak, and the inland areas of Peninsular Malaysia. These regions face challenges due to inconsistent or absent grid access. However, they are often overlooked in typical energy legislation discussions (Othman et al., 2018), 2018; Green Technology Master Plan Malaysia 2017-2030, 2017). Instead of incorporating decentralized renewable systems such as solar-powered irrigation or biogas digesters into the legal and financial framework, Malaysian energy law tends to be overly technical. In other words, Malaysian energy law is effective in its policy language but limited in its practical application. The absence of inclusive legislative planning hinders the country's efforts to meet the sustainable development goals.

Furthermore, the lack of legal attention towards decentralised renewable energy also poses serious and harmful consequences for the future of organic farming. This is because organic practices depend significantly on eco-friendly systems like drip irrigation, composting units, and storage, all of which need a reliable electricity supply. As a result, rural farmers struggle to grow their organic practices, embrace smart technologies, or lessen their reliance on chemical inputs that worsen water pollution without dependable off-grid energy access. Hence, the lack of a legal framework to support or encourage these technologies is a significant barrier to achieving sustainable agriculture where it is most needed (Çerçioğlu et al., 2025; Uyir Organic, 2024). Moreover, while the efficiency of water use in organic farming is a key advantage, this benefit is often undermined when irrigation relies on diesel pumps or makeshift grid connections. In addition, Malaysia's



water crisis is closely linked to the challenges posed by inefficient and chemically intensive agriculture (Ritchie & Roser, 2024). Despite this, the current energy laws do not provide a supportive framework for farmers to transition to more sustainable practices. This structural failure, therefore, poses a significant threat to Malaysia's goals outlined in the National Agrofood Policy 2021–2030 and, in the long run, jeopardises the sustainability of rural livelihoods. Furthermore, if organic farming continues to be seen as an exclusive or specialised practice instead of a legally endorsed movement across the country, then the environmental and social aspirations linked to it will only hold symbolic value.

Moreover, by looking at energy justice, it is clear that Malaysia's legal framework falls short across all four dimensions, which are distributive, procedural, recognition, and restorative justice. However, the shortcomings in distributive and recognition justice are particularly severe for rural organic farmers.

These structural weaknesses are clearly reflected in distributive justice, which calls for fair access to energy resources. Nonetheless, rural communities, particularly in Sabah where over 70% of those without electricity reside, continue to be neglected (Ministry of Finance Malaysia, 2024; SabahRE2, 2023). These disparities are not random; rather, they are embedded in the very structure of the law. The existing energy legislation fails to guarantee equitable access and does not allocate infrastructure development in a way that aligns with the energy demands of rural populations.

In addition, the concept of recognition justice emphasises the importance of acknowledging the specific needs and challenges faced by neglected groups. However, this aspect is frequently ignored. Rural farmers are not recognised as a distinct category of energy users under the law, despite their heavy dependence on land and water. Without legal mechanisms tailored to their circumstances, they remain invisible in national energy planning. As a result, policies aimed at modernising agriculture often ignore the needs of rural farmers, whose practices are closely tied to ecological and social sustainability. This legal and institutional exclusion reveals a deeper pattern of systemic inequality, in which those most vulnerable to environmental degradation are the least protected by existing energy policies (Agbaitoro et al., 2024).

One of the reasons for this failure is in the fragmentation of Malaysia's legal policy frameworks across the sectors such as energy, water and also agriculture. Even though we have the Renewable Energy Act 2011, the Green Technology Master Plan (GTMP) shares the common goal to promote sustainability, they operate in silos which leads to a lack of institutional or legal framework that requires a cross-sectoral cooperation. Hence, the opportunities to create synergies are often ignored, such as incorporating biogas systems into the organic farms or employing decentralised solar power for irrigation. This lack of coherence in the law is also evident in other South and Southeast Asian countries, where it can be seen that fragmented mandates and unaligned planning cycles hinder effective resource governance (Rasul & Neupane, 2021).

