



Bringing the Sun to the Fields: Reflections from Egypt's Shift to Solar Farming

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Synopsis

In response to the growing challenges of diesel-powered irrigation, Egypt's El Beheira Governorate has embraced solar-powered systems to support more sustainable agricultural practices. This article reflects on Egypt's transition, focusing on

the environmental, economic, and social impacts of solar irrigation. With notable improvements in water efficiency, reduced pollution, and better rural livelihoods, this case study highlights solar energy's potential as a catalyst for greener farming.

Overview of Egypt's Agricultural Sector

Agriculture is more than just a way of life in Egypt; it's a backbone of the national economy. The sector provides jobs for millions and plays a major role in food production and exports. But in a country where rainfall is scarce and the land is largely arid, farming depends almost entirely on irrigation, making it extremely vulnerable to shifts in energy prices and fuel supply disruptions.

Many farms, especially those in desert regions, rely on groundwater extraction, which is a process that demands a steady and affordable power source. Traditionally, that power comes from diesel generators, which are costly, polluting, and increasingly unsustainable.

Now, a promising alternative is gaining ground: solar-powered irrigation. This technology is being adopted across many low- and middle-income countries, and Egypt is no exception. By harnessing the country's abundant sunlight, solar irrigation systems help farmers reduce their dependence on fossil fuels, lower greenhouse gas emissions, and save on operating costs in the long run.



Beyond powering water pumps, solar energy is also opening the door to smarter, more efficient farming. Photovoltaic systems can drive agricultural automation and robotics, offering a clean, cost-effective energy source that supports modern farming techniques.

As Egypt looks toward a more sustainable and resilient agricultural future, solar power is proving to be a bright idea, both economically and environmentally.



The Need for Sustainable Irrigation in El Beheira

Egypt's agricultural sector is undergoing a major transformation, driven by rising fuel costs and the urgent need for more sustainable farming practices. One solution gaining momentum is solar-powered irrigation, a cleaner, more efficient way to water crops without relying on fossil fuels.

Traditional farming methods, especially those using diesel-powered pumps, have long been a double-edged sword. While keeping irrigation systems running, the traditional farming also contributes heavily to air and soil pollution and greenhouse gas emissions. Diesel generators, in particular, are surprisingly inefficient, in which only about 30-40% of the energy in the fuel is turned into electricity, with the rest wasted as heat. On top of that, the operating cost is expensive, with difficult maintenance, and vulnerability to fluctuating fuel prices.

Every liter of diesel provides only a few hours of operation, making these systems costly in the long run. In contrast, solar irrigation systems, while more expensive to install at first, offer long-term savings and environmental benefits that are hard to ignore.

In many of Egypt's farming communities, diesel-powered irrigation has long been the norm, but it has come at a cost. Exposure to diesel fumes puts farmers' health at risk, while transporting fuel across long distances adds to both carbon emissions and logistical headaches. Over time, the drawbacks have piled up, especially in high-output agricultural regions like El Beheira Governorate in northern Egypt. Once heavily dependent on diesel systems, the area has faced worsening environmental damage, rising costs, and deepening fuel dependence.

Recognizing the urgent need for change, the Egyptian government teamed up with international and local partners, including the United Nations Development Programme (UNDP), the Food and Agriculture Organization (FAO), the Global Environment Facility (GEF), solar energy company SunEdison, and Heliopolis University, to launch a series of solar-powered irrigation projects. One flagship initiative, the Agricultural and Freshwater Integrated Resources (AIAFIR) project, aimed to phase out diesel pumps and replace them with solar-powered alternatives across several governorates.



This shift is not merely about cleaner energy. It represents a comprehensive approach to sustainability for reducing environmental harm, lowering long-term farming costs, and empowering local communities through new technologies and training.

In this article, we take a closer look at the environmental, economic, and social impacts of Egypt's move to solar irrigation, focusing on El Beheira as a case study. We also explore how countries in Southeast Asia who are facing many of the same agricultural challenges, could adopt similar solar solutions to build a more sustainable farming future.

