POWER FOR ALL

Powering Agriculture With Renewable Energy: A Just Transition for Food Systems

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Contents

About this Paper

Fragile and unsustainable, the modern fossil-fueled agrifood system is both a cause and effect of climate change. Today's global food system accounts for nearly one-third of all GHG emissions. With extensive supply chains, dependency on fossil fuels, and inequitable access to the means of productivity—the agribusiness sector is failing to deliver a food system that can feed our collective future.

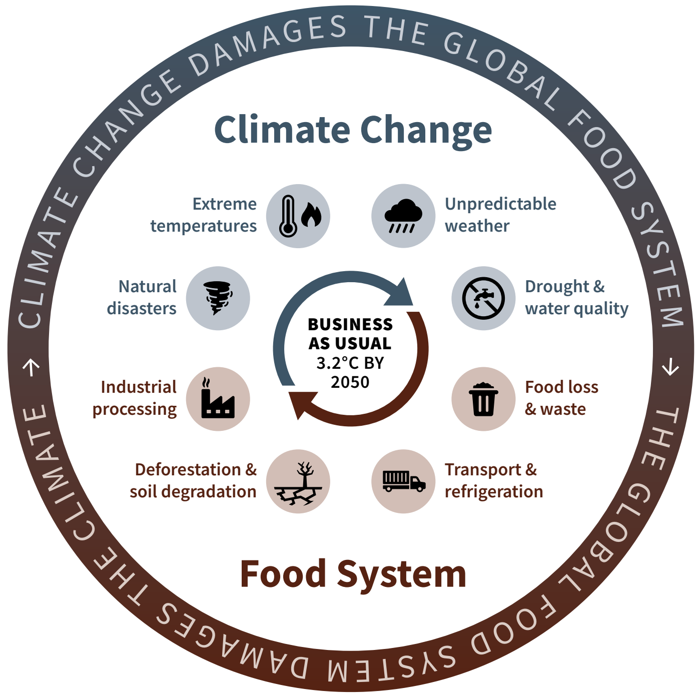
Decarbonizing our food system across the value chain—starting with the type of energy used to power it—can improve outcomes globally and locally. There are specific actions that governments, farmers and bankers can take to transform this system and support greater use of renewable energy. These actions help create a world where the tools for productive use, mini-grids, and rooftop systems collaborate to create a future of food that is localized, sustainable, and resilient.

Power for All is a global campaign to end energy poverty by accelerating adoption of distributed renewable energy (DRE). This Call to Action is part of the Powering Agriculture campaign, a multi-stakeholder initiative to increase use of renewable energy across the global food system for more sustainable, resilient and equitable future. Learn more at powerforall.org.

I. Executive Summary

The Sustainable Development Goals (SDGs) are in trouble. The twin challenges of food insecurity (SDG 2) and energy poverty (SDG 7) are among the most intractable of the Global Goals, and the most damaging to people and planet if not progressed by 2030. The climate crisis at this nexus of energy and agriculture is due to a complex, fossil fuel-intensive system that, as currently designed, is not sustainable, resilient, or equitable. In fact, today's $8 trillion international agribusiness industry[1]—including production, aggregation, processing, distribution, and disposal—is a core driver of climate change, accounting for 30 percent of all global GHG emissions.[2] (See Appendix A)

FIGURE 1: INCREASING FOOD PRODUCTION INTENSIFIES CLIMATE CHANGE



An estimated 80 percent of power used by the food system is derived from fossil fuels.[3] Current efforts to meet the 60 percent increase in demand for food by 2050—due to an expected 10 billion people on the planet by mid-century—will warm the globe far past the limit of 1.5 degrees Celsius.[4] As the current agrifood system accelerates climate change—contributing to higher temperatures, sea level rise, increasing drought—the sector's ability to feed the population is increasingly compromised. (Figure 1) The climate knows no state lines or national boundaries; the Global North is responsible for the vast majority of climate change, but the countries least responsible for the intensifying food-climate crisis across the Global South suffer the most. This inequity threatens to destabilize regional economies and the global environment—further handicapping disadvantaged food systems in regions like sub-Saharan Africa to keep pace with regional population growth.[5,6]

Given the interdependent nature of the climate crisis, imbalances in the food system threaten lives and livelihoods alike, wherever they reside. Alongside prioritizing clean power across the SDG 2 ecosystem, increasing access to sustainable and affordable energy and equipment for the world's smallholder farmers can play an outsized role mitigating the inequity and insecurity in agribusiness today, while helping meet the food demands of tomorrow. Decentralized renewable energy or DRE, such as mini-grids, PV systems, and agricultural appliances will not only support livelihoods of smallholder farmers—part of an equitable agricultural sector—but can help decarbonize the food system while growing national economies. With political will and financial support, the DRE market has the potential to reduce transport, decrease site-based use of fossil fuels and increase productivity of local farmers and cooperatives, ratcheting down the impacts of diesel, petrol, and kerosene—and helping to decarbonize the future of food.

Driving adoption of DRE in developed and developing countries alike can localize clean, productive use of energy such as solar water pumps and cold storage. Decentralization can both mitigate current and future emissions, and support adaptation to the effects of climate change. In particular, DRE can help address energy and economic inequities that are limiting the ability of Africa—and therefore the rest of the food system—to meet the demands of a growing population in a climate-changed world. Underutilized today, DRE can be part of a set of solutions to grow production by increasing affordability of energy democratizing productivity and supporting climate change adaptation and mitigation. Indeed, DRE has the potential to recalibrate the global balance of power in the food system, and increase humanity's chances to do more than survive—but to thrive—in 2050 and beyond.