In Malaysia, this problem is very noticeable. Although the GTMP promotes green technologies, it lacks any legally binding mechanisms to align energy initiatives with water and agriculture needs. This is largely because agriculture is not identified as a core sector, and the plan itself is not legally enforceable but functions merely as a policy guideline (Malaysian Green Technology Corporation, 2017). The water, energy and agricultural sectors are governed separately with minimal coordination which contributes to the broader issue of policy fragmentation. Although Malaysia has the Renewable Energy Act 2011 and the National Water Resources Policy, there is still no legal mechanism to enable effective coordination between these sectors. The Water Sector Transformation 2040 report emphasises that institutional segregation and limited data exchange continue to impede integrated planning and progress in rural agricultural sustainability (Economic Planning Unit & Academy of Sciences Malaysia, 2022). In contrast, India's PM-KUSUM scheme incorporates solar energy into agriculture through legal and financial support for decentralised irrigation systems. This shows how aligned policies can help to improve rural sustainability (International Institute for Sustainable Development [IISD], 2023).

The problems discussed so far show that policies in Malaysia will remain ineffective and fragmented without legal reform, especially as climate change increases water scarcity and threatens rural farming systems. Although Malaysia's plans, such as the GTMP and Renewable Energy Act, aim to support sustainability, it is not enough, as they are not legally binding and do not facilitate different sectors to work together. Because of



this, organic farmers find it difficult to get the energy they need for irrigation and other farming tasks. Therefore, stronger laws are required to protect the rights of future generations as according to Weiss (1989), fairness between generations means that we must care for the environment today so that others can benefit tomorrow. Otherwise, efforts to support rural farming and solve the water crisis will remain just ideas on paper and not real change if legal reform does not happen.

RECOMMENDATION

In light of the doctrinal gaps identified between Malaysian energy laws and the practical needs of organic farming to mitigate the national water crisis, it is recommended that Malaysia adopt an integrated, legally binding framework combining decentralised renewable energy incentives with targeted support for small-scale and organic farmers.

Establishing a Statutorily Mandated Cross-Sectoral Legal Framework Integrating Energy, Water and Agricultural Policies.

To effectively support organic farming in Malaysia and address the escalating national water crisis, a statutory framework that legally binds the energy, water and agriculture sectors is crucial. Current Malaysian legal structure functions in isolated silos with each sector operating under its own regulatory ecosystem. This fragmentation hinders the ability to develop a cohesive national strategy for sustainable agriculture that includes energy access as a core component. The Renewable Energy Act, Green Technology Master Plan and National Agrofood Policy offer commendable sustainability goals yet they lack enforceable mechanisms that encourage inter-ministerial cooperation or cross sectoral legal mandates. As a result, though Malaysia aspires toward environmental and agricultural resilience, these goals remain largely rhetorical though legal instruments that translate them into actionable synergies.

According to Rasul & Sharman (2016), Malaysia should enact the Water-Energy-Agriculture Nexus Act which mandates coordinated planning and implementation by the Ministry of Agriculture and Food Security, Ministry of Energy Transition and Public Utilities. This is to ensure effectiveness in operation and it should be binding provisions for joint environmental targets, shared resource databases and collaborative funding models. It should also explicitly recognise and support organic farmers as key stakeholders in the clean energy transition.

This Act, as supposed by Endo et al (2017), will help Malaysia fulfill its obligation under the SGD particularly on Goal 2 of Zero Hunger, Goal 6 of Clean Water and Sanitisation and Goal 7 of Affordable and Clean Energy.

