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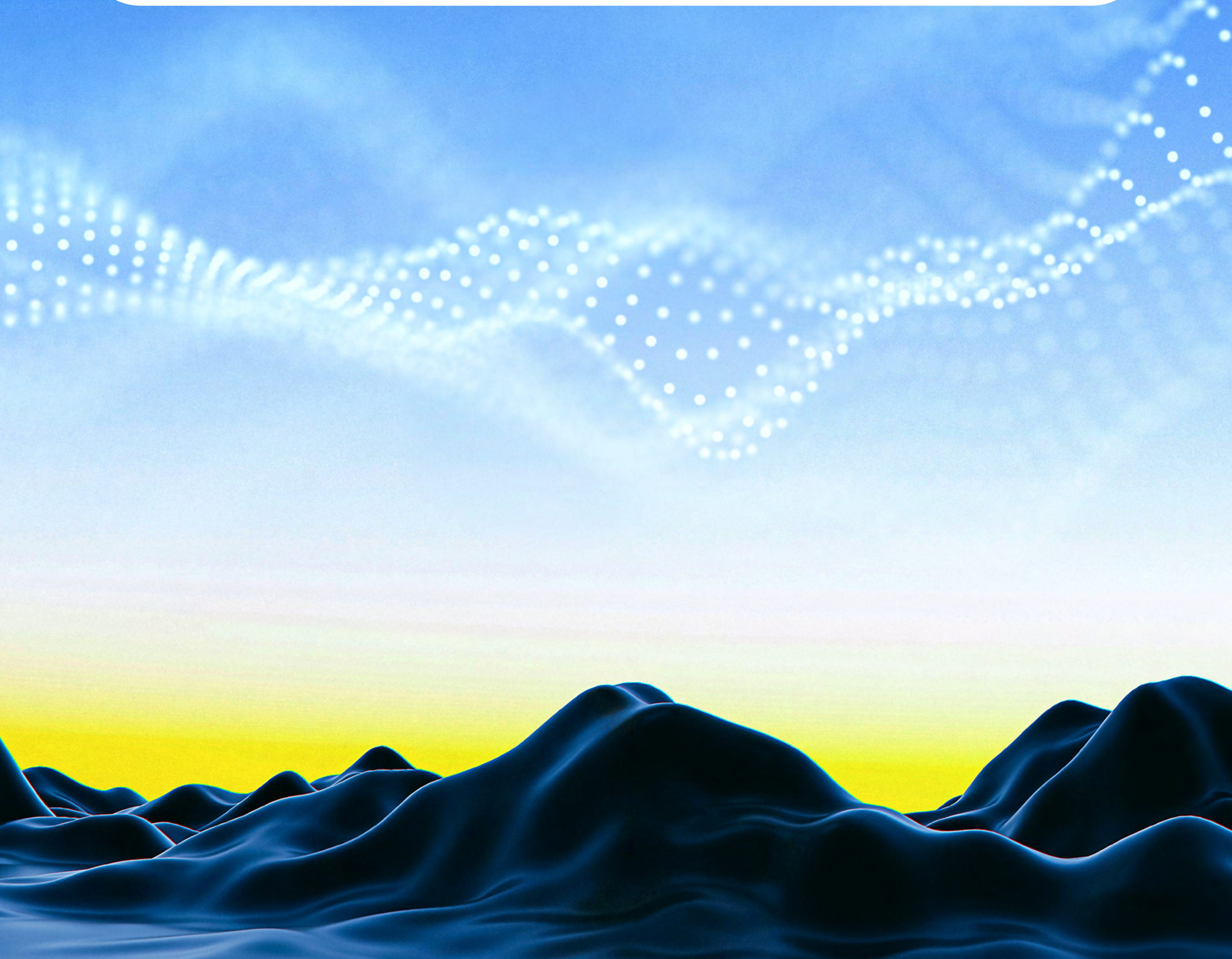
September 2026

Climate Resilience, Desertification and Applied Innovation Report

A Strategic Framework for Applied Innovation
in Arid and Climate-Vulnerable Regions



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Foreword

Climate change is reshaping how societies manage water, land, food, energy and economic resilience. Desertification is one of the clearest examples of this challenge, but also an area where science, technology and collaboration can make a tangible difference.

This report is built on the premise that climate resilience depends on connecting scientific excellence with applied innovation. Across water technologies, precision agriculture, remote sensing, artificial intelligence, biotechnology, soil intelligence, renewable energy and advanced materials, new solutions can help communities, farmers, utilities and governments manage climate stress and scarce resources.

Israel's experience demonstrates how scarcity can become a catalyst for innovation. Decades of water stress, arid agriculture and resource constraints have helped create an ecosystem that brings together research, entrepreneurship, public policy and real-world validation. The Negev serves as a living laboratory for developing and testing solutions relevant to other climate-vulnerable regions.

Yet technology alone is not enough. Climate resilience requires an integrated approach connecting water, land, agriculture, energy, data, finance and governance, as well as international cooperation. By bringing together complementary expertise, testing solutions across different environments and creating pathways for technology transfer and deployment, partnerships can help innovations reach scale faster.

The Israel Innovation Authority is committed to supporting this pathway from research and development to validation, commercialization and global deployment. By connecting innovators with research institutions, partners, markets and international networks, we aim to transform technological potential into scalable impact.

I hope this report contributes to that effort and encourages new collaborations across disciplines, institutions and regions. I thank the many partners and experts from Israel and around the world who made this work possible.

Dror Bin
CEO,
Israel
Innovation
Authority

Climate change and desertification increasingly impact every facet of human life. Desertification, accelerated by climate change, triggers a severe environmental crisis by destroying topsoil and collapsing dryland ecosystems. Rising temperatures and erratic rainfall patterns intensify droughts. This accelerates severe soil erosion, induces dust storms, depletes organic nutrients, and turns once-arable land barren.

Agricultural productivity crumbles, threatening global food security. As vegetation vanishes, water cycles are disrupted; the degraded ground loses its ability to absorb rainwater, leading to flash floods, depleted aquifers, and water scarcity.

These interconnected environmental failures compromise human health. Food and water insecurity trigger widespread malnutrition and waterborne diseases, while dust storms cause severe respiratory illnesses. The loss of habitable land forces the mass displacement of vulnerable populations, transforming land degradation into a global humanitarian crisis.

Solving these complex problems requires research, education, and proactive policymaking. It is essential to bridge the gaps between academic experts, public institutions, educational systems, private industry, and the general population.

The Goldman-Sonnenfeldt School of Sustainability and Climate Change at Ben-Gurion University of the Negev was established as an interdisciplinary institution dedicated to building sustainable climate resilience. We are committed to developing actionable solutions that mitigate global changes and empower us to adapt to a shifting world.

Only a comprehensive, multidisciplinary approach that learns from both past and present will secure a sustainable future. I am confident that this report will contribute to humanity's collective efforts to prosper in a sustainable manner, while adapting to and mitigating the dual crises of climate change and desertification.

Shimon Rachmilevitch
Head, Goldman-Sonnenfeldt School of Sustainability and Climate Change, Ben-Gurion University of the Negev, Israel

About the partners

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The Israel Innovation Authority is the strategic engine behind Israel's globally renowned tech ecosystem: a statutory, independent agency charged with shaping innovation policy, attracting investment, and fueling disruptive technologies. By bridging financial gaps - especially in deep tech - through conditional loans and matched funding, building forward-looking ecosystems in AI, bio-convergence, climate tech and quantum, and catalyzing collaborations among academia, startups, multi-national R&D centers and government, it ensures both technological and economic leadership. For investors, that means reduced risk (via early-stage funding and infrastructure), exposure to high-growth frontier sectors, and confidence that Israel's innovation environment is purposefully structured to nurture and scale breakthrough ideas with global market potential.

אוניברסיטת בן-גוריון בנגב
جامعة بن غوريون في النقب
Ben-Gurion University of the Negev

Ben-Gurion University of the Negev, brings together complementary expertise in sustainability, climate policy and desert research through the Goldman Sonnenfeldt School of Sustainability and Climate Change, the National Institute for Climate and Environmental Policy (NICEP), and the Blaustein Institutes for Desert Research (BIDR). The School is a trans-faculty academic center advancing interdisciplinary research, teaching and practical solutions across the natural sciences, engineering, health, social sciences and humanities. NICEP strengthens the university's science-policy interface by translating research into clear, feasible and measurable recommendations and fostering collaboration among academia, government, civil society and industry. BIDR is an internationally recognized research campus focused on the Food–Water–Environment–Energy nexus in arid and semi-arid regions. Its work spans water resources, reuse and desalination, sustainable agriculture, aquaculture, renewable energy, climate adaptation and ecosystem resilience. Together, these institutions connect research, policy and implementation to address desertification, water scarcity and long-term food, water, energy and environmental security in drylands.

Israel
Centre for the
Fourth Industrial
Revolution

C4IR Israel, The Centre for the Fourth Industrial Revolution (C4IR) Israel, hosted by the Israel Innovation Authority, is part of the World Economic Forum's global C4IR Network. The Centre connects Israel's innovation ecosystem with international partners to advance the responsible adoption and scaling of emerging technologies. It promotes collaboration across government, industry, academia and innovation communities, supporting policy learning, knowledge exchange and cross-border implementation. C4IR Israel led and coordinated the development of this report, convening national and international partners across research, policy, innovation and implementation to shape its analysis and recommendations.

4SIM
CENTER FOR ANALYSIS
& COORDINATION
OF THE FOURTH
INDUSTRIAL REVOLUTION

C4IR Azerbaijan, Established by Presidential Decree on 6 January 2021, the Center for Analysis and Coordination of the Fourth Industrial Revolution (4SIM) is a public legal entity under the Ministry of Economy of the Republic of Azerbaijan. As part of the World Economic Forum's Fourth Industrial Revolution Network, 4SIM supports Azerbaijan's digital economy, business transformation, and competitive human capital aligned with evolving labour-market needs. Working with government, industry, academia and international partners, it strengthens the Science-Industry Cluster 4.0 ecosystem and promotes innovative solutions across the national economy. In this report, 4SIM contributes Azerbaijan's perspective and expertise on renewable and distributed energy, off-grid systems, and integrated water–energy–food solutions for arid and degraded regions, highlighting pathways for climate resilience, sustainable development and technology deployment.