II. The Food System: Limits of Business As Usual

Africa's agricultural system holds more promise to transform the food system than any other region.

Despite SDG 2's success being intertwined with SDG 7, the benefit of an energy transition for agriculture has largely been overlooked at both local and global levels. Modern agribusiness practices—with extensive supply chains, unchallenged use of fossil fuels and inequitable access to affordable mechanization—pose an unprecedented threat when combined with population growth and climate change.[7,8,9] Climate change cannot be contained by lines drawn on a map; as vulnerability grows in one region, the entire food system becomes more fragile. The populations most impacted are often the least responsible and the least equipped to adapt—the same regions where population and food demand will be exploding in the next 25 years.[10] (Figure 2) Among these regions, Africa is ground zero: With vast arable lands, a booming population, and lowest rates of energy access in the world, Africa's agricultural system holds more promise to transform the food system than any other region on the globe and as such is a focus of this paper.

Africa: The State of Energy Access and Agriculture

Africa is home to the majority of the world's uncultivated land and is abundant in sunshine, but has stubbornly low rates of energy use and agricultural productivity. The inequities that limit agricultural independence—access to energy, tools, and finance for farmers and co-ops—and the impacts of other regions' "value additions" coalesce in Africa. Of the 10 most climate-vulnerable and least resilient countries, nine are in Africa, where millions rely on agriculture for jobs, but lack access to the (clean) energy needed to power a more resilient and profitable food future.[11] With over 600 million people without power, decades of compounded income inequality and growing climate fragility, the African continent has been systemically prevented from achieving its full agricultural—and human—potential. Without reliable access to energy, tools, and finance to support a robust independent, regional food system, Africa is increasingly dependent on foreign countries to feed its population. Dependence on others is not food security at all. As the consequences of climate change and the demands of a growing population intensify, vulnerability will only increase. As agricultural supply chains are interrupted and climate patterns become more

Box 1: How The Green Revolution Failed Africa

Agriculture is the world's largest economic sector, and deeply entwined with poverty and wealth alike. Wealthier regions have monopolized the value creation of food. Processing (e.g., roasting and packaging coffee) is the highest income-generating link in the agribusiness value chain. Africa is the only region in the world where the GDP contribution from agriculture is higher than that from agribusiness.[20] Africa is capturing far less profits from food production due to limited processing capabilities on the continent, much of which is traceable to energy poverty. The lack of energy access on the continent—particularly in peri-urban and rural areas, where most farms exist—has inhibited the widespread adoption of technology and hence productive use of energy for agriculture in many developing regions, but none more so than Africa. (See Appendix B)

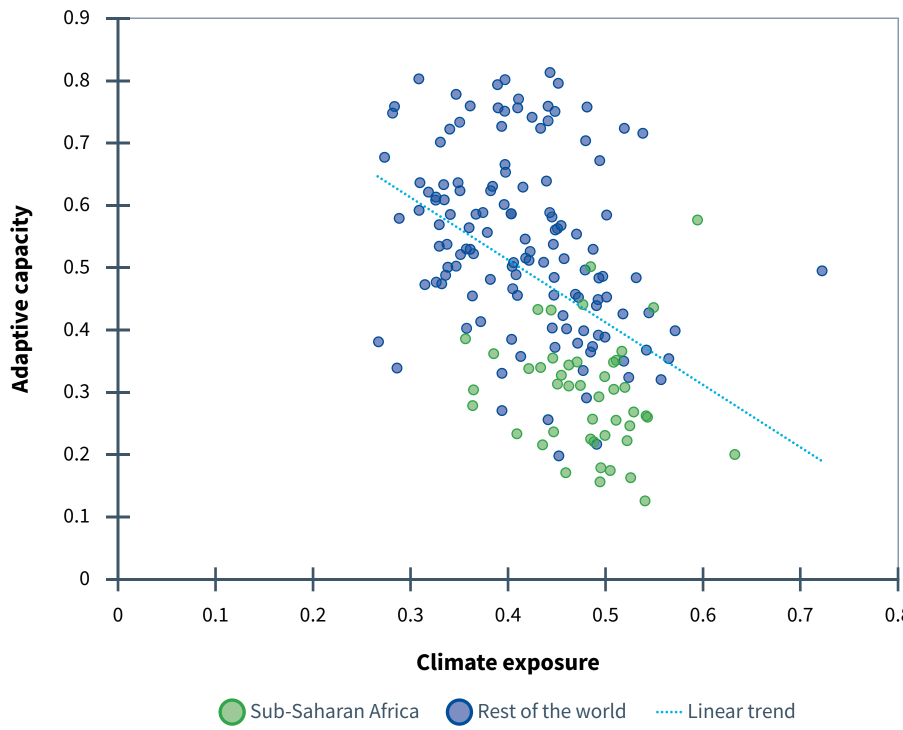
II. The Food System: Limits of Business As Usual

unpredictable, an energy transition for Africa's agriculture sector is a necessity.

