Innovating the Water–Energy–Agriculture Nexus in Lebanon

STARTUPS AT THE CORE OF SYSTEMIC IMPACT

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1. UNDERSTANDING THE WATER–ENERGY–AGRICULTURE (WEA) NEXUS

Lebanon's agricultural future depends on how effectively it manages three vital resources: water, energy, and land. The water–energy–agriculture (WEA) nexus provides an integrated lens to understand how these systems interact, and how innovations optimized practices in one can strengthen the others.

Water and energy are the lifelines of food production. Every irrigation system, storage unit, and processing facility depends on them. Yet the relationship flows both ways: agricultural practices also shape how much energy and water are consumed or conserved. When one system becomes inefficient, the others inevitably suffer.

The nexus approach encourages collaboration across disciplines and sectors. It moves beyond fragmented fixes toward solutions that reflect how interconnected these challenges truly are. Through innovation, circularity, and technology, agricultural systems can conserve resources while increasing productivity.

Startups are becoming key actors in this transformation. Their agility allows them to design context-based solutions that respond directly to Lebanon's sustainability needs, from renewable energy and smart water use to waste valorization and adaptive farming. Together, these innovators form a growing ecosystem proving that sustainability can be both achievable and economically viable.

2. WHY THE NEXUS MATTERS FOR LEBANON

Lebanon's economy and food system are highly vulnerable to external pressures. For decades, the country has relied heavily on imported fuel, fertilizers, and food, leaving it exposed to fluctuating global prices and regional instability. This dependence has weakened local production capacity and turned sustainability into a national concern.

At the same time, Lebanon faces mounting environmental stress. Water scarcity and land degradation continue to worsen, driven by both climate change and outdated farming practices. Over-irrigation, soil exhaustion, and inefficient energy use have placed increasing strain on natural resources, threatening the livelihoods of small and medium farmers.

Yet these same challenges are now giving rise to opportunity. The combined economic and energy crises have pushed the country toward decentralized, homegrown solutions. Across Lebanon, startups are experimenting with solar solutions, alternative fertilizers, and soilless agriculture, building a new model of resilience that directly addresses local realities.

These emerging solutions share three defining qualities:

Figure 1 Defining qualities of newly emerging solutions in Lebanon

Together, they are laying the groundwork for a new era of food security and sustainability, one where growth is measured not only by scale but by resilience.

3. STARTUPS DRIVING IMPACT ACROSS THE NEXUS

Local innovation is becoming one of Lebanon's strongest tools for agricultural resilience. Across the country, entrepreneurs are developing practical solutions that make farming more efficient, affordable, and sustainable.

Eight startups illustrate this shift. Each addresses a specific challenge within the Water–Energy–Agriculture (WEA) nexus, and together they demonstrate how targeted innovation can strengthen the entire system.

They fall under three interconnected categories:

3.1 Renewable Energy

Powering agriculture through clean, efficient, and decentralized systems.

Energy is the backbone of agricultural production; it fuels irrigation, processing, and storage. Renewable energy solutions reduce dependence on costly, polluting fuels and allow farmers to access reliable, locally managed power. By integrating clean energy into the agricultural value chain, these startups help stabilize production costs and make farming more sustainable.

Caesar's Flame

Caesar's Flame converts organic and agricultural waste into biomass briquettes and pellets, clean, long-burning fuel that replaces diesel and heavy oil.

By turning farm residues into energy, Caesar's Flame closes the loop between production and power. It provides farmers and agri-processors with a renewable, locally sourced alternative that reduces fuel costs, lowers carbon emissions, and prevents waste from becoming an environmental burden.

Green Grid Trade

Green Grid Trade enables households, farms, and cooperatives to produce, consume, and trade solar power through a shared digital platform.

The model decentralizes energy generation, giving farmers access to collective solar infrastructure that stabilizes power supply and reduces dependency on national grids. This enhances the sustainability of energy-intensive operations such as irrigation, refrigeration, and food processing.

Nuwatt

Nuwatt designs smart solar systems and software that monitor energy generation and consumption in real time, integrating directly with irrigation and pumping networks.

Impact on the agricultural sector: By linking energy management to water systems, Nuwatt allows farmers to optimize both simultaneously, reducing waste, securing stable water access, and lowering operational costs.

3.2 Soilless Agriculture

Transforming how food is grown through water-efficient, space-saving, and circular systems.

As accessible land and water resources shrink, soilless farming is offering new possibilities for production. Through hydroponics, aeroponics, and biotechnology, these startups reduce resource use while expanding agriculture into urban and degraded areas.

Cultiva

Cultiva uses biotechnology to convert banana tree waste into organic fertilizers and soil substitutes that restore soil microbiology and fertility.

Cultiva simultaneously addresses soil exhaustion and waste accumulation. By turning crop residues into nutrient-rich organic matter, it gives farmers a local, affordable alternative to imported fertilizers, reinforcing soil health and closing material cycles.

Urban Leaf

Urban Leaf designs hydroponic systems that grow crops in nutrient-rich water instead of soil, cutting water consumption by more than 80%.

Its systems make farming possible in homes, schools, and small urban spaces, diversifying production sources, increasing water efficiency, and promoting awareness of sustainable food practices.

AgroConnect

AgroConnect integrates aeroponics, greenhouse engineering, and digital monitoring into modular systems suited for both home and commercial use.

The startup demonstrates how precision control and modular design can raise productivity while conserving water and land. It enables high-value cultivation even in non-arable zones, expanding the geography of Lebanese agriculture.

3.3 Agri-Input Producers

Providing farmers with the resources to cultivate resilient, high-yield crops.