India
Centre for the Fourth Industrial Revolution

C4IR India, a member of World Economic Forum's Global C4IR Network, serves as a hub for advancing the responsible adoption of emerging technologies to address societal challenges and accelerate inclusive economic growth in India. Established in 2018, C4IR India facilitates the development and dissemination of policy frameworks, encouraging multistakeholder collaboration and supporting the responsible deployment of technology innovations. As of 2026, the Centre has a diverse portfolio covering themes including agritech (agricultural technology), AI, autonomous mobility, advanced manufacturing, digital health, the space economy and urban transformation. In these themes, the Centre convenes multistakeholder partnerships and mobilizes collective action towards some of the most pressing developmental challenges.

Stanford | DOERR
SCHOOL OF SUSTAINABILITY

The Governance for Risk, Resilience, and Recovery (GR3) program is a multidisciplinary, community-focused, and partnership-driven research initiative within the **Stanford Doerr School of Sustainability.** GR3 is dedicated to transforming how climate-related risks, including extreme weather events, are assessed, governed, and managed across the full resilience continuum, from planning and adaptation to response and recovery. In collaboration with researchers, policymakers, practitioners, industry leaders, and communities, the program co-develops governance innovations that (1) enable communities to strengthen their resilience to extreme weather events, respond effectively to disasters, and lead recoveries that prioritize equity and long-term stability, and (2) create scalable governance models that can be adapted and adopted by other regions facing similar challenges.

Nura Global Innovation Lab

Nura Global Innovation Lab is an Israeli nonprofit organization advancing technology-driven solutions for low- and middle-income countries. It connects innovators, researchers, private-sector partners and local ecosystems to co-create, validate and scale solutions to global challenges. Building on more than a decade of experience through the Pears Program for Global Innovation, Nura specializes in venture building, market validation, cross-border partnerships and innovation ecosystem development across climate resilience, water, agriculture, health and digital technologies.

JEWISH CLIMATE TRUST
صندوق المناخ קרן האקלים

Jewish Climate Trust (JCT) is a unique philanthropic partnership working to maximize the Jewish people's positive impact on climate. We seek to improve climate performance in Israel and diaspora Jewish communities, to further a range of co-benefits alongside climate outcomes, and to leverage climate impact beyond the borders of Israel and the boundaries of the Jewish community. JCT practices strategic venture philanthropy, investing deeply in a small number of grants and initiatives with significant potential for impact.

EVERGREEN INNOVATION PLATFORM

Evergreen Innovation Platform (EIP), identifies, validates, and scales climate-smart agricultural technologies and business models to improve the productivity, resilience, and climate adaptation of smallholder farmers. Founded in 2022 with the Sustainable Agriculture Foundation (SAF, formerly the Syngenta Foundation for Sustainable Agriculture) and the Milken Innovation Center, EIP delivers its programs on the ground in India through operational partners including the Agri-Entrepreneurship Growth Foundation (AEGF) and Syngenta Foundation India (SFI). To date, EIP has validated over 20 companies, whose successful solutions are now implemented at multiple locations across India.

DeserTech & Climate
Innovation Center

The DeserTech & Climate Innovation Center, based in the Israeli Negev, accelerates the development and deployment of climate technologies addressing desertification and climate resilience. The Center connects startups, researchers, industry, government and global partners to real-world challenges, enabling technology validation, pilots, commercialization and international market access. Leveraging the Negev's unique conditions and expertise, DeserTech positions the region as a global testing ground for solutions designed to thrive under increasingly extreme climate conditions.

Executive Summary

Desertification is no longer a localized environmental challenge affecting only arid and semi-arid regions. It is becoming a systemic resilience risk with implications for water security, food production, soil health, energy systems, economic development and regional stability. As climate change accelerates drought, heat stress, groundwater depletion and land degradation, the need for scalable and integrated solutions is becoming increasingly urgent.

This report reframes desertification as a deployable agenda for climate resilience and applied innovation. It argues that effective responses require moving beyond isolated technologies toward integrated systems that connect water, agriculture, land restoration, environmental intelligence and distributed energy. These solution areas complement and reinforce the integrated technology cycle: circular water systems can reduce pressure on freshwater resources; climate-resilient agriculture can help producers adapt to water and soil constraints; soil and ecosystem restoration can rebuild natural resilience; environmental intelligence can enable earlier detection and intervention; and renewable energy can power water, food and restoration systems in arid regions.

The report also emphasizes that technology alone is insufficient. Scaling desertification solutions depends on enabling governance, blended finance, public-private collaboration, field-validation environments, local implementation capacity and cross-regional learning. The challenge is to identify promising innovations, and create the conditions that allow them to move from fragmented pilots to scalable, locally adapted deployment models.

Israel and the Negev are presented as a reference model for arid-climate innovation, showing how scarcity and climate constraints can drive applied research, pilot infrastructure and public-private collaboration. This is reflected in Israel's position among countries combining a high density of climate-resilience startups with strong capital investment relative to population (Figure 1). The report also draws on global examples, emphasizing that solutions must be adapted to local contexts.

The call to action is clear: governments, investors, industry, research institutions and international organizations should work together to build integrated resilience systems. Aligning innovation, policy, finance and implementation can help climate-vulnerable regions build long-term resilience and sustainable development.

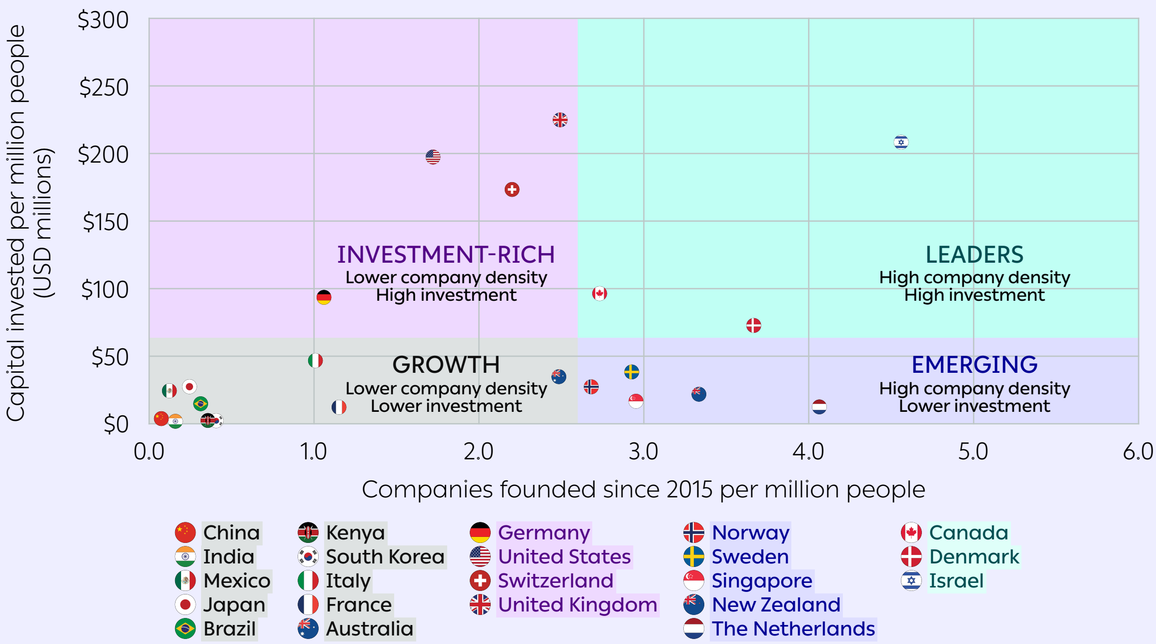


FIGURE 1: CLIMATE-RESILIENCE INNOVATION BY STARTUP DENSITY AND CAPITAL INVESTMENT

Source: PitchBook Data, Inc. (2026); countries are positioned by companies founded since 2015 and capital invested-both normalized per million residents-with quadrant thresholds set at the 65th percentile of the 22 countries for which both measures are available

1 Desertification as a Global Systemic Challenge

Global Systemic Challenge Overview

Desertification is not the natural expansion of existing deserts but the degradation of land in arid, semi-arid, and dry sub-humid areas. It is a gradual process of soil productivity loss and the thinning out of vegetative cover because of human activities and climatic variations such as prolonged droughts and floods. Though the land's topsoil, if mistreated, can be blown and washed away in a few seasons, it takes centuries to build up. Among human causal factors are overcultivation, overgrazing, deforestation, and poor irrigation practices. Such overexploitation is generally caused by economic and social pressure, ignorance, war, and drought. With population growth and increasing water scarcity, the fact that more fertile soils become non-fertile is a major concern. Desertification processes further elevate food insecurity, especially in developing countries.

Among practical measures undertaken to prevent and restore degraded land are prevention of soil erosion; improved early warning systems and water resource management; sustainable pasture, forest and livestock management; agroforestry ecosystems; afforestation and reforestation; and the introduction of new species and varieties with a capacity to tolerate salinity and/or aridity.

Because poverty forces people who depend on land for their livelihoods to overexploit the land for food, energy, housing and income, desertification is both a cause and consequence of poverty. Any effective strategy must therefore address poverty at its center and consider social structures and land ownership, while paying proper attention to education, training and communication as part of an integrated approach to combating desertification.

> "Desertification degrades land, deepens poverty, and threatens global food security. Through international cooperation, smart resource management, and community participation, we can halt soil loss and restore degraded land."

Prof. Noam Weisbrod
Alain Poher Chair in Hydrogeology and Arid Zones Research, Blaustein Institutes for Desert Research, Ben-Gurion University of the Negev; Israel National Focal Point to the UNCCD

Desertification is a worldwide problem directly affecting 250 million people and a third of the earth's land surface or over 4 billion hectares. In addition, the livelihoods of some one billion people who depend on land for most of their needs and usually the world's poorest in over one hundred countries are threatened. According to the UN, desertification is one of the major environmental problems of the 21st century, and it affects more than 170 countries.

Though desertification affects Africa the most, where two-thirds of the continent is desert or drylands, it is not a problem confined to drylands in Africa. Over 30 percent of the land in the United

States is affected by desertification. One quarter of Latin America and the Caribbean is deserts and drylands. In Spain, one fifth of the land is at risk of turning into deserts. The growing severity of the threat in the Northern Hemisphere is also illustrated by severe droughts in the United States and water scarcity in southern Europe. In China, since the 1950s, sand drifts and expanding deserts have taken a toll of nearly 700,000 hectares of cultivated land, 2.35 million hectares of rangeland, 6.4 million hectares of forests, woodlands and shrub lands. Worldwide, some 70 percent of the 5.2 billion hectares drylands used for agriculture are already degraded and threatened by desertification.