Benefits and Applications

Solar-powered irrigation is gaining traction as a sustainable solution in low- and middle-income countries, including Egypt. This technology offers numerous advantages, such as reduced reliance on fossil fuels, lower greenhouse gas emissions, and decreased operational costs for farmers. Photovoltaic systems are particularly well-suited for agricultural automation and robotics, offering an energy-saving and cost-effective alternative to traditional power sources.

Harvesting the Sun: How Solar Irrigation is Transforming Egypt's Farmlands

Egypt's Agricultural and Freshwater Integrated Resources (AIAFIR) project marks a major milestone in the country's shift toward sustainable farming. With support from the National Water Research Center, Heliopolis University, the FAO, and solar energy company SunEdison, the initiative replaced polluting diesel pumps with clean, solar-powered irrigation systems in El Beheira, a key agricultural region in northern Egypt. This switch has delivered wide-reaching environmental, economic, and social benefits.

Greener Fields, Cleaner Air

One of the biggest reasons for adopting solar irrigation was to reduce the environmental damage caused by diesel use. Every cubic meter of water pumped with diesel released about 1.11 kilograms



of CO₂ into the atmosphere. Beyond climate impact, diesel pumps leaked oil into the soil, emitted noise that disrupted nearby communities, and polluted the air, which posing health risks to farmers and damaging crop quality.

Solar-powered irrigation systems changed all that. They run quietly, emit no greenhouse gases during operation, and produce no chemical waste. In El Beheira, farmers noticed healthier soils and fewer respiratory issues among workers after switching to solar energy. The cleaner environment even helped boost local biodiversity.

From Upfront Costs to Long-Term Gains

While installing solar systems isn't cheap, the payoff comes quickly. Unlike diesel pumps, which constantly require fuel and maintenance, solar irrigation systems operate at almost no cost once they're up and running. That's a game-changer for smallholder farmers. For example, wheat production in Egypt rose from 8.5 million tonnes in 2016 to nearly 9 million tonnes in 2023. A key factor? Stable, reliable energy from solar-powered irrigation, which allowed farmers to stick to consistent watering schedules.

With lower operating costs, many farmers were able to reinvest in their land, buying better equipment or

expanding their farms. For them, solar power isn't just an environmental solution; it is an economic lifeline.

Empowering Communities Through Clean Tech

The social benefits of solar irrigation have been just as powerful. By cutting down on diesel use, farming communities saw improvements in public health, especially fewer respiratory problems. But the ripple effects didn't stop there. The transition created local jobs in solar installation, maintenance, and technical training.

Institutions like Heliopolis University stepped in with workshops to train farmers in how to operate and maintain the new systems. As a result, farmers became more self-reliant—and young people who had left rural areas in search of work began returning, drawn by new opportunities in modern, sustainable agriculture.

A Blueprint for the Global South

Egypt's success with solar irrigation is already inspiring others. India's **PM-KUSUM** (Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan) initiative is rolling out solar pumps to help farmers cut back on diesel. In the Philippines, government-backed solar irrigation projects are being introduced to support remote farming communities. These





efforts share a common goal: to create cleaner, more resilient agricultural systems in regions where farming is crucial to both livelihoods and national food security.

As Egypt's experience shows, solar irrigation doesn't just water crops; it powers economic growth, strengthens communities, and protects the planet.

Future Directions:

Pathways Toward Wider Adoption

The Egyptian government is actively promoting renewable energy across sectors, including agriculture, through supportive policies and regulatory frameworks. With a national target of sourcing 42% of its energy from renewables by 2035, solar-powered irrigation is central to this vision.

Egypt's transition offers valuable insights for countries, particularly in Southeast Asia, facing similar agricultural challenges. Several future efforts to be considered are: 1) Developing hybrid systems that combine solar energy with battery storage to ensure continuous irrigation, especially during cloudy weather or nighttime; 2) Scaling farmer training programs to improve maintenance skills and system longevity; and 3) Integrating smart irrigation technologies, such as soil moisture sensors and remote monitoring tools, to optimize water use and improve crop productivity.

These innovations not only address technical needs, but also contribute to global priorities such as access to clean water (SDG 6), affordable clean energy (SDG 7), climate action (SDG 13), and sustainable land use (SDG 15). By reducing reliance on fossil fuels and improving water efficiency, solar-powered irrigation promotes both ecological resilience and rural development.