Implement Dedicated Financial and Technical Support Schemes for Decentralised Renewable Energy Adoption in Organic Farming

In addition, to genuinely assist organic farming in Malaysia and address the escalating water crisis, it is essential to enhance efforts in providing rural farmers with financial aid and adequate training to adopt decentralized renewable energy solutions. For instance, it can be highlighted that current mechanisms, such as feed-in tariffs, fail to adequately assist individuals and small businesses during the installation process. This emphasizes the need for new green financial frameworks, including green loans, bonds, and subsidies, to address the financing gaps for renewable energy projects. Additionally, SEDA and energy regulators may also jointly work with banks and investors in order to create a blended-finance scheme. This idea is proposed to lower the upfront costs for small producers (Abd Aziz et al., 2024). Similarly, Bank Negara's JC3 initiative has introduced a RM1 billion guarantee scheme for ESG financing, designed to enhance SME access to green credit. JC3 has introduced an exciting new Green AgriTech program in collaboration with the Agriculture Ministry and LPP. This initiative aims to assist farmers in embracing sustainable technologies, highlighting the importance of innovation support and funding in the agricultural sector (JC3 Announces Initiatives to Support an Inclusive Transition to a Greener Economy, 2023).

Furthermore, building capacity is also an important aspect to look at. This can be seen whereby Malaysia's adoption of renewable energy is hindered by a lack of awareness initiatives in rural regions. This calls for

enhanced public education and technical support to encourage community participation (Abd Aziz et al., 2024). Likewise, according to Khazanah Research Institute (2020), a survey shows that smallholders with organic certification (MyGAP) were significantly more likely to have received training, cooperative assistance, and access to technology compared to uncertified farmers. This shows that an adequate agricultural support level is essential to improve farmers' practices and advocates for increased knowledge-sharing and training sessions for smallholders.

Legal Recognition and Prioritisation of Organic Farming in National Energy and Environmental Policy

Lastly, organic farming should be recognised by the law in Malaysia as an essential component of its environmental and clean energy policies. Although policies such as Renewable Energy Act 2011 and Green Technology Master Plan encourage sustainability, organic farmers especially those in rural areas, are not specifically protected by the law (Malaysian Green Technology Corporation, 2017). Because of this, the government should therefore take action to amend current energy and environmental laws in order to make organic farming widely recognised and accepted. For instance, an amendment to the Renewable Energy Act 2011 could include a special clause that allows organic farmers to access solar-powered systems, biogas and other small-scale clean energy technologies. By doing this, organic farming benefits significantly from these technologies, particularly in remote areas with limited access to grid electricity.

Moreover, this amendment will help places like Sabah and Sarawak, where many rural farmers struggle to access reliable electricity. According to the Ministry of Finance (2024), Sabah accounts for 72% of rural Malaysians without electricity. These farmers are frequently excluded from national programmes that focus mainly on grid-connected systems.

In addition, according to Malaysian Green Technology Corporation (2017), the Green Technology Master Plan promotes sustainable practises but is not legally binding. These policy objectives could become enforceable if organic farming were given legal status under energy and environmental laws. This can be achieved by enacting a 'green agriculture' provision that gives certified organic farmers access to simplified permits, tax exemptions, or government grants to implement renewable energy sources like solar irrigation and biogas systems. Thus, by putting such legal amendments into effect, Malaysia would also be able to get closer to its energy and environmental goals, particularly those related to reduced pollution, clean water access and renewable energy development. In order to address rural energy inequality and the national water crisis, these initiatives would further Malaysia's commitment to the Sustainable Development Goals, especially Goal 6 (Clean Water and Sanitation) and Goal 7 (Affordable and Clean Energy).

CONCLUSION

In conclusion, organic farming has been identified as a viable solution as it uses less water and adopts environmentally friendly methods. Although organic farming is essential to Malaysia's environmental sustainability, current laws and policies fail to provide sufficient support particularly for farmers in rural areas. For instance, Malaysia has introduced several policies such as the Renewable Energy Act 2011, Green Technology Master Plan, and the National Agrofood Policy 2021–2030. However, these frameworks remain disconnected from the actual needs of smallholder farmers.

The legal framework remains fragmented making it difficult for organic farmers to benefit from renewable energy initiatives. Therefore, legal changes are required to solve this, integrating agricultural and energy policy, offering targeted financial support, and formally recognising organic farming under energy and environmental laws.