Desertification is at the root of political and socio-economic problems and poses a threat to the environmental equilibrium in affected regions. The land's loss of productivity exacerbates poverty in the drylands, forcing its farmers to seek a way of living in more fertile lands or cities. In fact, 135 million people- the equivalent to the population of Germany and France combined - are at risk of being displaced because of desertification. Some 60 million people are expected to eventually move from the desertified areas in Sub-Saharan Africa towards northern Africa and Europe in the next 20 years. Every year, between 700,000 and 900,000 Mexicans leave their rural dryland homes to find a living as migrant workers in the United States. Half of the 50 armed conflicts in 1994 were driven by environmental factors characteristic of drylands.

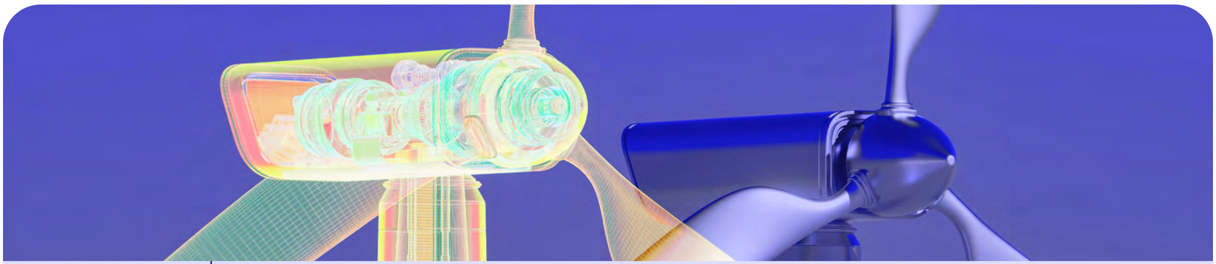
Desertification also has grave natural consequences. It makes land areas flood-prone, causes soil salinisation, results in the deterioration of the quality of water, silting of rivers, streams and reservoirs. Unsustainable irrigation practices can dry up the rivers that feed large lakes: the Aral Sea and Lake Chad have both seen their shorelines shrink dramatically in this way. Land degradation is also a leading source of land-based pollution for the oceans, as polluted sediment and water washes down major rivers.

At the global level, desertification first received focused international attention at the 1977 United Nations Conference on Desertification in Nairobi. However, limited political, administrative and financial support constrained early efforts to address the challenge effectively. In 1992, the United Nations Conference on Environment and Development (UNCED), known as the Rio Earth Summit, called for the establishment of a dedicated international convention. The United Nations Convention to Combat Desertification (UNCCD) was subsequently adopted in 1994, creating a legally binding global framework to address desertification, land degradation and drought.

The Convention is based on the principles of participation, partnership and decentralization and emphasizes the involvement of affected communities and stakeholders. At its core are national action frameworks designed to identify the drivers of desertification and the practical measures required to combat land degradation and mitigate the effects of drought.

More recently, the UNCCD has placed increasing emphasis on Land Degradation Neutrality (LDN), encouraging countries to avoid and reduce land degradation while restoring degraded land. The framework also supports international cooperation, knowledge exchange, capacity building and technology transfer for sustainable land management.

To summarize, desertification, resulting from both natural processes and human activities, is one of the major environmental challenges of the 21st century. With increasing climate instability, desertification processes are intensifying and becoming a growing threat to food security and livelihoods. Through better resource management, smart and careful land use, awareness, international cooperation, and appropriate local and global projects, desertification processes can be reduced and Land Degradation Neutrality advanced.



2 Core Technological Solution Areas

Desertification and water scarcity are increasingly recognized as cross-sector challenges that affect food production, economic development, energy systems, and urban resilience. As climate pressures intensify and populations continue to grow in water-stressed regions, addressing these challenges requires moving beyond isolated technological interventions toward integrated systems that connect water, energy, agriculture, ecosystems, and digital infrastructure.

By 2050, an estimated 1.7–2.4 billion people are projected to live in urban areas facing water scarcity[1]. At the same time, emerging industries including advanced manufacturing and digital infrastructure are increasing demand for reliable water and energy resources. These trends create a growing need for technologies that improve resource efficiency while strengthening long-term resilience.

The following solution areas should be read as interconnected components of a wider resilience system rather than as separate technology categories. Each sub-chapter follows a common structure: the specific desertification challenge, the core technology domains, current activity and emerging models, barriers to scale, and the strategic opportunity created when the solution area is connected with water, agriculture, soil, data and energy systems. A unified action agenda at the end of the chapter translates these shared needs into cross-cutting priorities for implementation.

2.1 Water Systems for Arid Environments

1. The Challenge

Water scarcity is one of the most critical consequences of desertification and climate change in arid and vulnerable regions. Rising temperatures, prolonged droughts, groundwater depletion, land degradation, rapid urbanization, and increasing food demand are placing severe pressure on limited freshwater resources.[2] Traditional water management systems based on surface water storage and groundwater extraction are approaching their environmental and economic limits.

This growing water stress threatens ecosystems, agriculture, public health, industrial productivity, and regional stability. Agriculture alone accounts for more than 70% of global freshwater withdrawals, often even higher in arid countries.[3] At the same time, climate variability increases uncertainty in water availability and accelerates soil degradation.

Addressing these challenges requires a transition from linear, supply-focused systems toward integrated and circular water resilience strategies. These systems combine demand management, non-conventional water sources, water reuse, and digital optimization to improve efficiency and strengthen long-term climate resilience.

> **"Water resilience in arid regions will depend not on a single technology, but on integrating water reuse, desalination, circular resource recovery, and smart management into one resilient system."**
>
> Amit Gross
> Dean, Jacob Blaustein Institutes for Desert Research, Zuckerberg Institute for Water Research, Ben Gurion University of the Negev

2. Technology and Solution Landscape

Sustainable water resilience in arid environments is achieved not through a single technology but through a diverse and integrated portfolio of solutions. **Four** key domains form the foundation of modern implementation strategies.

Table 1: COMPARATIVE ASSESSMENT OF MAJOR WATER SOLUTIONS FOR ARID REGIONS[4]

Solution	Typical Contribution to Water Supply	Relative Energy Requirement	Technology Maturity	Primary Constraint
Water Reuse	Medium–High	Low–Moderate	High	Regulatory frameworks and public acceptance
Desalination	High	High	Very High	Energy intensity and brine management
Smart Irrigation	Demand reduction (20–50%)	Low	High	Farmer adoption, training, and capital cost
Smart Infrastructure	Loss reduction (10–30%)	Low	High	High capital investment and institutional capacity

a. **Water Reuse and Circular Water Systems:** Water reuse is one of the most scalable and cost-effective pathways to augment water availability. Advanced treatment of municipal and industrial wastewater can produce high-quality water suitable for a range of applications, including agricultural irrigation, industrial processes, ecosystem restoration, and managed aquifer recharge. In highly advanced systems, it can also supplement drinking water supplies through direct or indirect potable reuse. Modern treatment trains incorporating technologies like membrane bioreactors (MBRs), ultrafiltration (UF), reverse osmosis (RO), ultraviolet (UV) disinfection, and advanced oxidation processes (AOPs), all of which can produce water tailored to specific end-use requirements. These systems also offer co-benefits, such as nutrient recovery for agriculture and reduced pollution of natural water bodies.

b. **Desalination** has become a strategic and essential water source for many coastal and water-stressed economies. Seawater reverse osmosis (SWRO) and brackish water reverse osmosis (BWRO) are the dominant technologies, accounting for the majority of global desalination capacity due to significant improvements in membrane performance and declining energy requirements.[5,6] While desalination provides a reliable, climate-independent water supply, its large-scale deployment necessitates careful management of two primary challenges: high energy consumption and the environmentally sound disposal of brine concentrate.

Solution Snapshot: Laguna Innovation - Circular water infrastructure for off-grid resilience

Laguna Innovation (Laguna Innovation | Onsite Wastewater Treatment) demonstrates how decentralized wastewater reuse can turn a sanitation liability into a local resilience asset. The company's modular, solar-powered system treats sewage onsite, produces reclaimed water for irrigation and other non-potable uses, and can be remotely monitored in off-grid or infrastructure-constrained environments. For water-scarce communities, this model offers more than wastewater treatment: it creates a circular resource loop that reduces freshwater extraction, limits environmental pollution, supports local agriculture, and links sanitation, water security, energy and food production in one deployable system.

c. Given agriculture's substantial share of global water consumption, the adoption of **smart irrigation and precision agriculture technologies** is increasingly important for reducing water demand while maintaining or improving agricultural productivity. These approaches include drip and micro-irrigation systems that deliver water directly to the root zone, thereby reducing evaporation and distribution losses; soil moisture and weather sensors that enable data-driven irrigation scheduling; remote sensing and drone-based imagery for monitoring crop conditions and identifying water stress at scale; fertigation systems that integrate irrigation and nutrient delivery to improve both water- and nutrient-use efficiency; and Controlled-Environment Agriculture (CEA), including greenhouses and vertical farming systems, which can substantially reduce water consumption per unit of agricultural output. Industry leaders such as Netafim have demonstrated how targeted water delivery can significantly improve agricultural productivity while reducing water consumption. Emerging solutions such as N-Drip further expand access to efficient irrigation through gravity-powered systems suitable for low-infrastructure environments. These technologies collectively improve water productivity (crop yield per unit of water) and reduce non-beneficial losses from evaporation, runoff and over-irrigation.[7]

d. Modernizing water infrastructure and integrating digital systems are fundamental to strengthening water resilience. Key interventions include reducing Non-Revenue Water (NRW) through active leakage detection and pressure management to minimize losses across urban distribution networks; deploying digital metering and analytics to provide real-time consumption data that can improve utility operations and influence consumer behavior; and adopting decentralized treatment systems that enable localized water reuse while reducing the energy requirements associated with large-scale water conveyance.