Healthy inputs, seeds, soil, and nutrients form the base of every sustainable system. By developing bio-based fertilizers and preserving local seed varieties, these startups strengthen the foundations of production and help farmers adapt to climate and market pressures.

Grade A Plus

Grade A Plus produces natural fertilizer pellets from sheep wool, rich in nutrients and water-retentive properties.

The product improves soil structure, enhances moisture retention, and supports stronger root systems, reducing the need for irrigation and chemical fertilizers. This helps farmers maintain yields under dry conditions and contributes to long-term soil resilience.

Gharset Kheir

Gharset Kheir collects, enhances, and distributes native Lebanese seed varieties through a national seed bank.

By reviving seeds adapted to local climates and pests, Gharset Kheir strengthens food sovereignty and biodiversity. Farmers benefit from crops that require less water, resist disease naturally, and preserve Lebanon's agricultural heritage.

4. INTERCONNECTED INNOVATION: THE TRIANGLE OF SYNERGY

The impact of these eight startups is deeply interconnected in potential. Individually, they tackle specific challenges within the Water–Energy–Agriculture nexus, yet their solutions naturally complement one another. If leveraged collectively, their combined impact could multiply across the agricultural system, turning stand-alone innovations into collective impact.

Some of the strongest examples of this complementarity come from within the same subsectors. *Cultiva*, for instance, turns banana waste into organic soil alternatives that restore fertility. But not all plants thrive in these soils, and that is where *AgroConnect's* aeroponic systems can step in. Together, they make it possible to grow a wider range of crops with minimal water and land.

A similar link exists between *Gharset Kheir* and *Grade A Plus.* Gharset Kheir develops local, climate-adapted seeds that strengthen Lebanon's biodiversity but can struggle with lower yields. Grade A Plus, producing fertilizers from sheep wool, has worked with them to enhance soil quality and boost growth. The collaboration connects resilient genetics with natural soil enrichment, pairing biodiversity with productivity.

Each startup solves part of the challenge, energy, water, soil, or seed, but together, they show how local innovation can address agriculture as a whole. Renewable energy powers production; sustainable agriculture conserves resources; and eco-friendly inputs close the loop.

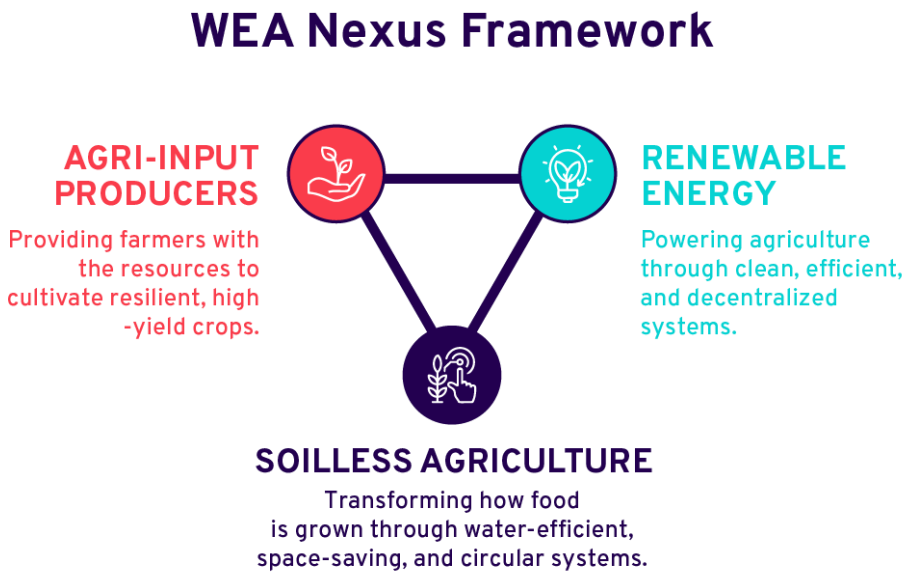

Figure 2. The interconnection of subsectors under the WEA Nexus

This triangle of synergy creates a continuous cycle where energy fuels agriculture, agriculture feeds input production, and sustainable inputs make energy and water use more

efficient. It's a model that shows how Lebanon can move from scattered efforts to a truly circular, collaborative agricultural economy.

5. SCALING THE SUPPORT SYSTEM

The insights drawn from these startups point to a clear direction for Lebanon's innovation landscape: it's not only about creating new solutions, but about **connecting the ones that already exist.** Innovation and interconnection must advance hand in hand.

Encouraging the creation of new ideas remains vital, Lebanon still needs technologies that respond to its specific resource, climate, and market realities. But equal value lies in fostering innovations that **bridge sectors and subsectors**, where energy meets agriculture, waste meets production, and technology meets sustainability. These are the points where small breakthroughs can turn into systemic change.

To nurture that kind of growth:

- **Accelerators and incubators** can pair startups from different sectors within joint programs, prompting collaboration between complementary technologies.
- **Investors and donors** can prioritize cross-sector solutions, ones that generate value simultaneously for multiple industries or communities.
- **Research and academic institutions** can drive applied innovation that connects disciplines and translates scientific knowledge into integrated solutions.
- **Public partners** can strengthen enabling frameworks, from circular economy incentives to green procurement, that make collaboration economically viable.

Over the years, Lebanon has often turned to creativity and resourcefulness to navigate difficult times, turning scarcity into ingenuity and crisis into opportunity. By pairing that same mindset with nexus thinking and interconnectivity, the country can move from individual breakthroughs to collective progress, unlocking an even broader and more lasting impact.