Moreover, from the view of energy justice, Malaysia's legal framework falls short across all dimensions which are distributive, procedural, recognition, and restorative. The unequal distribution of electricity in rural areas, lack of inclusive decision-making, and failure to acknowledge the unique needs of smallholder farmers in

policy design show deep-rooted systemic injustices. Without deliberate legal measures to prioritise and empower these communities, the cycle of neglect will continue, leaving the country's sustainability goals



unachievable.

These changes are crucial for achieving energy justice and reducing rural inequality. Enhancing the legal backing for organic farming would contribute to the development of a more sustainable and inclusive Malaysian future.

REFERENCES

1. Abd Aziz, A. J., Baharuddin, N. A., Md. Khalid, R., & Kamarudin, S. K. (2024). Review of the policies and development programs for renewable energy in Malaysia: Progress, achievements and challenges. *Energy Exploration & Exploitation*, 42(4), 1472–1501. <https://doi.org/10.1177/01445987241227509>
2. Achkar, R. (2024). The intersection of climate justice and energy equity. LinkedIn. <https://www.linkedin.com/pulse/intersection-climate-justice-energy-equity-dr-roger-achkar-wl5vf>
3. Agbaitoro, G., Hulme, K., & Wewerinke-Singh, M. (2024). Energy justice discourse: Global South perspectives. *Journal of Energy & Natural Resources Law*, 42, 251–254. <https://doi.org/10.1080/02646811.2024.2368985>
4. Ahmad, E. Z., Halyani, M. Y., Norain, I., Windiarti, H., Firdaus, H. M. S., Miswan, N., & Zulfattah, Z. M. (2015). Stand-alone solar photovoltaic for rural electrification: A case study in Kampung SG Lah, Tapah, Malaysia. *Jurnal Teknologi*, 76(4), 65–69. <https://doi.org/10.11113/jt.v76.5487>
5. Arfa, A. (2025, April 7). Who's blocking the sun? Barriers to solar power in Malaysia. Taylor's University. <https://university.taylors.edu.my/en/student-life/news/2025/who-blocking-the-sun-barriers-to-solar-power-in-malaysia.html>
6. Asri, E. A., Khalit, S. I., Hampden, A. Z., Mustafa, M. A., & Mohd, N. (2020). Prototype design of rainwater harvesting and solar irrigation system for small-scale farm. *Journal of Agrobiotechnology*, 11(1S), 92–102. <https://doi.org/10.37231/jab.2020.11.1S.238>
7. Barry, B. (1999). Sustainability and intergenerational justice. In A. Dobson (Ed.), *Fairness and futurity: Essays on environmental sustainability and social justice* (pp. 93–117). Oxford University Press. <https://doi.org/10.1093/0198294891.003.0005>
8. Bartlett, E., & Sayol, M. (2024, December 23). Key functions of specialization in energy law. Esade. <https://www.esade.edu/beyond/en/key-functions-of-specialization-in-energy-law/>
9. Çerçioğlu, M., Udawatta, R. P., & Anderson, S. H. (2025). Use of cover crops for sustainable management of soil condition and health: A review. *Soil Security*, 18, Article 100177. <https://doi.org/10.1016/j.soisec.2025.100177>
10. Che Omar, S., Abu Rahim, M. A. R., Nik Sharifulden, N. S. A., & Teoh, A. N. (2024). Understanding the landscape of agrifood smallholders in Malaysia: Climate risks, sustainable standards, and gender gap. Khazanah Research Institute. <https://www.krinstitute.org/publications/understanding-the-landscape-of-agrifood-smallholders-in-malaysia-climate-risks-sustainable-standards-and-gender-gap>
11. Codogni, T. (2026). Sustainable energy consumption and prosumer models in Polish law. *Sustainability*, 18(16), 8038 <https://doi.org/10.3390/su18168038>.
12. Dunlap, A., & Sovacool, B. K. (2020). The dark side of 'renewable' energy: Green extractivism, environmental injustice and a political ecology of decarbonization. *Energy Research & Social Science*, 68, 101524. <https://doi.org/10.1016/j.erss.2020.101524>
13. Dworkin, R. (1977). *Taking Rights Seriously*. Harvard University Press.
14. Economic Planning Unit. (2022). Water sector transformation 2040 (WST2040): Integrated Water Sector Data Centre (IWSDC) (Vol. III). Academy of Sciences Malaysia. https://www.ekonomi.gov.my/sites/default/files/2022-10/6.%20WST2040%20VOLUME%20III_IWSDC.pdf
15. Encyclopaedia Britannica. (n.d.). Organic farming. <https://www.britannica.com/topic/organic-farming>
16. Endo, A., Tsurita, I., Burnett, K., & Orenco, P. M. (2017). A review of the current state of research on the water, energy, and food nexus. *Journal of Hydrology: Regional Studies*, 11, 20–30. <https://doi.org/10.1016/j.ejrh.2015.11.010>
17. European Commission. (2020, May 20). A farm to fork strategy for a fair, healthy and environmentally-friendly food system (COM(2020) 381 final). <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0381>