The Green Revolution That Left Millions Behind

Global food security has been a focus of the U.N.'s Food and Agriculture Organization (FAO) since the organization was established in the 1940s. Stretching back to the 1970s, concerns about food supply—including the global food crisis of 2008-2009, the Ethiopian famines in the 1980s, and the events that led to Green Revolution in the 1970s—were solved largely by intensification and mechanization, mostly powered by fossil fuels.[12,13,14] This revolution shaped modern agricultural practices and increased productivity and farmer incomes in some countries, but largely bypassed Africa, due to differences in population densities, poor infrastructure, and lack of political support.[15,16] Despite Africa being a potential breadbasket for the planet with 65 percent of the world's remaining uncultivated arable land, the continent imports a sizable proportion of its food demand (estimated net imports of $50 billion), around 1.6 percent of its GDP.[17,18,19] Many well-funded, well-intentioned philanthropic initiatives have attempted to build a more self-reliant agriculture sector in Africa (including the Alliance for a Green Revolution in Africa or AGRA's emphasis on high-yield seeds), but have failed to increase access to reliable, affordable and renewable energy, without which, agricultural independence cannot occur.

FIGURE 2: CLIMATE-EXPOSED COUNTRIES HAVE LESS ADAPTIVE CAPACITY[10]



The adaptive capacity index summarizes the availability of resources that countries have to adapt to climate change and maintain livelihoods and well-being. The climate exposure index measures the exposure and vulnerability of countries to climate change, independent of their economic resources. Source: Power for All calculations based on ND-GAIN data.

Growing Food Security: Transformation Plans

Agriculture is the main economic activity across the African continent, employing the majority of the population and providing the largest source of income and foreign exchange for many countries.[20] Most African countries (85 percent) have developed agricultural transformation plans (ATPs), created by either ministries of agriculture or national planning agencies to expand the economic power of each nation's agribusiness. A local echo to a global problem, only a fraction of the plans name energy, let alone renewable energy, as a critical input. While some ATPs mention sustainable farming and "climate smart" agriculture, access to renewable energy (primarily solar water pumps) is only mentioned in 26 percent of the existing plans, and DRE—purpose built for peri-urban and rural areas, where most farms are located, and function outside of national electrification plans and grids—is noted even less. (Appendix D) Despite the interconnected nature of SDG 2 and SDG 7, most ATPs lack a shared sense of responsibility between agricultural and energy ministries, departments or agencies. With one exception (Uganda), all ATPs fail to assign budgets and responsibilities, omit baselines, and lack measurable targets, suggesting "transformation" is in danger of not being implemented at all.[21]

III. Localizing the Global Food System with DRE

The modern food system is responsible for climate change and disparities between the Global North and the Global South, but the agriculture sector can also be a powerful lever of change. Agriculture plays a central role in the economies of almost all African countries and can be a source of great transformation. Africa's low agro-economic productivity is governed by a lack of energy access that limits the use of critical farming inputs like irrigation systems or cold storage. The good news: Accelerating adoption of renewable solutions into the agribusiness value chain can help achieve what the Green Revolution failed to do: map one of the key inputs for agricultural transformation—energy—to fit the needs of the population.

Decentralized Renewable Energy's Potential to Build a Robust and Resilient Food System

Africa's agrifood sector has low mechanization and high labor intensity; almost 85 percent of farms lack energy access, only 5 percent of cropland is equipped with irrigation, and 65 percent is tilled, plowed, or weeded manually.[27,28,29,30] Mechanization is critical to improving agricultural productivity, and is essential for meeting the food needs of a population expected to reach 10 billion by 2050. Given that half of the global population explosion in the coming decades will be centered in Africa, a new food framework that reduces dependencies on international supply chains (which are largely powered by fossil fuels) is foundational to agricultural transformation plans, and requires prioritization of local energy access. While numerous organizations—including IRENA, FAO, Efficiency for Access, CLASP, RMI, SNV and others—have addressed a range of opportunities to improve the agrifood system, detailed understanding of energy flows in the agrifood system is critical to well-informed decision-making for public and private sectors alike.

To this end, increased energy access through DRE technologies has the

Box 2: The Missing Link: Smallholder Farmers, Renewables and the Future of a Food System

Smallholder farmers are the foundation of a sustainable food system. Accounting for the vast majority of farmers globally (over 80 percent), smallholders are responsible for almost a third of the total food production.[22] Defined as farms less than two hectares in size, smallholders are on the front lines of SDG 2 and SDG 7,[23] suffering both food and energy insecurity. Smallholder farms and cooperatives can play a critical, underestimated role in the agricultural energy transition, if empowered with access to renewable technology. Smallholders mostly sell locally, helping to reduce imports, which are a major source of both emissions and institutionalized dependence.[24,25] Given their critical role in achieving food self-sufficiency and mitigating emissions, a wholesale effort to convert smallholders to DRE could increase productivity, incomes, and overall food supply, especially in the 65 percent of the land in sub-Saharan Africa that is currently tilled, plowed and weeded manually.[26]

III. Localizing the Global Food System with DRE

TABLE 1: DRE POTENTIAL TO IMPROVE AGRICULTURAL ECONOMICS, SOCIAL BENEFIT, AND REDUCE CLIMATE RISK[A]