UN and Global Funding Opportunities

Support from global organizations has played a crucial role in the implementation and scalability of solar-powered irrigation. Projects such as the one in El Beheira often attract international donors, particularly when they align with United Nations frameworks and global development goals. The United Nations Development Programme (UNDP) and Green Climate Fund (GCF) are examples of UN-affiliated bodies that provide financial and technical assistance to countries adopting clean energy solutions in agriculture.

To replicate success, governments and NGOs should actively seek alignment with these entities to access funding and policy support. Highlighting contributions toward SDGs increases visibility and eligibility for such international grants.

By reducing fossil fuel reliance and improving water management, solar-powered irrigation supports

both ecological protection and rural development. Expanding solar infrastructure in rural farming can enhance resilience to climate change while fostering economic growth and environmental preservation.

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Readings

- Ashraf, M., Fouad, M. M., & Shihata, L. A. (2019). A solar-powered irrigation system for conserving water and energy consumption in Egypt. *Journal of Clean Energy Technologies*, 7(6), 81-5. DOI: 10.18178/JOCE.T.2019.7.6.514
- Balasubramanya, S., Garrick, D., Brozović, N., Ringler, C., Hope, L., et al. (2024). Risks from solar-powered groundwater irrigation: Emissions reductions may not meet expectations, and groundwater use will likely increase. *Science*, 383(6680), 256- 8. DOI: 10.1126/science.adi9497
- Closas, A., & Rap, E. (2017). Solar-based groundwater pumping for irrigation: Sustainability, policies, and limitations. *Energy Policy*, 104, 33-7.
- [FAO] Food and Agriculture Organization. (2018). Solar Powered Water Lifting For Irrigation In The Nile Delta. [Internet]. Available from: <https://openknowledge.fao.org/server/api/core/bitstreams/4b1a1483-7af5-4b8a-8f5c-db5495d49f31/content>
- Gorjian, S., Minaei, S., MalehMirchegini, L., Trommsdorff, M., & Shamshiri, R. R. (2020). Applications of solar PV systems in agricultural automation and robotics. In: Gorjian S. & Shukla A. (Editors.), *Photovoltaic Solar Energy Conversion: Technology, Applications and Environmental Impacts*. Chapter 7. Cambridge (US): Academic Press. p. 191-235. DOI: 10.1016/B978-0-12-819610-6.00007-7
- Guno, C. S., & Agaton, C. B. (2022). Socio-economic and environmental analyses of solar irrigation systems for sustainable agricultural production. *Sustainability*, 14(11), 6834.
- Kabeyi, M. J. B., & Olanrewaju, O. A. (2021). Dual cycle cogeneration plant for an operating diesel powerplant. DOI: 10.46254/an11.20210200
- Karnib, A., Elbendary, N., Abouelhassan, W., & Dawoud, M. A. (2024). Sustainability assessment of solar-powered drip irrigation for sugarcane in Egypt: A water–energy–food–ecosystem nexus perspective. *World Water Policy* 11(2), 393-409. DOI: 10.1002/wwp2.12247
- Mallan, S., Karthick, K., Cheran, B., & Karthickram, S. (2021). Smart solar powered agricultural fertilizer sprayer. *IOP Conference Series: Materials Science and Engineering*, 1084(1), 012072. DOI: 10.1088/1757-899X/1084/1/012072
- Maka, A. O. M., & Alabid, J. M. (2022). Solar energy technology and its roles in sustainable development. *Clean Energy*, 6, 476-83. DOI: 10.1093/ce/zkac023
- Ullah, I., Khan, N., Dai, Y., & Hamza, A. (2023). Does solar-powered irrigation system usage increase the technical efficiency of crop production? *Energies*, 16(18), 6641.
- Salah, S. I., Eltaweel, M., & Abeykoon, C. (2022). Towards a sustainable energy future for Egypt: A systematic review of renewable energy sources, technologies, challenges, and recommendations. *Cleaner Engineering and Technology*, 8, 100497. DOI: 10.1016/j.clet.2022.100497
- Senapati, A. K., & Dash, S. P. (2014). Thermo-Electric Generator in Turbocharged Diesel Engine - A Review. [Internet]. Available from: http://ijiset.com/v1s3/IJISSET_V1_I3_47.pdf

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