18. European Parliament & Council of the European Union. (2013). Regulation (EU) No 1305/2013 on support for rural development by the European Agricultural Fund for Rural Development (EAFRD). Official Journal of the European Union, L 347, 487–548. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32013R1305>
19. European Parliament and Council of the European Union. (2018). Directive (EU) 2018/2001 of 11 December 2018 on the promotion of the use of energy from renewable sources (recast). Official Journal of the European Union, L 328, 82–209. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32018L2001>
20. Falchetta, G., Semeria, F., Tuninetti, M., Giordano, V., Pachauri, S., & Byers, E. (2023). Solar irrigation in sub-Saharan Africa: Economic feasibility and development potential. *Environmental Research Letters*, 18(9), Article 094044. <https://doi.org/10.1088/1748-9326/acefe5>
21. Feenstra, M., & Özerol, G. (2021). Energy justice: A Framework For The Global Energy Transition. *Sustainability*, 13(18), 10142. <https://doi.org/10.3390/su131810142>
22. Finley-Brook, M., & Holloman, E. L. (2016). Empowering Energy Justice. *International Journal of Environmental Research and Public Health*, 13(9), 926. <https://doi.org/10.3390/ijerph13090926>
23. Hahn, C., Lindkvist, E., Magnusson, D., & Johansson, M. (2025). The Role Of Agriculture In A Sustainable Energy System – The farmers’ perspective. *Renewable and Sustainable Energy Reviews*, Article 115437, 1–12. <https://doi.org/10.1016/j.rser.2025.115437>
24. Hasim, K., Almsafir, M. K., & Kumaran, V. (2014). An economic evaluation of grid-connected photovoltaic generation system for residential house in Malaysia. *Journal of Advanced Science and Engineering Research*, 4(1), 47–60.
25. Heffron, R. J. (2022). Applying energy justice into the energy transition. *Renewable and Sustainable Energy Reviews*, 156, Article 111936.
26. Heffron, R. J., & McCauley, D. (2018). What is the “just transition”? *Geoforum*, 88, 74–77. <https://doi.org/10.1016/j.geoforum.2017.11.016>
27. Ibrahim, I. Z., Abdul Wahab, M. A. M., & Suhaimi, S. (2016, January 30). Organic agriculture in Malaysia. FFTC Agricultural Policy Platform. <https://ap.fftc.org.tw/article/1010>
28. Joint Committee on Climate Change. (2023, October 23). JC3 announces initiatives to support an inclusive transition to a greener economy. <https://www.jc3malaysia.com/news/jc3-announces-initiatives-to-support-an-inclusive-transition-to-a-greener-economy>
29. Kardooni, R., Yusoff, S. B., & Kari, F. B. (2015). Barriers to renewable energy development: Five fuel policy in Malaysia. *Energy & Environment*, 26(8), 1353–1361. <https://doi.org/10.1260/0958-305X.26.8.1353>
30. Kong, H. W. (2002). Policy Analysis Of Malaysia’s Bioenergy Programme: A Study On Social And Economic Impact. FAO. <https://www.fao.org/4/XII/0856-A1.htm>
31. Malaysian Green Technology and Climate Change Corporation. (2023). Green practices guideline for livestock sector. https://www.mgtc.gov.my/wp-content/uploads/2023/08/2-MGTC-GG_2023_Livestock_030823_SINGLE_Rv1.1.pdf
32. Malaysian Investment Development Authority. (2023, December 27). Home rooftop solar energy system – a reality check. <https://www.mida.gov.my/mida-news/home-rooftop-solar-energy-system-a-reality-check/>
33. Malik, V., Tomar, B., Kumar, M., & Kumari, M. (2023). Exploring the benefits of organic farming for health and the environment. *Agri India Today*, 5(10), 362–365. <https://www.researchgate.net/publication/374587072>
34. Marciniuk-Kluska, A., & Kluska, M. (2023). Forecasting energy recovery from municipal waste in a closed-loop economy. *Energies*, 16(6), 2732. <https://doi.org/10.3390/en16062732>
35. McCauley, D., & Heffron, R. (2018). Just transition: Integrating climate, energy and environmental justice. *Energy Policy*, 119, 1–7. <https://doi.org/10.1016/j.enpol.2018.04.014>
36. Ministry of Agriculture and Food Industries Malaysia. (2021). National agrofood policy 2021–2030 (NAP 2.0). <https://faolex.fao.org/docs/pdf/mal211654.pdf>
37. Ministry of Energy, Green Technology and Water Malaysia. (2017). Green technology master plan Malaysia 2017–2030. <https://www.pmo.gov.my/wp-content/uploads/2019/07/Green-Technology-Master-Plan-Malaysia-2017-2030.pdf>
38. Ministry of Finance Malaysia. (2024). Statistical tables: Economic outlook 2025.