Value chain stage	Total African agrifood system GHG	Tools and technology	Incumbent technology	GHGs of business as usual	DRE technology	% GHG reduction with DRE	Potential economic impact
Production	1,117,733 Kt CO_2 eq per year	Water pump	Diesel	2,333 Kt CO_2 eq per year	Solar-powered water pumps	20%	$5,379 million
		Cold storage[B]	Diesel generators, grid	218,694 Kt CO_2 eq per year	Solar-powered cold storage		$626 million
		Lighting (for night fishing)	Kerosene, diesel	1,498 Kt CO_2 eq per year	Solar lamps		$700 million
Processing	111,773 Kt CO_2 eq per year	Milling	Diesel generators	1,185 Kt CO_2 eq per year	Electric mill	1%	$192 million
Distribution	363,263 Kt CO_2 eq per year	Transport	Diesel, gasoline, petrol	55,887 Kt CO_2 eq per year	Electric vehicles	15%	$17,594 million
Total African agrifood system[C]	**2,794,333 Kt CO_2 eq per year**			**279,597 Kt CO_2 eq per year**		**10%**	**$24,491 million**

[A] The economic and climate benefits assume a complete adoption of DRE across the entire continent in irrigation, cold storage, milling, transportation, and night fishing.
[B] Cold storage can reduce food losses from spoilage and contamination during processing, while also reducing GHG from the distribution stage (i.e., the use of milk chillers during the distribution of fresh milk). Note: Kt CO_2 eq stands for kilo tonnes of carbon dioxide equivalent.
[C] Total agrifood emissions also include emissions from land-use and consumption stages, not represented here.

potential to solve the dual challenge of feeding a growing population and reducing the agricultural carbon footprint. Currently, agricultural value chains across Africa are land and labor intensive, with great potential to increase productivity through mechanization. Renewables have the potential to increase yields and climate resilience, while also reducing the need for more land, saving on additional emissions from deforestation. Power for All has estimated the potential economic gains (in additional revenues) and the potential emission reductions from adopting five DRE technologies in agriculture in developing countries. (See Table 1 and Appendix C for methodology and assumptions. Some benefits stem from adopting machinery for the first time, some from replacing fossil fuel alternatives.)

Currently, the African food system emits 2.8 gigatons (Gt) of CO_2 equivalent GHGs, a vast majority (59 percent) of the continent's total emissions.[2,31] With most of the population engaged in farming, a sustainable agricultural transformation is needed to increase climate resilience, feed the growing population, and improve the standard of living of smallholders. Power for All's analysis, showcased in Table 1, reveals that placing DRE at the forefront of mechanization can yield a 10 percent reduction of GHG while driving economic gains as high as $24.5 billion per year—larger than the GDP of most African countries. The total economic impact encompasses both potential additional revenues for farmers as well as overall potential savings on diesel. The increase in farming revenues, estimated at $6.2 billion per year, would stem from larger yields due to increased productivity and reduced waste when DRE powered irrigation, cold storage, and milling are fully adopted. The savings on diesel would be generated by a complete switch to electric vehicles in agriculture and solar night fishing lights, and are estimated at $18.3 billion.

IV. Call to Action: Food System Energy Transition

The global community must focus on an energy transition for the food system. Adaptive agriculture that incorporates DRE and a new financial framework could drive affordable access to energy that rebalances the international food system.

It is possible—and necessary—to achieve both SDG 2 and SDG 7, increasing both agricultural productivity to meet future food demands and reducing environmental externalities. A number of vital institutions—AGRA, IFPRI, The Nature Conservancy and others—are focused on addressing many causes of GHGs in the food system (e.g. deforestation), and agroecology and regenerative agriculture are increasingly a focus of global forums (such as the September 2023 Africa Food Systems Forum). However, there are no voices advocating to remove fossil fuels in the food system. It is time for a call to action: The global community must focus on an energy transition for the food system. Adaptive agriculture that incorporates DRE and a new financial framework could drive affordable access to energy that rebalances the international food system.

Energy Transition for Agriculture

Today, talk of a just energy transition permeates high-level discussions around the world, but those discussions often focus on ensuring jobs for displaced fossil fuel workers. Without an energy transition for agriculture and nearly 600 million smallholder farmers, the business-as-usual approach to powering the food system will both overheat the planet and fail to meet the increasing food demand. A global resolve to transform the energy that powers the food system must challenge the role of fossil fuel subsidies across the sector. In total, fossil fuels received over $1 trillion in subsidies in 2022, with oil and coal subsidies increasing by 83 percent and 200 percent, respectively, in a year.[32] With rapid population growth, especially in the most climate-vulnerable countries, a shift in food production toward a more climate-resilient and productive agriculture sector is not a luxury, but a necessity.

Clean energy access is a condition for sustainable farming, regenerative agriculture, and agroecology. In order to transition the fossil-fueled food system, decision frameworks need to include opportunity costs and potential dividends of investing in accelerating access to DRE—the fastest and least-cost way to meet SDG 2 goals for farms in peri-urban and rural areas. For instance, a 2020 study by RMI finds that increased renewables-based energy access for six value chains in Ethiopia (for irrigation, milling, baking, cooling, and washing) can unlock $4 billion in farming revenues in just five years.[33] To realize the full benefits, key stakeholders—national governments, development partners, smallholder farmers, and the private sector—must align and work cooperatively to support an energy transition for the agricultural sector.

Alignment can start with national Agricultural Transformation Plans (ATPs). Across Africa, ATPs largely ignore renewable energy—despite transition commitments from several countries. Similarly, prioritizing truly integrated plans—including cross-government collaborations between the ministries for agriculture, energy, and environment and climate change (or equivalents)—that elevate the role of renewables and specific goals will accelerate change. A great example is Uganda's third National Development Plan (NPD), which prioritizes irrigation schemes for smallholder farmers. The plan document has assigned this responsibility to more than one ministry, including agriculture, energy, and finance.