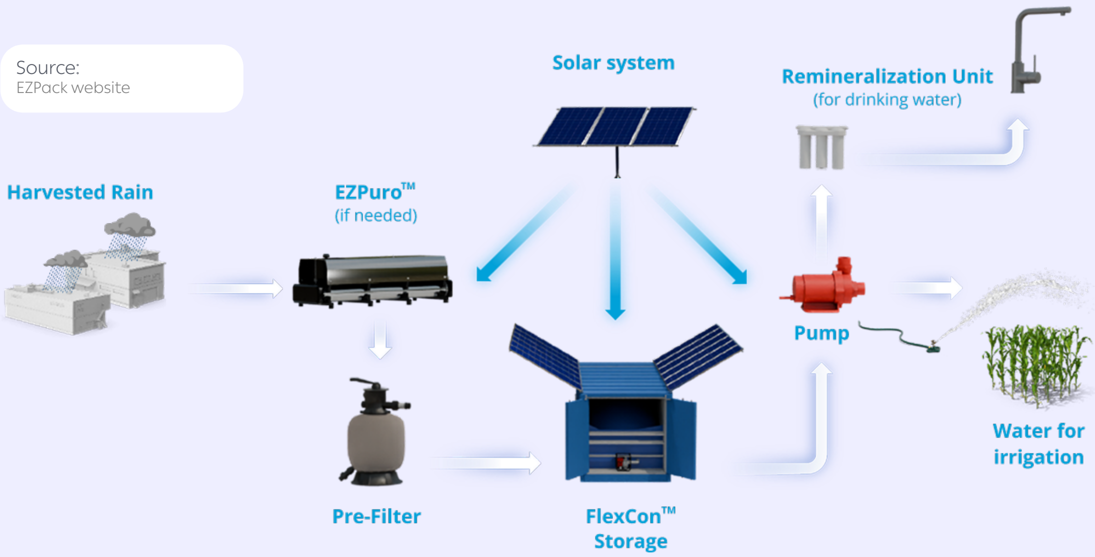
Additional approaches include Managed Aquifer Recharge (MAR) and Soil Aquifer Treatment (SAT), which use excess surface water or treated wastewater to replenish groundwater resources, as well as integrated water–energy planning aimed at optimizing treatment and distribution systems and reducing their overall energy intensity.[8]

Platforms such as TaKaDu illustrate the growing role of data analytics in water infrastructure management, supporting leak detection, predictive maintenance, and operational optimization across municipal and industrial networks.

Solution Snapshot: EZPack – Modular off-grid water resilience systems

In regions where permanent water infrastructure is limited, damaged or unavailable, modular off-grid systems can provide rapid access to safe and usable water. EZPack designs water resilience systems that can purify, store, transport and distribute water without reliance on electricity, pipelines or permanent infrastructure. Its components include robotic reverse-osmosis treatment, salinity treatment for irrigation, flexible water storage and mobile distribution units. Such systems are relevant for drought response, rural resilience and emergency deployment, while irrigation salinity treatment can help reduce one of the mechanisms through which water scarcity accelerates land degradation. deployable system.

Source:
EZPack website



3. Current Activity and Emerging Models

Several regions serve as powerful demonstrations for integrated water systems that can operate successfully at scale.

- Israel: A global leader in diversified water management, Israel reuses approximately 90% of its treated wastewater for agriculture, operates large-scale desalination plants that provide a significant portion of its municipal water, and has pioneered precision irrigation technologies.[9] This integrated portfolio has largely decoupled the nation's water supply from natural freshwater variability.

- Morocco: In response to severe, multi-year droughts, Morocco is aggressively expanding its desalination capacity and developing large-scale regional water transfer infrastructure to secure supply for major urban and agricultural centers as a core component of its long-term climate adaptation strategy.

- Jordan: As one of the world's most water-scarce countries, Jordan is advancing major desalination and conveyance projects, such as the Aqaba-Amman Water Desalination and Conveyance Project, to avert a critical shortfall in urban water security.

- Saudi Arabia and the Gulf States: These nations are increasingly integrating water supply with advanced digital water management systems and investments in controlled-environment agriculture to enhance food and water security.

Emerging implementation models are deepening integration and sustainability by combining renewable-powered desalination, decentralized water treatment and reuse, and resource recovery from wastewater streams. They also include circular water–food systems such as aquaponics using marginal waters, alongside integrated Water–Energy–Food (WEF) nexus planning at the national level.[10]

4. Strategic Opportunity and Vision

Water systems for arid environments address the basic resource constraint behind many desertification dynamics: too little reliable water, too much dependence on groundwater extraction, and growing competition between cities, agriculture, ecosystems and industry. The challenge is to shift from linear supply expansion toward circular and digitally managed water systems. The key technology domains are wastewater reuse, desalination, smart irrigation, non-revenue water reduction, managed aquifer recharge, decentralized treatment and data-enabled water management. Current activity shows that integrated portfolios can work at scale, but adoption is still constrained by regulation, energy intensity, public acceptance, capital cost and institutional capacity. The strategic opportunity is to make water systems the backbone of wider desertification resilience by linking reuse, energy, agriculture, soil restoration and environmental intelligence.

FIGURE 2: THE WATER RESILIENCE PORTFOLIO FOR ARID REGIONS. THIS FIGURE ILLUSTRATES A HIERARCHICAL APPROACH TO BUILDING A ROBUST WATER RESILIENCE PORTFOLIO.

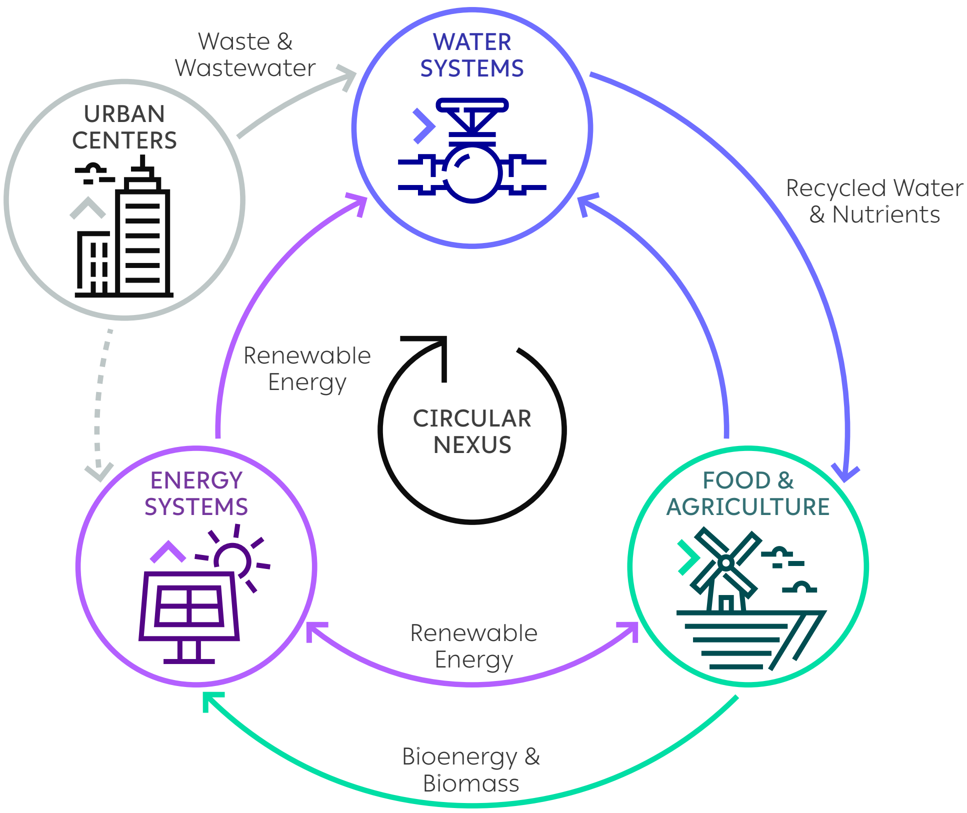


FIGURE 3: INTEGRATED WATER-ENERGY-FOOD NEXUS FRAMEWORK FOR A CIRCULAR ECONOMY

Figure 3 visualizes a circular, integrated approach to resource management, moving beyond linear "take-make-dispose" models. In this framework, outputs from one sector become valuable inputs for another. Key circular flows include treating wastewater to provide recycled water and nutrients for agriculture; using agricultural and urban waste to generate bioenergy; and powering water treatment and irrigation with renewable energy. This "nexus" approach creates a synergistic system that simultaneously enhances water, energy, and food security, reduces environmental degradation, and builds systemic resilience to desertification.[11]

2.2
The agriculture-desertification nexus

1. The Challenge

Transforming agriculture toward sustainability is critical to addressing desertification globally. The sector is both a driver of land and water degradation and one of the systems most exposed to their impacts. Unsustainable practices, including monocropping, overuse of chemical inputs, overgrazing, deforestation, inefficient irrigation, and excessive groundwater abstraction, have accelerated soil erosion, nutrient depletion, salinization, and the loss of soil organic matter. Today, nearly one-third of the world's soils are degraded[12], while agriculture accounts for around 72% of global freshwater withdrawals amid growing water stress.[13] These pressures reduce agricultural productivity, heighten exposure to drought and other climate shocks, and create systemic risks for food security and the livelihoods of millions of people who depend on the sector.

2. Technology and Solution Landscape

Recent advances in frontier technologies, including AI, remote sensing, robotics, and biotechnology, can help agriculture both reduce its contribution to desertification and strengthen future food security. In this context, DeserTech for agriculture refers to a set of technologies that help producers in arid, semi-arid, and degradation-prone regions anticipate environmental stress, adapt production to water and soil constraints, and regenerate degraded land. The following table highlights three core categories of DeserTech use cases for the agriculture sector.