- <https://belanjawan.mof.gov.my/pdf/belanjawan2025/economy/Statistical-Tables.pdf>
39. Muhammad-Sukki, F., Abu-Bakar, S. H., Munir, A. B., Mohd Yasin, S. H., Ramirez-Iniguez, R., McMeekin, S. G., Stewart, B. G., & Abdul Rahim, R. (2014). Progress of feed-in tariff in Malaysia: A year after. *Energy Policy*, 67, 618–625. <https://doi.org/10.1016/j.enpol.2013.12.044>
40. Nazarov, D., Sulimin, V., Shvedov, V., & Larionova, N. (2024). Biomass energy use in greenhouse agriculture in the Netherlands. *E3S Web of Conferences*, 541, Article 01002. <https://doi.org/10.1051/e3sconf/202454101002>
41. Omar, Z., Saili, A. R., Abdul Fatah, F., Abd Aziz, A. S., Yusup, Z., Rola-rubzen, F., & Bujang, A. S. (2024). Exploring the challenges of adopting smart farming in the agriculture sector among smallholders in Malaysia. *International Journal of Academic Research in Business and Social Sciences*, 14(6), 1654–1663. <https://doi.org/10.6007/IJARBSS/v14-i6/21810>
42. Othman, N. F., Mat Su, A. S., & Ya'Acob, M. E. (2018). Promising potentials of agrivoltaic systems for the development of Malaysia green economy. *IOP Conference Series: Earth and Environmental Science*, 146(1), Article 012002. <https://doi.org/10.1088/1755-1315/146/1/012002>
43. Othman, N. F., Ya'acob, M. E., Lu, L., Jamaluddin, A. H., Mat Su, A. S., Hizam, H., Shamsudin, R., & Jaafar, J. N. (2023). Advancement in Agriculture Approaches with Agrivoltaics Natural Cooling in Large Scale Solar PV Farms. *Agriculture*, 13(4), 854. <https://doi.org/10.3390/agriculture13040854>
44. Rahman, H. A. (2021). Water Issues In Malaysia. *International Journal Of Academic Research In Business And Social Sciences*, 11(8), 860–875. <https://doi.org/10.6007/IJARBSS/v11-i8/10783>
45. Ramli, F. (2024, November 19). Insights into Sabah's rural and interior poverty. *Bernama*. <https://www.bernama.com/en/news.php?id=2364927>
46. Rasul, G., & Neupane, N. (2021). Improving policy coordination across the water, energy, and food sectors in South Asia: A framework. *Frontiers in Sustainable Food Systems*, 5, Article 602475. <https://doi.org/10.3389/fsufs.2021.602475>
47. Rasul, G., & Sharma, B. (2016). The nexus approach to water–energy–food security: An option for adaptation to climate change. *Climate Policy*, 16(6), 682–702. <https://doi.org/10.1080/14693062.2015.1029865>
48. Ritchie, H., & Roser, M. (2024). Water Use And Agriculture. *Our World In Data*. <https://ourworldindata.org/water-use-agriculture>
49. Rowlands, I. H., Ahmad, M. S., & Herdem, M. (2025, March 21). Exploring hydrogen for energy development in remote communities: Comparing Canadian and Malaysian prospects. *pv magazine*. <https://www.pv-magazine.com/2025/03/21/exploring-hydrogen-for-energy-development-in-remote-communities-comparing-canadian-and-malaysian-prospects/>