Supporting Adaptive Agriculture With DRE Technology

Integrating DRE into the food system and a network of smallholder farmers is achievable, but is currently not the highest priority of climate funders, national governments or farmers themselves. However, a global commitment for an agricultural energy transition, supplemented with direct efforts to integrate DRE into local food systems, will help accelerate change. Given the very real interdependency of SDG 2 and SDG 7, funds that specifically incentivize and reward coordination between agriculture and energy in public as well as private sectors are a critical part of the effort to accelerate adoption of DRE-powered machinery.

Awareness of DRE applications for agriculture—a critical path for market building—is currently too low to be effectively integrated into the food system. In a recent example, Sustainable Energy for Smallholder Farmers (SEFFA) has identified insufficient demand for solar productivity-enhancing technologies due to very low levels of awareness among farmers in Ethiopia, Kenya, and Uganda.[34] However, education campaigns implemented with farmer cooperatives and civil society are proven to raise awareness and drive demand.

Direct-to-consumer educational campaigns are essential for building demand, but need to be tagged to addressing systemic barriers to adoption. Providing incentives for companies and consumers, such as tax incentives and subsidies, can lower the costs of DRE-powered appliances and machinery, and create a healthy, competitive market. For example, in 2019 Ethiopian trade tariffs were removed for solar irrigation equipment imports—reducing the price of solar water pumps by 40 percent and thus making them more affordable for farmers in lower income market segments.[35] For countries with limited foreign exchange, prioritizing agricultural solar products' access to Forex would expedite timelines and provide a clear incentive. Finally, rewarding compliance with quality standards (e.g., GOGLA's Consumer Protection Code or VeraSol's quality assurance program) with VAT-free importation has been shown to increase uptake of high quality solar products.[36,37]

Clean energy access is a condition for sustainable farming, regenerative agriculture, and agroecology.

A Financial Framework for the Future of Food

Current investment and concessional finance is insufficient to affect the magnitude of change needed in food systems, and does not recognize the interdependent nature of SDG 2, energy, and climate. At a global level, only 4 percent of annual climate finance is allocated to agriculture, forestry, and other land use (AFOLU)—despite the fact that agrifood systems contribute to a third of the global GHG emissions.[38,39,40] More, the Climate Policy Initiative (2021) shows that funding would need to increase by almost 600 percent (to about $4.35 trillion annually) to achieve the goal of limiting global warming to 1.5 degrees Celsius by 2050.

At a national level, public-private partnerships (PPPs) can be workhorses of the energy transition for agriculture by helping to reduce first costs and encouraging market development. When well-orchestrated, PPPs infuse projects with technical acumen and operational efficiency. With this approach, governments purchase assets and leave operations to the private sector, de-risking the investment and lowering the cost of capital to help grow the market.[41] Classic PPPs can also help foreign exchange shortages in countries with capital controls, since the government has access to foreign currency needed to purchase agricultural assets. For instance, the government of Ethiopia has partnered with Ethio Lease to increase the adoption of agricultural machinery, and provide over $150 million worth of equipment to support smallholders through a one-stop farm service centers (FSC).[42]

At a local level, many microfinance institutions (MFIs)—the main avenue for smallholder farmers to access solar products at scale—are critical but often reluctant partners in funding energy access. Today, DRE technologies are more affordable than alternatives over their lifetimes, but upfront costs can be a barrier for most farmers. In just one example, a solar water pump is one of the most affordable DRE-based agricultural technologies, yet represents at least 3 times the average farmer's income in Ethiopia.[43] While some appliance companies provide loans to their customers, MFIs are needed to accelerate adoption of solar technologies in agriculture—given their comparative advantage in financing lower income households. Driving awareness and support inside of MFIs for this sector will help prioritize initiatives that target financing at scale, such as a fund that supports MFIs to work collaboratively with retailers of productivity-enhancing solar technologies. While there currently exist some coordinated efforts like CLASP and Nithio's $6.5 million financing facility, more development partnerships with microfinance institutions (MFIs) are needed to achieve large-scale adoption.[44,45]

V. Answering the Call to Action

The energy transition for agriculture requires a coordinated, system-wide approach.

Halfway to 2030, the international community is at a key decision point, with a singular opportunity to execute a vision for the future of food. No one climate intervention alone can achieve SDG 2 and SDG 7, but a comprehensive effort to support an energy transition of agriculture can roll back business-as-usual practices that threaten people and planet. Two of the clearest conclusions from a comprehensive review of both energy and agricultural literature are (1) advances in sustainable food production can be achieved with the concerted application of current technologies, and (2) investing in comprehensive modeling, predictive analysis, and scenario planning will help ensure sufficient food production while keeping global warming to 1.5 degrees Celsius.[46] Rather than proposing a complete set of recommendations, this paper identifies targeted paths forward to address SDG2 and SDG7 in unison. With the entire agriculture ecosystem—governments, funders and lenders, companies, farmers, consumers—supporting an energy transition for agriculture, a new future of food is possible.