Table 2: ILLUSTRATIVE TECHNOLOGY USE CASES SUPPORTING DESERTIFICATION RESILIENCE IN AGRICULTURE

Use-case category	How the segment enables response to desertification	Use-case examples
Monitor and forecast	Use-cases that detect, track and anticipate land, soil, vegetation and water stress to support early action and targeted interventions.	› Climate early warning systems (including drought and heatwave monitoring) › Geospatial land degradation monitoring dashboards › Soil moisture and groundwater sensors › Carbon Monitoring, Reporting, and Verification Platforms
Adapt and optimize	Use-cases that enable farmers and other value chain actors manage desertification risks and improve resource use-efficiency.	› Precision irrigation and fertigation › Climate advisory services › Controlled environment cultivation › Drought- and heat-tolerant crop varieties
Restore and regenerate	Use-cases that support the recovery of degraded soil, water, other natural resources and ecosystem functions, helping rebuild long-term agricultural resilience.	› Biochar and other land-enhancing inputs › Microbial and biological soil solutions. › Digital platforms for carbon markets › Regen agriculture specific advisory

Solution Snapshot: SaliCrop - Seed Enhancement for Climate-Resilient Agriculture

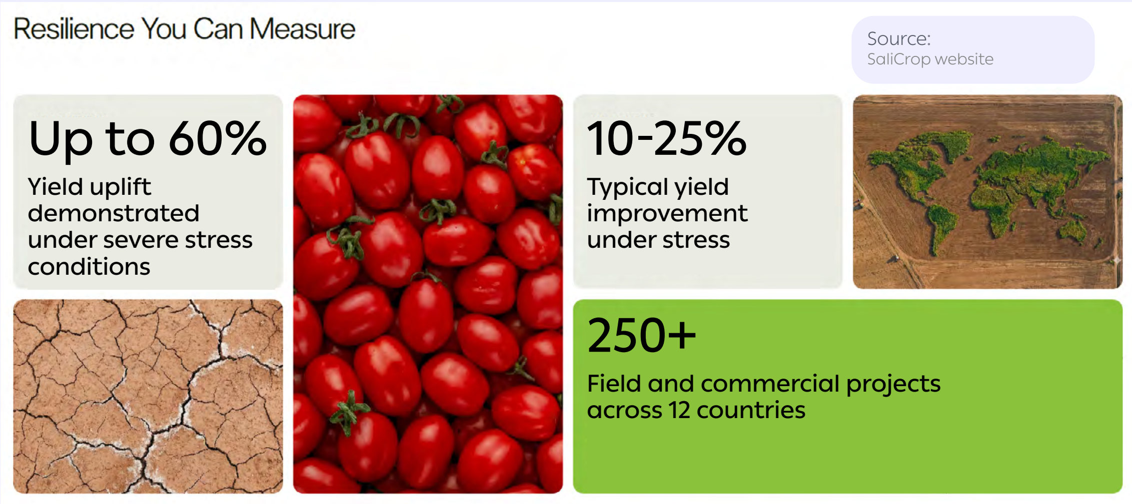
Crop resilience technologies can help farmers maintain productivity under increasing salinity, heat and drought stress, while reducing pressure to expand cultivation into fragile or degraded land.

SaliCrop has developed a non-GMO seed enhancement platform designed to activate multiple natural stress-response mechanisms in the plant before planting. The technology is adapted to specific crop varieties and stress conditions and is designed to improve cropestablishment, stability and yield under abiotic stress.

SaliCrop's technology has been validated through more than 250 field and commercial projects across 12 countries, including tomato production in Mediterranean regions exposed to recurring heat stress and field programs in saline environments.

Across multiple crops and geographies, SaliCrop has demonstrated typical yield improvements of approximately 10–25% under stress conditions, with significantly higher results achieved in severe stress environments.

This type of solution can support both food security and the productive use and rehabilitation of agricultural land affected by salinity, heat, drought and other climate-related stresses.



Precision agriculture illustrates how the "adapt and optimize" category can translate frontier technologies into measurable resource-efficiency gains. AI-based analytics platforms, such as CropX, can support climate-risk management and resource optimization by improving irrigation and input decisions. Real-time plant monitoring solutions, such as SupPlant, enable irrigation decisions based on plant stress indicators, helping improve resilience during drought conditions. Integrated soil sensors further support the precision application of water and nutrients, reducing resource consumption while improving agricultural productivity and resource-use efficiency.

These use cases increasingly combine sensing, analytics and automation to improve resource efficiency and agricultural resilience. Their broader integration within environmental-intelligence systems is discussed in Section 2.4

Case Study 1: CRISPR-Cas for Climate Resilient Plant Varieties

In 2025, the Indian Council for Agricultural Research announced India's first genome-edited rice varieties: DRR Rice 100 (Kamla) and Pusa DST Rice 1. Developed using CRISPR-Cas technology, the varieties make precise genetic changes without adding foreign DNA. ICAR reports that these varieties can increase yields by 19%, reduce greenhouse gas emissions by 20%, save 7,500 million cubic metres of irrigation water and improve tolerance to drought, salinity and climate stresses. DRR Rice 100 matures 20 days earlier, helping reduce water and fertilizer use, while Pusa DST Rice 1 can increase yields by 9.66% to 30.4% in saline and alkaline soils. The example demonstrates how biotech can enable cultivation of staples by optimizing the use of natural resources and also making crops resilient to desertification induced droughts.

Case Study 2: BioEnsure - Symbiotic Microbial Technology for Climate-Resilient Agriculture

Developed by Adaptive Symbiotic Technologies (AST) and field-validated by the Evergreen Innovation Platform (EIP), BioEnsure is a low-cost, easy-to-apply fungal endophyte inoculant that colonizes plant tissue to improve crops' tolerance to drought, heat, and salinity. **The technology was validated across nine villages in four Indian states, with its impact evaluated on five crops** (paddy, tomato, soybean, cotton and sugarcane) involving 12 smallholder farmers.

Treated crops showed yield gains of up to 36% in paddy and 20.65% in cotton, alongside consistently lower canopy temperatures indicating improved stress tolerance under real seasonal heat and rainfall variation. EIP's impact assessment estimates potential income gains of ₹22,520–₹58,760 per farmer per season, illustrating how low-cost biological inputs can help smallholder farmers adapt to increasingly erratic climate conditions.

Case Study 3: Fasal's precision water management technologies

Fasal is an Indian precision agriculture company that uses IoT sensors, AI and farm-level analytics to guide irrigation and crop management. It collects real-time data on soil moisture, microclimate and crop conditions, then provides crop-specific recommendations that help optimize water use on farms, a key driver of land degradation in arid and semi-arid farming systems. Over the years, Fasal has helped save over 52 billion litres of water across 10,000 acres, while improving yields and reducing pesticide use. By enabling need-based irrigation, it can reduce groundwater pressure, limit salinity risks and sustain productivity in degradation-prone landscapes.

Solution Snapshot: NOF - Off-grid post-harvest resilience for hot and remote regions

NOF develops an off-grid post-harvest treatment system designed to slow produce deterioration, reduce spoilage, and extend the usable shelf life of fresh agricultural products. The system lowers produce temperature, reduces metabolic stress, and supports the crop's natural defense mechanisms through a short, controlled treatment process.

By operating close to the source of production, NOF can help reduce post-harvest losses in hot and remote agricultural regions with limited cold-chain infrastructure, while preserving the value of existing agricultural output and reducing pressure on land, water, and other production resources.

3. Current Activity and Emerging Models

While frontier technologies have significant potential to reduce the risks of desertification in agriculture, their potential is constrained by several barriers. Some of the key barriers that restrict destertech for agriculture are highlighted below:

Design and Development

- **Limited access to quality data:** Fragmented or unavailable data on soil, water, climate and land degradation limits model training, validation and localization of AI models for climate resilient agriculture.
- **Lack of agri-sandboxes:** Limited real-world testing environments specifically designed for agriculture slow experimentation and adaptation to local crops, soils and farming systems.
- **High product development costs:** R&D, field trials, localization and technical support for new use-cases require significant capital investment. The returns on these investments are unclear as farmers and producers often do not have the ability to pay.

Validation and Pilots

- **High upfront adoption costs:** Frontier tech use-cases often require farmers and producers to invest in equipment, software, data services and training. These investments may not be viable for a majority of farmers globally, and especially those who have small land holdings.
- **Unclear farm-level ROI:** Adoption is limited when benefits to yield, income, water security or cost savings are not immediate or clearly demonstrated.
- **Low trust and high perceived risk:** Producers may hesitate to integrate unfamiliar technologies without local validation, credible intermediaries and proof from comparable contexts.

Commercialization and Scale

- **Limited scale-up funding:** Investors may be cautious due to a challenging market to service. This limits enterprises from raising capital for scale.
- **Weak delivery and support models:** Scaling requires distribution channels, extension services, maintenance, after-sales support and integration with value chains which may not be available in producing regions.
- **Limited digital literacy:** Sustained use depends on the ability of farmers, cooperatives, extension agents and institutions to invest in digital literacy and skilling.
- **Regulatory uncertainty:** For fast-evolving technologies such as gene editing, nanotechnology and biological inputs, regulatory frameworks often lag innovation, creating uncertainty around approvals, field deployment and market adoption.

FIGURE 4: CHALLENGES TO DESERTECH FOR AGRICULTURE

4. Strategic Opportunity and Vision

Addressing these barriers requires a coordinated pathway from technology development to local validation and commercial scale. Priorities include improving access to localized data, reducing adoption costs, expanding real-world testing environments, strengthening extension and technical support, clarifying regulatory pathways, and mobilizing patient capital for deployment.

2.3 From Land Degradation to Soil Health: Building Resilient Drylands

1. The Challenge

More than two billion people depend on drylands for their livelihoods, food production, and economic well-being, making these regions central to global climate resilience and sustainable development.[14]

Drylands, defined by the UNCCD as regions with an aridity index below 0.65, cover more than 41% of the Earth's land surface.[15] Across these regions, climate change, unsustainable land use, and increasing development pressures are accelerating land degradation, threatening food security, water resources, biodiversity, and economic resilience.[16,17] Rising temperatures, prolonged droughts, and more frequent extreme events are degrading soil health, reducing vegetation cover, and increasing susceptibility to wind and water erosion. If left unmanaged, these processes can trigger irreversible ecosystem degradation and undermine the livelihoods of millions of people.

Marsabit County, Kenya, illustrates the growing vulnerability of dryland communities to climate change and land degradation. Approximately 95% of the population depends on pastoral and agropastoral livelihoods, making local economies highly sensitive to drought and ecosystem decline (Fig. 4). Successive droughts between 2010 and 2022 caused extensive livestock losses, while the Marsabit Forest Reserve lost more than half of its closed forest and three-quarters of its open forest between 1990 and 2010.[18] Together, these trends highlight how climate and land-use pressures can rapidly erode ecosystem resilience and threaten food security, livelihoods, and biodiversity. Similar patterns are emerging across dryland regions worldwide, including the Sahel, the Horn of Africa, Central Asia, Australia, the Mediterranean Basin, western North America, and parts of South America, underscoring that land degradation is a global challenge rather than a localized environmental issue.[19]

FIGURE 5: HUMAN AND ECOLOGICAL IMPACTS OF LAND DEGRADATION IN DRYLANDS.

Representative scenes from Marsabit County, Kenya, illustrate the impacts of prolonged drought and land degradation on pastoral communities, livestock production, water scarcity, and dryland ecosystems.