50. Sabah Renewable Energy Rural Electrification Consortium. (2023). Sabah Renewable Energy Rural Electrification Roadmap. <https://www.sabahre2roadmap.org/>
51. Sarawak Energy Berhad. (n.d.). Rural Electrification. <https://www.sarawakenergy.com/what-we-do/rural-electrification>
52. Schnetzer, J., & Pluschke, L. (2017). Solar-powered irrigation systems: A clean-energy, low-emission option for irrigation development and modernization. Food and Agriculture Organization of the United Nations. <https://www.fao.org/3/bt437e/bt437e.pdf>
53. Shamsuddin, A. H. (2012). Development of renewable energy in Malaysia-strategic initiatives for carbon reduction in the power generation sector. *Procedia Engineering*, 49, 384–391. <https://doi.org/10.1016/j.proeng.2012.10.150>
54. Sheehan, K. (2019, December 23). Section 1—Defining energy justice: Connections to environmental justice, climate justice, and the just transition. Initiative for Energy Justice. <https://iejusa.org/section-1-defining-energy-justice/>
55. Sovacool, B. K., Ali, S. H., Bazilian, M., Radley, B., Nemery, B., Okatz, J., & Mulvaney, D. (2020). Sustainable minerals and metals for a low-carbon future. *Science*, 367(6473), 30–33. <https://doi.org/10.1126/science.aaz6003>
56. Streimikiene, D., & Siksnyte-Butkiene, I. (2021). Barriers and drivers of renewable energy penetration in rural areas. *Energies*, 14(20), 6452. <https://doi.org/10.3390/en14206452>
57. Sustainable Energy Development Authority Malaysia. (n.d.). Net energy metering (NEM) 3.0. <https://www.seda.gov.my/reportal/nem/>
58. Taguta, C., Dirwai, T. L., Senzanje, A., Sikka, A., & Mabhaudhi, T. (2022). Sustainable Irrigation



Technologies: A Water-energy-food (Wef) Nexus Perspective Towards Achieving More Crop Per Drop Per Joule Per Hectare. *Environmental Research Letters*, 17(7), 073003. <https://doi.org/10.1088/1748-9326/ac7b39>

59. Tan, H. P., Yap, E. H., & Abakr, Y. A. (2020). A system dynamics analysis of the water–energy nexus in Malaysia. *Systems*, 8(2), Article 19. <https://doi.org/10.3390/systems8020019>
60. United Nations General Assembly. (2015). Transforming our world: The 2030 Agenda for Sustainable Development (A/RES/70/1). <https://undocs.org/A/RES/70/1>
61. Uyr Organic. (2024). The Environmental Impact Of Organic Farming Vs. Conventional Farming. <https://uyirorganic.farm/the-environmental-impact-of-organic-farming-vs-conventional-farming/>
62. Weiss, E. B. (1989). In fairness to future generations: International law, common patrimony, and intergenerational equity. Transnational Publishers.