Government Ministries, Departments, and Agencies

National policies will be maximized if agricultural, energy, and climate goals are integrated with growth, electrification, and emissions reduction targets—for developed and developing countries alike. Most governments have regular cycles for policy updates (e.g., 5 years), but accelerating revisions to agricultural transformation plans that integrate decentralized renewables into the food system will facilitate greater change, faster. Enacting a suite of enabling regulation—ranging from tax codes reforms to import prioritization—will help facilitate deployment and use of renewables in crucial regions like Africa. Over the last 10–15 years, VAT-free importation of quality assured DRE-based products has proven to be among the most effective stimulus to grow the private sector.

Development Partners, Foundations, and Investors

According to the International Fund on Agricultural Development (IFAD), mobilizing $400 billion per year until 2030 far exceeds the cost of inaction—calculated at $12 trillion per year in environmental, social, and economic damage.[47] Ranging from aid agencies to foundations to investors, sources of capital are in a unique position to be agents of change in supporting an energy transition for agriculture. By incentivizing integrated efforts between SDG 2 and SDG 7 with programs, funds and vehicles, funders will facilitate a critical change in behavior across the agriculture and energy sectors. Development institutions—including aid agencies, foreign governments, multilateral banks, and microfinanciers—are critical partners to ensure solar technologies for smallholder farmers are available and affordable.

Microfinance Institutions

The energy transition for agriculture requires a coordinated, system-wide approach to encourage market adoption alongside market development. To ensure funding gets to smallholders, MFIs are

critical partners for increasing access to sustainable, reliable and affordable energy and equipment. However, many MFIs have rigid mandates and are risk averse. Development partners can de-risk ventures for MFIs by providing additional capital to expand climate-conscious ventures. For example, a fund for risk mitigation (e.g. repayment losses) and expansion to new markets, supported with grant capital and long-term repayable loan assistance would accelerate change. This approach can help reduce risk to MFIs, support a larger loan portfolio and additional asset classes (de-risking through diversification), while delivering high impact in a priority development or climate change area—all the while growing market sales.

DRE Companies, Civil Society, and Farmers

Given the role that smallholders will play in a more sustainable future of food (Box 2)—including reduced supply chains and increased productivity—prioritizing smallholder-boosting agricultural initiatives is critical for every country. Growing awareness and building trust in DRE agricultural assets is job one. Climate funders and government support can lend critical financial and reputational backing to the civil society, agrifood organizations, and DRE companies that work closely with farmers to encourage adoption of renewable energy for productive use. In addition to aligning with quality assurance standards, customer-centric design that meets the needs of smallholder farmers is essential. Companies have demonstrated that adoption grows more quickly when technologies are right-sized, fit for purpose and affordable—maximizing returns for farmers and suppliers alike.

A global commitment for an agricultural energy transition, supplemented with efforts to integrate DRE into local food systems, will help accelerate change.

Power for All: The Future of Energy Requires Us All

It is time for a new call to action: The global community must focus on an energy transition for the food sector, drive adaptive agriculture that incorporates DRE, and support a new financial framework for affordable access to renewable energy that rebalances the impact of agribusiness. Importantly, the Global North must recognize its contribution to this crisis. The developed world is responsible for helping to transform the footprint of the current food system. Public and private entities alike residing in the Global North are obligated to stop funding deforestation, support reforestation and encourage localized sustainable approaches to agricultural productivity. In addition, while developed nations need to make good on pledges to the Loss and Damage Fund, the countries designing the fund need to consider how renewable energy projects can do more than compensate for the past, but also help build the future. Renewable energy projects can contribute to both mitigation and adaption efforts, which can reduce loss and damage in the longer term.

From pushing consumers to purchase "farm to fork" to mandating greening of distribution with electric vehicles, everyone has a role to play. Renewables can be the source of a new Green Revolution to increase food security and drive agricultural productivity. The global community must unwind dependence on high-emission supply chains and decarbonize systems—especially when doing so improves outcomes globally and locally. While not a silver bullet, driving adoption of renewable energy across the global food system can create a more sustainable, resilient and equitable future—and power for all.

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Photos generously provided by: Brendan Davis (p. 10 bottom right), d.light/duncanwilletts.com (cover center left), Futurepump/jeffreymwalcott.com (p. 11), IWMI/jeffreymwalcott.com (cover top right, p. 6 top left), Mlinda (p. 4, p. 8), and Smart Power India (p. 10 top right).

Appendix A: Emissions From Food Systems

FOOD SYSTEMS' RESPONSIBILITY FOR GLOBAL ANTHROPOGENIC GHG EMISSIONS[48]

Step of the value chain	Emissions	Activities	How emissions happen
Land use	32%	Deforestation for agricultural use, afforestation	Carbon losses from deforestation and degradation of organic soils
Production	40%	Farming (13%) Livestock (17%) Chemicals (2%) Others (8%)	Use and production of chemicals (e.g., fertilizer) Livestock (e.g., methane release) Diesel irrigation, diesel tractors, etc.
Processing	4%	Primary, secondary, and tertiary processing	Energy for production Industrial waste
Distribution	13%	Transport (5%) Packaging (4.5%) Retail (3.5%)	Emissions from transport (road, freight, and air) Emissions from industrial packaging facilities
Consumption	2%	Cooking	Residential use of energy for cooking
End of life (waste)	9%	Waste water (6%) Solid waste (3%)	Emissions from solid waste disposal and waste water treatment
TOTAL	**100%**	**100%**	

Appendix B: Untapped Revenue Potential of DRE

Methodology

This analysis considers the five technologies with the highest potential in both revenues and emissions reduction: solar water pumps, electric mills, solar cold storage facilities, electric vehicles, and solar night fishing lights. Potential revenues from the increased adoption of DRE in Africa's agrifood sector stem from three sources: (1) increased yields due to higher productivity, (2) waste reduction due to availability of proper technologies and/or increased efficiency, and (3) cost savings due to cheaper or more efficient technologies. Below is a summary of the methodology and sources employed to calculate the potential revenues for each technology. For simplicity, maize is considered the average crop.

