光伏技术有望重塑全球粮食供应韧性

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光伏技术有望重塑全球粮食供应韧性。近日，隆基绿能创始人、首席技术官李振国在国际顶级学术期刊《自然 · 可持续发展》上发表题为《光伏技术助力粮食安全》的前瞻性观点文章。文章系统阐述了光伏技术在提升全球粮食供应韧性方面的巨大潜力，并提出了两条具有应用前景的技术路径，展现了光伏在能源转型之外，对全球可持续发展的重要支撑作用。

李振国在文章中指出，传统粮食生产高度依赖自然光合作用与气候条件，受干旱、洪涝等极端天气事件影响显著。在全球气候变化加剧的背景下，农业生产面临日益严峻的挑战，粮食供应的稳定性成为国际社会共同关注的焦点。作为全球能源转型的重要力量，光伏技术不仅在降低碳排放方面发挥着关键作用，更有望为粮食供应韧性提供全新解决方案。

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Photovoltaics for food security

By Zhenguo Li

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Besides decarbonizing energy supply, photovoltaics can also largely enhance the resilience of global food supply, argues Zhenguo Li.

Climate change is increasingly disrupting agriculture globally by continuously shifting rainfall patterns, heating up the whole planet and intensifying extreme weather events. As a result, crop production and farm management are facing great challenges, which amplify concerns regarding food supply stability, such as whether we can still produce enough food to feed the ever-growing global population under the pressures of climate change.

The answer to this question is not clear yet, but we know that photovoltaics (PV) can contribute to enhancing the resilience of food supply. As a widely deployed technology pivotal to the global energy transition, PV adoption is projected to expand further as manufacturing costs decline. In addition to mitigating climate change, use of PV can also contribute to stabilizing agricultural production and securing food supply – particularly when framed within the integrated energy–water–food nexus essential for sustainable development.

Conventional food production relies on natural photosynthesis, which is constrained by weather conditions and the availability of natural resources, including sufficient arable land. All of these factors make food production highly vulnerable to the impacts of natural disasters, which are aggravated by climate change. In response to these challenges, the agricultural sector could take advantage of the immense potential of solar energy: the annual solar radiation incident on the Earth's surface – equivalent to 130 trillion tonnes of standard coal – exceeds the combined reserves of all other energy sources. But there is the question of how exactly PV can support food security. Two promising pathways emerge – each with notable potential yet also accompanied by open questions and feasibility challenges.

The first pathway is PV-driven artificial carbon fixation for food production. The key to this pathway is using solar power to electrolyse water to produce green hydrogen, which is then coupled with captured CO_2 to synthesize green methanol. Subsequent processes, including oxidation and polymerization, convert the methanol into starch. The feasibility of this approach is already demonstrated by researchers. Crucially, it has a higher efficiency of solar energy use than plant-based natural photosynthesis processes. This pathway is not constrained by other natural conditions, as it requires only solar light. Harnessing only part of the world's desert areas for this green energy artificial photosynthesis pathway could largely improve global food security. For instance, covering just 3.7% of the Sahara Desert with PV panels could generate 26 trillion kWh of green electricity. This energy output would be sufficient to produce 520 million tonnes of green hydrogen, which, when combined with CO_2, could synthesize 3 billion tonnes of food – enough to supply the current global population. However, serious questions remain regarding upscaling and sustainability: the economic viability of large-scale green hydrogen and methanol synthesis, the energy and environmental costs of CO_2 capture, and the life-cycle impacts of industrial food synthesis require further research before this pathway can be deemed broadly feasible.

The other pathway is leveraging PV power to enable an effective energy–water–food nexus. This pathway leverages the ability of PV systems to transform arid and desert lands into more ecologically friendly land. The PV panels provide shade, which lowers ground-level solar radiation and substantially reduces soil evaporation. This effect narrows the gap between evaporation and precipitation rates, consequently reducing irrigation demands. Given the vast global extent of desert regions, integrated 'PV and soil improvement' systems could dramatically reduce the water consumption needed for soil improvement, facilitating the development of new arable land. When combined with large-scale, PV-powered seawater desalination and water transport, this approach can further facilitate the transformation of barren lands into productive croplands, adding grain production surplus capacities. During productive years with excess grain production, excess grain and straw can be converted into energy, while the enhanced production capacity provides a critical buffer against shortages in disaster-prone years. Nevertheless, this integrated approach must be carefully evaluated before its implementation. Potential ecological impacts of large-scale desert modification, the sustainability of intensive water use in arid regions and the long-term maintenance of 'PV and agriculture' systems in harsh environments point to substantial uncertainties that necessitate further interdisciplinary study.

Although PV offers promising pathways to bolster food supply resilience alongside the low-carbon energy transition, these prospects should be viewed as potential rather than ready-to-implement solutions. Both technical pathways require more comprehensive assessment of their environmental, economic and social feasibility under real-world conditions. Strengthening the sustainability of PV-based food system solutions requires holistic thinking so that potential synergies and trade-offs are brought to bear and the desired system can ensure not only food security and clean energy, but also responsible water use, ecosystem protection and inclusive development. As PV technology advances, its role in supporting sustainable food systems should continue to be explored – with humility, rigour and an emphasis on systemic resilience – to help shape a truly sustainable future on a global scale.

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Competing interests

Z.L. is the founder of LONGi Green Energy Technology Co., Ltd.

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文章截图。

文章重点阐述了光伏技术支撑粮食供应保障的两条技术路径：

第一，光伏驱动的二氧化碳人工合成淀粉路径。该路径利用光伏发电进行水电解制取绿氢，并将其与捕集的二氧化碳耦合，合成绿色甲醇，进而通过氧化、聚合等过程转化为淀粉。相较于传统自然光合作用，该路径具有更高的太阳能利用效率，且不受土地、气候等自然条件制约。文章测算，若仅利用撒哈拉沙漠3.7%的面积部署光伏，即可产生26万亿千瓦时的绿电，足以支撑生产5.2亿吨绿氢，进而合成30亿吨粮食，满足当前全球人口的粮食需求。

尽管该路径在实验室层面已得到验证，但其大规模经济性、二氧化碳捕集的能耗与环境影响、以及工业化食品合成的全生命周期评估，仍需进一步研究。李振国说。

第二，光伏驱动的能源-水-食物协同系统路径。该路径充分发挥光伏系统的多功能属性，通过在荒漠地区建设光伏电站，利用光伏组件的遮荫效应降低地表辐射、减少土壤水分蒸发，从而改善土壤微气候，降低灌溉需求。结合光伏驱动的海水淡化与跨区域输水工程，该路径可将原本不宜耕种的荒漠土地逐步改造为可耕作农田，提升粮食生产储备能力。在丰产年份，富余的粮食与秸秆可转化为能源；在灾害年份，新增的耕地资源则可作为粮食供给的关键缓冲。

李振国表示，该路径在实现土地改良与粮食增产的同时，也需审慎评估大规模荒漠改造的生态影响、干旱区高强度水资源利用的可持续性，以及光伏+农业系统在严酷环境下的长期运行可靠性。这些不确定性，仍需通过跨学科研究进一步厘清。（来源：中国科学报 李媛）

相关论文信息：https://doi.org/10.1038/s41893-026-01792-0

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