At the core of resilient dryland ecosystems is healthy soil.[20,21,22] Healthy soils regulate water availability, store carbon, cycle nutrients, support biodiversity, and sustain agricultural productivity.[23,24,25] As soil health declines, ecosystems become increasingly vulnerable to soil erosion and vegetation loss, creating self-reinforcing feedback that accelerates degradation and reduces ecosystem resilience.[26]

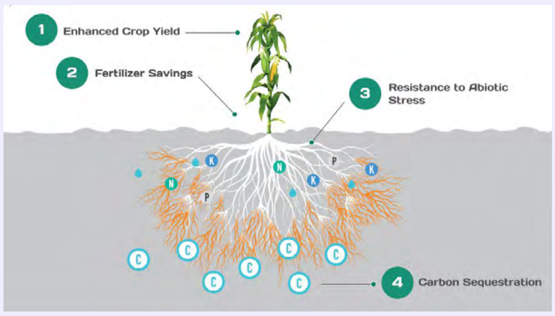
The consequences extend far beyond the environment, threatening food and water security, increasing pressure on energy systems and public health, and undermining sustainable economic development.[27,28] Protecting and restoring soil health should therefore be recognized as a strategic investment in climate resilience and treated as critical natural infrastructure, rather than solely as an environmental resource.

"Healthy soils are the foundation of resilient dryland ecosystems. By integrating Earth observation, artificial intelligence, and soil intelligence systems, we can transform land restoration from reactive interventions into predictive, data-driven solutions that strengthen climate resilience, food security, and sustainable development."

Prof. Tarin Paz-Kagan
(Associate Professor) Head, Remote Sensing and Agroinformatics Laboratory
French Associates Institute for Agriculture and Biotechnology of Drylands,
The Jacob Blaustein Institutes for Desert Research, Ben-Gurion University of the Negev, Israel

Solution Snapshot: Groundwork BioAg - Mycorrhizal solutions for soil and drought resilience

Groundwork BioAg develops highly concentrated mycorrhizal inoculants that strengthen the natural relationship between fungi and plant roots. Its Rootella® product line helps extend plant root systems, improving access to water and nutrients in the soil. By supporting water uptake, soil structure, and crop resilience under drought conditions, the technology can help farmers maintain productivity in water-stressed and degraded environments. This approach can also contribute to soil rehabilitation, reduced water use, and more resilient agricultural production in regions facing desertification.



2. Technology and Solution Landscape

Soil health is the capacity of soil to function as a living ecosystem that sustains biological productivity, regulates water and nutrient cycles, stores carbon, and supports biodiversity.[29] As an emergent property of soil systems, soil health cannot be captured by a single measurement; it requires integrating physical, chemical, and biological indicators, including molecular analyses of microbial diversity, functional genes, and soil biological activity. Restoring soil health and reversing land degradation, therefore, depend on integrated monitoring frameworks that detect degradation early, quantify ecosystem change, and support evidence-based management.[30,31] Recent advances in sensing technologies, Earth observation, artificial intelligence (AI), and digital agriculture are transforming soil management from reactive restoration to predictive, data-driven management.[32,33]

At the field scale, conventional laboratory analyses are increasingly complemented by rapid, in situ technologies. Portable spectroscopic instruments, such as Near-Infrared (NIR) and Laser-Induced Breakdown Spectroscopy (LIBS), enable rapid assessment of soil organic carbon, nutrients, and contaminants with minimal sample preparation.[34,35] National and global soil spectral libraries provide standardized databases that support soil characterization, Digital Soil Mapping (DSM), and AI-driven prediction of soil properties across diverse landscapes.[36] Electrochemical and biological sensors further enhance monitoring of soil biological activity, while integration with Internet of Things (IoT) networks, autonomous robotics, and precision agriculture systems enables continuous assessment of soil moisture, compaction, nutrient status, and overall soil health.[37]

At regional and landscape scales, **Earth observation** has become a cornerstone of soil and ecosystem monitoring.[38] New multispectral, hyperspectral, thermal, and radar satellite missions, complemented by uncrewed aerial vehicles (UAVs), provide continuous information on vegetation cover, soil moisture, erosion risk, land surface temperature, and indicators of land degradation.[39,40,41,42,43] Integrating these observations with AI and machine learning enables predictive models of soil health, nutrient dynamics, erosion risk, and agricultural productivity. These advances strengthen Digital Soil Mapping (DSM), which combines field observations, remote sensing, and geostatistical modeling to generate high-resolution, continuously updated soil information.[44,45,46,47] They also enable Digital Twin technologies that create dynamic virtual replicas of agricultural and natural ecosystems, allowing evaluation of management scenarios before implementation.[48,49,50] These capabilities are discussed as part of the broader environmental-intelligence framework in Section 2.4.

Soil health is the capacity of soil to function as a living ecosystem that sustains biological productivity, regulates water and nutrient cycles, stores carbon, and supports biodiversity.[51] As an emergent property of soil systems, soil health cannot be captured by a single measurement; it requires integrating physical, chemical, and biological indicators, including molecular analyses of microbial diversity, functional genes, and soil biological activity. Restoring soil health and reversing land degradation, therefore, depend on integrated monitoring frameworks that detect degradation early, quantify ecosystem change, and support evidence-based management.[52,53] Recent advances in sensing technologies, Earth observation, artificial intelligence (AI), and digital agriculture are transforming soil management from reactive restoration to predictive, data-driven management.[54,55]

3. Current Activity and Emerging Models

Soil restoration is rapidly evolving from research into large-scale implementation. The European Union is leading this transition through its Mission "A Soil Deal for Europe", which aims to establish 100 Living Labs and Lighthouses by 2030 to test and scale regenerative land management practices.[56] Supporting initiatives include AI4SoilHealth, EJP SOIL, PrepSoil, Soil Health Benchmarks, and WorldSoils, which collectively advance AI-driven monitoring, harmonized soil assessment, carbon sequestration, soil biodiversity restoration, and knowledge exchange. In the United States, the USDA Climate-Smart Commodities Program, the USDA Soil Health Initiative,[57,58] and the Long-Term Agroecosystem Research (LTAR) Network are promoting regenerative agriculture and generating scientific evidence for sustainable land management. At the global level, the UNCCD Land Degradation Neutrality (LDN) framework,[59] the FAO Global Soil Partnership (GSP), and the UN Decade on Ecosystem Restoration (2021–2030) are harmonizing monitoring standards, strengthening international collaboration, and mobilizing investments.[60] Together, these initiatives demonstrate that soil restoration has evolved from isolated pilot projects to coordinated, science-based implementation supporting climate resilience and sustainable development.

4. Strategic Opportunity and Vision

Despite rapid advances, soil restoration remains fragmented and largely project-based[61]. Policy and regulatory frameworks are often poorly coordinated across agriculture, water, biodiversity, and climate sectors, while financial incentives rarely reward ecosystem services such as carbon sequestration, biodiversity conservation, and water regulation[62]. Many regions, particularly degraded and low-income drylands, lack harmonized soil datasets, standardized indicators, and digital infrastructure needed to support evidence-based decision-making. At the same time, limited knowledge transfer, technical capacity, and economic incentives continue to slow the adoption of sustainable land management practices[63,64]. Yet these barriers also create opportunities for innovation and coordination. Integrating Earth observation, AI, Global Soil Libraries, and DSM into soil intelligence systems can provide continuous monitoring, predictive analytics, and transparent assessment of restoration outcomes[65]. Such systems can support carbon markets, ecosystem service payments, and risk-informed investment while enabling governments and land managers to prioritize interventions and monitor progress toward climate resilience and Land Degradation Neutrality targets[66].

2.4 Environmental Intelligence for Desertification Resilience

1. The Challenge

Unlike the preceding solution areas, environmental intelligence represents a cross-cutting layer that enables monitoring, prediction and decision-making across water, land and agricultural systems. As efforts to address desertification progressively shift from reactive interventions to proactive resilience-building, the ability to monitor environmental conditions, anticipate risks, and support timely decision-making has become a strategic capability. International frameworks for land degradation monitoring place a growing emphasis on the integration of Earth observation, sensor networks, predictive analytics, and decision-support tools to support sustainable land management and restoration outcomes.[67]

While Israel's contribution to desertification resilience spans a broad range of technologies, this chapter focuses specifically on data-driven monitoring, artificial intelligence (AI), and decision-support systems (DSS). These technologies form an important layer within desertification resilience strategies by enabling the early detection of environmental stress, improving the management of scarce water and soil resources, and supporting timely

> "Environmental intelligence is about more than observing change. Its real value lies in connecting data, prediction and decision-making to enable earlier and more effective responses to environmental risks."

Reut Guy
Senior Manager, Technological Research and Bio-Convergence, Technology Division

interventions that can prevent land degradation from becoming irreversible.

[68]A mapping exercise conducted for this report identified approximately 100 Israeli companies operating in data, sensing, AI, and decision-support technologies relevant to desertification resilience, compared with roughly 900 companies identified globally in adjacent fields. While these figures should be viewed as indicative rather than comprehensive market estimates, they suggest a notable concentration of activity relative to Israel's size. The identified companies are distributed across four technology clusters (Figure 6): Water & Salinity Intelligence, Visual AI & Remote Sensing, Soil IoT & Precision Agriculture, and Decision Support Systems (DSS).

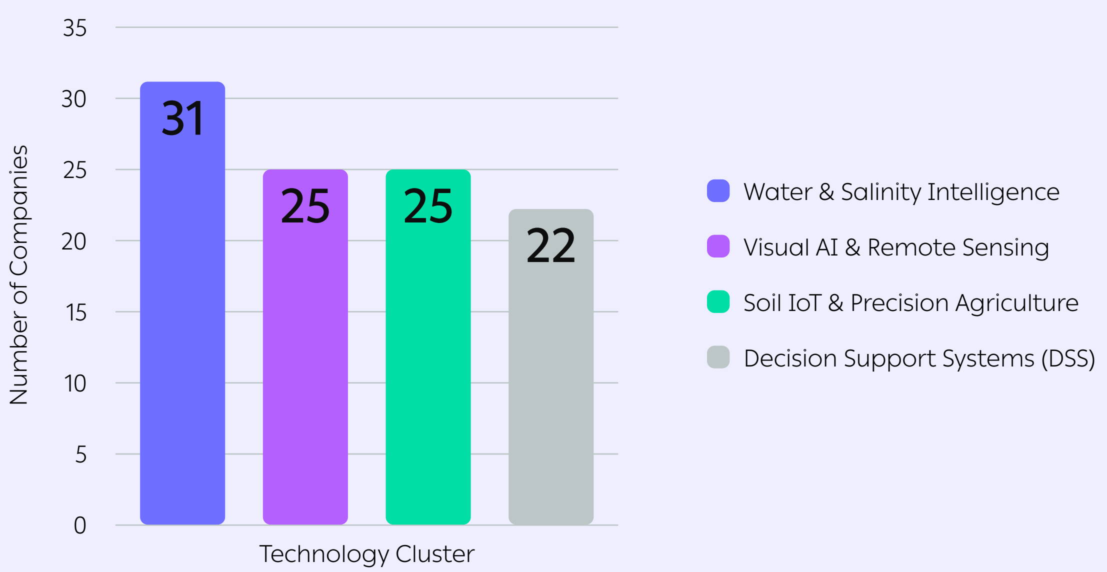


FIGURE 6: DISTRIBUTION OF ISRAELI DATA-DRIVEN SOLUTIONS FOR DESERTIFICATION RESILIENCE

Importantly, many of these companies operate across multiple layers of the value chain, combining sensing, analytics, prediction, and decision support within integrated platforms. Their classification reflects the primary capability identified during the mapping process rather than the full scope of their activities.