Solar Water Pumps (SWP):

Est. revenue gains = total addressable market x est. increase in production x average yield price

Total addressable market (total production in Africa, in tons) = 120,450,000
Percentage increase in production due to SWP (%) = 14
Total increase in production due to SWP (tons) = 16,863,000
Average yield price ($ / ton) = 319
Total revenue gain ($) = 5,379,297,000

Where total addressable market is obtained from the total output of cereals, pulses, roots, and tubers by SHF in Africa and the share of SHF that could adopt the technology, and the estimated increase in production is solely from irrigation.[30,49,50]

Electric Mills:

Est. revenue gains = total addressable market x price differential of milled vs. raw maize

Total addressable market (total production in Africa, in tons) = 120,450,000
Percentage of crops that can be milled using DRE (%) = 42
Total weight of crops that can be milled using DRE (tons) = 50,589,000
Price differential of milled grain ($) = 3.8
Total revenue gain ($) = 192,238,200

Total addressable market is obtained from the total output of cereals, pulses, roots, and tubers by SHF in Africa and the share of crops that can be milled with DRE.[49,51,52]

Cold Storage:

Est. revenue gains = est. African agrifood waste in $ x est. share of potential reduction by SHF

Monetary value of total agrifood waste ($) = 4,000,000,000
Percentage of food that can be saved using DRE technologies (%) = 15.65
Total revenue gain ($) = 626,108,108

Estimated African agrifood waste is obtained from the number of SHF without energy access, the average value of the produce, and the share of losses attributed to post-harvest handling and storage. Due to lack of data for Africa, the Latin American share of waste reduction via cold storage is used as the benchmark.[53,54,55,56]

Transport:

Est. revenue gains = est. fossil fuels consumption from road transport x average price

Total consumption of diesel in Africa's Agriculture (liters) = 20,698,763,348
Average price of diesel fuel per liter ($ / liter) = 0.85
Total cost saving by replacing diesel vehicles fleet with electric vehicles ($) = 17,593,948,846

Where estimated fossil fuels consumption from road transport are based on emissions.[31,48,57,20]

Night Fishing:

Est. revenue gains = total addressable market x average cost savings from using solar lamps

Number of fishing boats in Africa (#) = 180,000
Annual cost of kerosene for night fishing per boat ($ / year) = 3,888
Total cost saving by replacing kerosene lights with solar lamps ($) = 699,840,000

Where total addressable market is based on the number of fishing boats in Africa.[58,59]

Appendix C: Emissions Reduction Potential of DRE

Methodology

This analysis considers the five technologies identified in Appendix B. Below is a summary of the methodology and sources employed to calculate the emissions reduction potential of each technology. Depending on the information available, the emissions reduction was estimated by: (1) replacing fossil fuel powered technologies, or (2) total GHG from the sector multiplied by the share that the specific technologies could replace.

Solar Water Pumps (SWP):

Est. emissions reduction = est. diesel consumption per pump x est. number of potential diesel water pumps x GHG equivalent

Est. diesel consumption per pump and year (gallons): 38.63
Est. number of potential diesel water pumps to replace (#): 6,708,000
GHG Equivalent (Kt CO_2 eq / gallon): 0.000009

The annual emissions from diesel water pumps are computed based on the average operating hours per year and the hourly diesel consumption. The total number of pumps to be replaced is determined using the relationship between the irrigated potential area and the average coverage of a pump. It is estimated that the potential reduction from this replacement would amount to 2,333 Kt CO_2 eq per year.[30,60,61,62,63]

Electric Mill:

Est. emissions reduction = est. diesel consumption per mill x est. number of potential millers x GHG equivalent

Est. diesel consumption per mill and year (gallons): 495
Est. number of potential millers (#): 265,559
GHG Equivalent (Kt CO_2 eq / gallon): 0.000009

Where total addressable market is obtained from the total output by SHF in Africa and the share of crops that can be milled with DRE. Total diesel required (and its emissions) is calculated based on the number of mills and average diesel utilized in diesel mills. Using DRE pumps instead would save approximately 1,185 Kt CO_2 eq per year.[49,62,64,65]

Cold Storage:

Est. emissions reduction = total food and waste emissions x est. share reduction attributable to potential SHF adopting cold storage

Total food and waste emissions (Kt CO_2 eq): 1,397,167
Share reduction attributable to potential SHF adopting cold storage (%): 15.65

The overall emissions related to FLW are calculated using the total emissions from the agrifood system in Africa and the share attributed to food loss and waste (FLW). This emission is then multiplied by the share of emissions attributed to post-harvest losses, the share of Smallholder Farmers (SHF) in Africa, and the share of rural population without access to electricity. Additionally, the post-harvest loss reduction benchmark from Latin America is applied. This results in an emissions reduction of around 218,694 Kt CO_2 eq per year.[31,54,55,56,20,66]

Transport:

Est. emissions reduction = total agrifood emissions x est. share from road transport

Total agrifood emissions (Kt CO_2 eq): 2,794,333.05
Share from road transport (%): 2

Assuming 100% electric vehicles in agriculture implies a reduction of 55,887 Kt CO_2 eq per year.[31,48]

Night Fishing:

Est. emissions reduction = est. kerosene consumption x est. number boats x GHG equivalent

Est. kerosene consumption per boat and year (liters): 3328
Est. number of boats (#): 180,000
GHG Equivalent (Kt CO_2 eq / gallon): 0.0000025

The estimated GHG reduction is 1,498 Kt CO_2 eq per year.[58,59,67,68]

Appendix D: Agricultural Transformation Plans

AGRICULTURAL TRANSFORMATION PLANS (ATPS) AND ENERGY ACCESS

ATP rank	Number of countries	Country has ATP	ATP includes energy access	ATP includes DRE	Identified targets and ownership
Best	6	Yes	Yes	Yes	Yes
High	6	Yes	Yes	Yes	
Medium	15	Yes	Yes		
Low	19	Yes			

Country	Plan name	Year	Remark
Ethiopia	Climate Resilient Green Economy Strategy (CRGE): Agriculture and Forestry	2011	CRGE encourages the use of renewable energy in the agriculture sector
Uganda	Third National Development Plan	2016	Solar irrigation a priority intervention; implemented by Ministry of Agriculture
South Sudan	Transforming Agriculture in South Sudan	2022	Investment in PV machinery a priority intervention in immediate term (1–2 years)
Burkina Faso	Burkina Faso Climate-Smart Agriculture Investment Plan	2020	Mentions solar powered irrigation in investment activities for pilot projects
Mauritania	Stratégie Nationale de l'Environnement et du Développement Durable	2017	Substituting fuel oil with solar and wind is a key pillar of Mauritania's development plan
Niger	Stratégie et Plan National d'Adaptation face aux changements climatiques dans le secteur Agricole 2020–2035	2020	Niger aims to construct boreholes for small scale solar-powered irrigation
Djibouti	Vision Djibouti 2035	2014	DRE is included in ATPs, but there are no specific targets or responsible parties assigned toward the completion of the strategy.
Mozambique	PEDSA 2030	2022	
Angola	Angola Agricultural Transformation Project	2021	
Benin	National Development Plan (2018–2025)	2018	
Ghana	Medium Term Expenditure Framework for 2022–2025	2022	
Nigeria	National Agricultural Technology and Innovation Policy 2022–2027	2022	

Appendix D: Agricultural Transformation Plans

	Country	Plan name	Year	Remark
●	**Eritrea**	State of Eritrea Country Strategic Opportunities Programme	2020	These ATPs include energy access interventions but do not list DRE as a priority intervention.
●	**Madagascar**	Projet d'Elaboration du Schéma Directeur pour le Développement de l'Axe Economique TaToM	2019	
●	**Malawi**	National Agriculture Policy	2016	
●	**Zimbabwe**	National Agricultural Policy Framework	2018	
●	**Cameroon**	Cameroon Vision 2035	2009	
●	**Chad**	Chad Vision 2030	2017	
●	**Congo**	Poverty Reduction and Growth Strategy	2023	
●	**Democratic Republic of the Congo**	Strategic Development Plan 2019–2023	2019	
●	**Eswatini**	National Development Plan towards Economic Recovery	2019	
●	**Gambia**	Agriculture and Natural Resources Policy 2017–2026	2017	
●	**Guinea**	Strategie Nationale du Developpement Durable	2019	
●	**Liberia**	Food and Agriculture Policy and Strategy	2015	
●	**Mali**	Cadre Stratégique pour la Relance Économique et le Développement Durable 2019–2023	2019	
●	**Egypt**	Sustainable Agricultural Development Strategy Towards 2030	2009	
●	**Libya**	Libya Country Strategic Plan 2023–2025	2023	

Appendix D: Agricultural Transformation Plans

Country	Plan name	Year	Remark
Burundi	Strategie Agricole Nationale	2018	These ATPs do not include energy access.
Comoros	Plan Comores Émergent Synthese	2019	
Kenya	Agricultural Sector Transformation and Growth Strategy	2019	
Mauritius	Strategic Plan for The Food Crop, Livestock and Forestry Sectors (2016–2020)	2016	
Rwanda	Strategic Plan for Agriculture Transformation 2018–2024	2018	
Sudan	Sudan E-Agriculture Strategy and Action Plan (2018-2022)	2017	
United Republic of Tanzania	Agricultural Sector Development Programme Phase II	2017	
Zambia	The National Agriculture Policy	2011	
Gabon	Gabon Joint 2016–2020 Country Strategy Paper and Country Portfolio Performance Review Report	2016	
São Tomé and Príncipe	Republic of São Tomé and Príncipe, Country Strategy Note 2019–2021	2019	
Lesotho	Lesotho Food Security and Nutrition Policy (2016–2025)	2017	
Namibia	Namibia National Agricultural Policy	2015	
South Africa	Agriculture and Agro-processing Master Plan Social Compact	2022	
Côte d'Ivoire	Côte d'Ivoire Climate-Smart Agriculture Investment Plan	2019	
Sierra Leone	National Sustainable Agriculture Development Plan 2010–2030	2010	
Togo	Document de Politique Agricole pour 2016–2030	2015	
Morocco	Plan Maroc Vert	2008	
Tunisia	Tunisia country strategic plan (2022–2025)	2021	
Seychelles	Seychelles National Agricultural Investment Plan 2015-2020	2015	

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