Similar trends are increasingly visible worldwide, where Earth observation, IoT systems, AI analytics, and decision-support tools are becoming central components of land restoration, ecosystem monitoring, and climate adaptation efforts[69,70,71]. The four clusters represent complementary areas of environmental-intelligence activity, spanning monitoring, sensing, analytics and operational decision support.

2. Technology and Solution Landscape

Water and Salinity Intelligence

Water management has long been a focus of Israeli innovation, with growing emphasis on intelligence-driven optimization at both the national system level and through specialized technology companies.

Israel manages desalinated water, groundwater, surface water and reclaimed wastewater within a coordinated national framework. This integration is enabled through extensive monitoring, forecasting, operational control, and decision-support capabilities operated by Mekorot, Israel's national water company. These systems support the optimization of water allocation across diverse sources under conditions of chronic water scarcity, helping maximize water availability for agriculture while reducing pressure on natural resources.

Complementing such system-level capabilities, TaKaDu demonstrates the growing role of AI in water management. Using machine-learning and anomaly-detection algorithms, the platform identifies leaks, operational failures, and inefficiencies across water networks, enabling utilities to prioritize interventions and reduce water losses. Together, these examples illustrate a broader shift from managing water assets toward generating actionable water intelligence.

Visual AI and Remote Sensing

The growing availability of satellite imagery, aerial sensing, and AI-based image analysis is transforming how environmental conditions are monitored at scale. Earth observation has become a central component of global land degradation monitoring frameworks, enabling continuous assessment of vegetation cover, soil conditions, and ecosystem change across large geographic areas.

An illustrative example is PlanetWatchers, which combines satellite imagery and AI-driven analytics to generate agricultural intelligence for insurers and financial institutions. The platform helps quantify production risks, estimate yields, and assess environmental conditions that may affect agricultural performance in vulnerable regions.

As climate variability and land degradation increase agricultural uncertainty, predictive insights become increasingly valuable. In regions vulnerable to desertification, such platforms can support earlier detection of vegetation decline, drought impacts, and productivity losses, enabling intervention before degradation becomes widespread.

Soil Intelligence and Precision Agriculture

The integration of sensors, connectivity, and predictive analytics into agricultural systems has created new opportunities to optimize resource use while reducing environmental pressure.

Many contemporary precision agriculture technologies can be traced back to innovations in irrigation efficiency. In this context, Netafim provides a useful example. While widely known as a pioneer of drip irrigation, the company's more recent platforms integrate sensors, weather information, agronomic models, and digital control systems to support data-driven irrigation management. The resulting systems help align water application more closely with crop requirements, reducing both resource consumption and environmental stress.

Building on this foundation, companies such as CropX combine in-field soil sensors with weather forecasts, satellite data, and machine-learning models to provide real-time insights into soil moisture, salinity, and nutrient dynamics.

The significance of such technologies extends beyond productivity gains. By monitoring soil moisture and salinity in real time, they can help reduce the risk of over-irrigation, salinization and soil degradation, supporting long-term land resilience in water-scarce environments.

Decision Support Systems

As monitoring technologies generate increasingly rich streams of environmental data, decision-support platforms play a critical role in translating environmental insights into operational action.

Taranis provides a representative example of this trend. Combining aerial and satellite imagery, AI-based image analysis, agronomic intelligence, and operational recommendations, the platform helps growers identify priorities for intervention at field level. While the company could also be categorized within remote sensing or visual AI, its primary value proposition lies in helping users determine where attention and resources should be directed.

3. Current Activity and Emerging Models

Current activity in environmental intelligence increasingly reflects a shift from standalone monitoring and analytics tools toward more integrated systems that connect sensing, prediction and operational decision support.

By combining these capabilities, such platforms can help users prioritize actions, allocate resources and respond more effectively to environmental risks. In water-scarce and desertification-prone environments, earlier responses to crop stress and resource constraints can help maintain productivity while reducing the risk of further land degradation.

Collectively, the mapping and examples presented in this section indicate that Israeli activity spans multiple stages of the environmental-intelligence chain from sensing and monitoring to analytics, prediction and operational decision support. This breadth of capabilities provides a foundation for connecting data-driven solutions across water, soil, agriculture and land-management systems.

4. Strategic Opportunity and Vision

While no single technology can address desertification on its own, the integration of sensing, AI, analytics, and decision-support capabilities enables earlier intervention, more efficient resource use, and improved management of vulnerable ecosystems.

However, the growing number of systems and platforms can create new challenges for end users. While each system may support effective decision-making independently, farmers are often required to use multiple platforms whose recommendations may not be fully integrated or consistent.

An emerging opportunity is to develop integrated and interoperable environmental-intelligence infrastructure that connects data and insights across monitoring, sensing, analytics and decision-support platforms. Greater interoperability can reduce fragmentation for end users and support more coherent, cross-system decision-making. Over time, generative AI or AI agents may serve as one possible interface or orchestration layer within such systems, but the broader strategic objective is to connect environmental-intelligence capabilities into more integrated and actionable resilience systems.

2.5 Renewable and Distributed Energy Solutions

1. The Challenge

Energy access and land degradation are closely interconnected challenges across arid and semi-arid regions. Globally, drylands cover approximately 40.6% of the Earth's land area excluding Antarctica and are home to around 2.3 billion people. According to UNCCD data, the share of drylands increased from approximately 37.5% to 40.6% over the past three decades, representing an increase of approximately 3.1 percentage points.[72]

Renewable and distributed energy systems are increasingly recognised as critical enablers of climate resilience, supporting sustainable water management, productive agriculture and land restoration, reducing greenhouse gas emissions and improving air quality in these vulnerable areas.

Azerbaijan provides an illustrative case study. Large parts of the country's lowland areas experience arid and semi-arid climatic conditions, while land degradation associated with salinisation, water and wind erosion, unsustainable land use, and overgrazing affects significant parts of the territory.

Two landscapes illustrate the relationship between energy systems, water stress, and land degradation. On the Absheron Peninsula, high population and industrial concentration, combined with water scarcity, saline soils, and limited vegetation cover, contributes to pressure on land and natural resources. In the Kura-Aras Lowland, one of Azerbaijan's principal agricultural regions, soil degradation affects substantial areas of farmland.

In both cases, maintaining productive land depends on energy-intensive water-management systems, including pumping, conveyance, irrigation, water reuse and, where appropriate, desalination. Historically, much of this energy demand has been met through fossil-fuel-based electricity. The challenge is therefore twofold: to decarbonise the energy systems supporting agriculture and water management in arid regions, and to provide reliable distributed power to remote, degraded, and post-conflict territories where centralised grid infrastructure may be limited, damaged, or unavailable.

"Climate resilience is built through innovation, collaboration, and action. By connecting technology with local expertise and global partnerships, we can transform environmental challenges into sustainable opportunities for future generations."

Fariz Jafarov
Executive Director, C4IR Azerbaijan

2. Technology and Solution Landscape

Azerbaijan has a substantial renewable energy resource base. According to the Ministry of Energy, the country's economically viable renewable energy potential is estimated at approximately 27 GW, including around 23 GW of solar energy, 3 GW of wind energy, 380 MW of bioenergy potential, and approximately 520 MW of hydropower potential from mountain rivers. This economic-potential figure should be distinguished from the country's larger technical resource potential.[73]

In addition, the technical offshore wind energy potential within the Azerbaijani sector of the Caspian Sea is estimated at up to 157 GW, comprising approximately 35 GW in shallow water and 122 GW in deep water. This figure refers specifically to Azerbaijan's sector of the Caspian Sea and is not presented as a global ranking against the North Sea or other multi-country offshore regions.[74]

Translating this potential into effective solutions for arid and degraded regions requires renewable technologies that simultaneously improve energy access, strengthen water security, support agricultural productivity, and contribute to land restoration. Four complementary renewable-energy technology families are particularly relevant.

Utility-scale solar photovoltaic systems on degraded and low-productivity land

Locating solar projects on degraded, marginal, or low-productivity land can convert underutilised areas into productive energy assets while limiting direct competition with agricultural land. Such deployment should be based on appropriate land-use planning, environmental impact assessment, biodiversity safeguards, and site-specific ecological screening. Where properly implemented, renewable energy projects can contribute to the productive reuse of degraded land without creating new pressures on sensitive habitats or productive soils.

Distributed and off-grid energy systems

Rooftop solar PV, solar thermal collectors, small-scale wind installations, battery storage, and hybrid renewable systems can provide electricity to remote settlements and agricultural facilities independently of, or before connection to, the central electricity grid. These systems are particularly relevant for rural areas, water-pumping stations, irrigation infrastructure, agro-industrial facilities, and settlements in post-conflict territories where conventional grid expansion may require significant time and investment.

Solution Snapshot: ProjectAGrow: Off-grid solar-powered water generation for agriculture

ProjectAGrow develops a fully autonomous, off-grid agricultural platform that integrates solar energy, atmospheric water generation, and microclimate management within a single system. Its Irrigation-by-Condensation technology captures moisture from the air and delivers water directly to the root zone, while AgroPV solar panels provide the energy required to operate the system. By reducing dependence on groundwater and grid infrastructure, the platform can support agricultural production in arid, remote, and climate-vulnerable regions. The system also helps reduce crop heat stress and improve water-use efficiency, illustrating how integrated water-energy-food solutions can strengthen resilience under conditions of water and energy scarcity.

Hydropower, energy storage, and system flexibility

Hydropower facilities on mountain rivers can provide renewable electricity and contribute to power-system flexibility. Pumped-storage hydropower, battery energy-storage systems, and other flexibility solutions can support the integration of variable solar and wind generation. These technologies are also important for ensuring reliable electricity supply to water infrastructure, irrigation systems, and other essential services supporting climate resilience.

Water-energy-food integration

Renewable energy can power water pumping, irrigation, desalination, wastewater treatment and reuse, water storage, controlled-environment agriculture, and other modern agricultural systems. Integrating renewable energy with water and agricultural infrastructure can reduce operational emissions, improve resource efficiency, support soil productivity, and strengthen drought resilience. This approach is particularly relevant where water scarcity, energy costs, and land degradation reinforce one another.

Complementary low-carbon firm generation: nuclear energy

Nuclear energy is not classified as renewable energy and is generally deployed as centralised rather than distributed generation. Nevertheless, where countries choose to consider it within their long-term energy strategies, it can serve as a firm, low-carbon complement to variable renewable sources. Any such consideration should be subject to national energy policy and a comprehensive assessment of nuclear safety and security, independent regulation, emergency preparedness, radioactive-waste and spent-fuel management, financing and lifecycle costs, grid requirements, and cooling-water availability. The latter is especially relevant in arid and water-stressed regions. Decisions on nuclear-energy deployment should follow applicable international obligations and IAEA safety standards.[75]

3. Current Activity and Emerging Models

Azerbaijan has moved rapidly from renewable-energy policy development to practical implementation. According to the Ministry of Energy's current official data, renewable-energy power plants with a total installed capacity of approximately 2,070 MW are operating in the country, accounting for about 20.8% of total installed power capacity.[76]

The first phase of the current renewable-energy expansion, centred on projects to be commissioned by 2027, has an investment value of approximately USD 2.7 billion. Separately, signed contracts and the broader project portfolio envisage more than 6 GW of green-energy capacity by around 2030. These figures refer to different scopes and time horizons and should not be treated as a single USD 2.7 billion programme delivering the entire 6 GW portfolio.[77]

Flagship utility-scale projects include the 445 MW Bilasuvar and 315 MW Neftchala solar power plants, the 240 MW Absheron-Garadagh wind power project, and the 100 MW Gobustan solar power plant. The Gobustan project alone is expected to save around 57 million cubic metres of natural gas and reduce carbon emissions by approximately 124,000 tonnes annually once operational.[78]

Azerbaijan has officially announced a target of achieving at least 30% renewable energy in installed electricity-generation capacity by 2030. More recent project-based planning indicates that the share could reach approximately 38% by 2030. The 30% figure should therefore be understood as the official policy target, while the higher figure is a projection based on the expanding project portfolio.[79]

Karabakh and East Zangezur Green Energy Zone

The Green Energy Zone in Karabakh and East Zangezur demonstrates how renewable energy can support regional reconstruction in degraded and conflict-affected landscapes. Restoration and reconstruction are being implemented in line with modern urban-planning, environmental-sustainability, and low-carbon-development principles, while making efficient use of the region's economic and geographic potential.

The development model combines the Green Energy Zone, Smart City, and Smart Village concepts. It includes the wider application of renewable energy and green technologies across the electricity value chain - generation, transmission, distribution, and consumption - alongside energy-efficient buildings, modern engineering and communications infrastructure, digital management systems, smart technologies, efficient water use, contemporary municipal-waste management, and measures supporting the restoration of forests, flora, and fauna. Building design is also expected to reflect the renewable-resource potential of each location, including solar, wind, and other appropriate technologies, while infrastructure for cleaner transport is progressively developed.

Preliminary official assessments identify more than 7.2 GW of solar technical potential and around 2 GW of wind technical potential in the liberated territories, in addition to significant hydropower resources; taken together, these resources are commonly described as being on the order of 10 GW. According to official plans, generation capacity in Karabakh and East Zangezur is expected to reach approximately 1.6 GW by 2030.[80,81]

The Nakhchivan Autonomous Republic is also being developed as a green-energy zone. Recent official statements cite renewable-energy potential of approximately 6 GW, while project preparation and technical assessment continue.[82]

Aghali Smart Village in Zangilan is a practical example of this integrated approach. The wider reconstruction model is also reflected in the planning and development of settlements such as Dovlatyarli in Fuzuli, Bash Garvand in Aghdam, and other liberated localities, where smart technologies, energy efficiency, modern infrastructure, environmental sustainability, and resource-efficient development are being incorporated into settlement planning.[83]

Beyond Azerbaijan, this model offers transferable lessons for other arid, degraded, remote, and post-conflict regions: prioritising suitable degraded and low-productivity land for renewable-energy development; integrating energy planning with water management and agriculture; deploying distributed and off-grid systems for remote settlements; linking renewable-energy infrastructure with land rehabilitation and regional reconstruction; applying smart technologies and digital management systems; and embedding renewable-powered land restoration within broader climate-resilience strategies.

Table 3: SELECTED RENEWABLE ENERGY INDICATORS FOR AZERBAIJAN

Indicator	Updated value / clarification
Installed renewable-energy capacity (current official data, 2026)	Approximately 2,070 MW
Economically viable renewable-energy potential	Approximately 27 GW
Solar energy potential within the economic-potential estimate	Approximately 23 GW
Wind energy potential within the economic-potential estimate	Approximately 3 GW
Bioenergy potential within the economic-potential estimate	Approximately 380 MW
Mountain-river hydropower potential	Approximately 520 MW
Technical offshore wind potential in Azerbaijan's Caspian Sea sector	Up to approximately 157 GW
Broader green-energy project portfolio around 2030	More than 6 GW
Official renewable capacity-share target for 2030	At least 30%
Updated project-based projection for 2030	Approximately 38%
Karabakh and East Zangezur renewable technical potential	On the order of 10 GW
Planned generation capacity in Karabakh and East Zangezur by 2030	Approximately 1.6 GW
Nakhchivan renewable-energy potential cited in recent official statements	Approximately 6 GW

These indicators demonstrate that Azerbaijan's renewable-energy transition is progressing from resource assessment and policy planning toward financed, contracted, and operational deployment. Values should be interpreted according to their stated category (economic potential, technical potential, installed capacity, policy target, or project-based projection) to avoid conflating unlike measures.

4. Challenges to scale

Land-use planning and environmental safeguards

Renewable-energy projects should prioritise degraded and low-productivity land where technically and environmentally appropriate. Project development should avoid unnecessary competition with productive agriculture, biodiversity areas, and other sensitive land uses.

Environmental Impact Assessment safeguards

Large-scale renewable-energy projects, including utility-scale solar and onshore or offshore wind, should undergo rigorous Environmental Impact Assessments (EIA) in accordance with applicable national requirements in order to identify, avoid, minimise, and mitigate ecological impacts. Particular attention should be paid to avian migratory corridors, natural habitats, vulnerable soil ecosystems, cumulative impacts, and impacts arising during civil works and associated infrastructure development.

Operation, maintenance, and local capacity

Distributed renewable systems require trained personnel, reliable maintenance services, access to replacement components, and clearly assigned long-term institutional responsibility.

Inclusive access and affordability

Renewable-energy investments should provide tangible benefits to rural and climate-affected communities through affordable access, local participation, employment opportunities, and equitable service delivery.

Grid infrastructure and flexibility

The integration of increasing volumes of variable renewable energy requires transmission-network reinforcement, storage systems, flexible generation, digital grid management, and balancing capacity.

Project-pipeline continuity

Long-term targets require a continuous pipeline of technically feasible and financially viable projects. Announced objectives should be supported by clear procurement schedules, financing mechanisms, grid-connection planning, and implementation arrangements.

Water-energy coordination

Renewable-powered irrigation, desalination, and water-reuse projects require coordinated planning among institutions responsible for energy, water, agriculture, environmental protection, and regional development.

Finance and risk reduction

Distributed systems in rural and degraded regions may not benefit from the financing conditions available to major utility-scale power projects. Their expansion may therefore require blended finance, concessional lending, guarantees, grants, and risk-sharing mechanisms.

Nuclear-specific governance considerations

Where nuclear energy is considered as part of a broader low-carbon strategy, additional barriers include the need for a mature legal and regulatory framework, independent nuclear-safety oversight, long-term radioactive-waste and spent-fuel arrangements, emergency preparedness, specialised human capital, substantial upfront financing, and careful assessment of cooling-water requirements and climate risks.

5. Strategic Opportunity and Vision

For arid and degraded regions, distributed renewable energy offers a convergence of climate, development, economic, and security benefits. Clean, locally generated electricity can reduce the cost and carbon intensity of the water-management systems on which dryland agriculture depends. Renewable energy can support irrigation, desalination, water reuse, pumping, and storage without increasing dependence on fossil fuels.

Decentralised energy systems can also reduce dependence on centralised grid infrastructure. This can enable remote or post-conflict territories to be resettled, rehabilitated, and returned to productive use more rapidly than would be possible through conventional infrastructure development alone. At the national level, replacing part of domestic fossil-fuel-based electricity generation with renewable energy may release additional natural-gas volumes for other economic uses and exports while supporting the development of green-energy export infrastructure.

Planned regional interconnections, including the Caspian-Black Sea-Europe and Central Asia-Azerbaijan green-energy corridors, could position Azerbaijan as an important link between renewable-energy resources in Central Asia, the South Caucasus, Türkiye, and European energy markets. The strategic vision should therefore extend beyond increasing generation capacity and focus on integrated energy systems supporting water security, agricultural productivity, land rehabilitation, rural reconstruction, industrial development, energy-system flexibility, and cross-border clean-energy cooperation.[84]

2.6
A Shared Action Agenda for Integrated Desertification Resilience

The five core technology areas in this chapter should not be scaled through separate action plans. Water systems, agriculture, soil health, environmental intelligence and renewable energy depend on each other and therefore require a shared implementation agenda. The priority is to build integrated desertification resilience systems that combine circular water, climate-resilient agriculture, soil restoration, environmental intelligence and clean energy into locally adapted deployment models.

Taken together, the Chapter 2 action agenda is to shift from technology categories to deployable resilience systems: validate integrated solution bundles in real-world conditions, finance measurable resilience outcomes, build shared data and monitoring infrastructure, strengthen local implementation capacity, and align governance across interconnected resource systems.

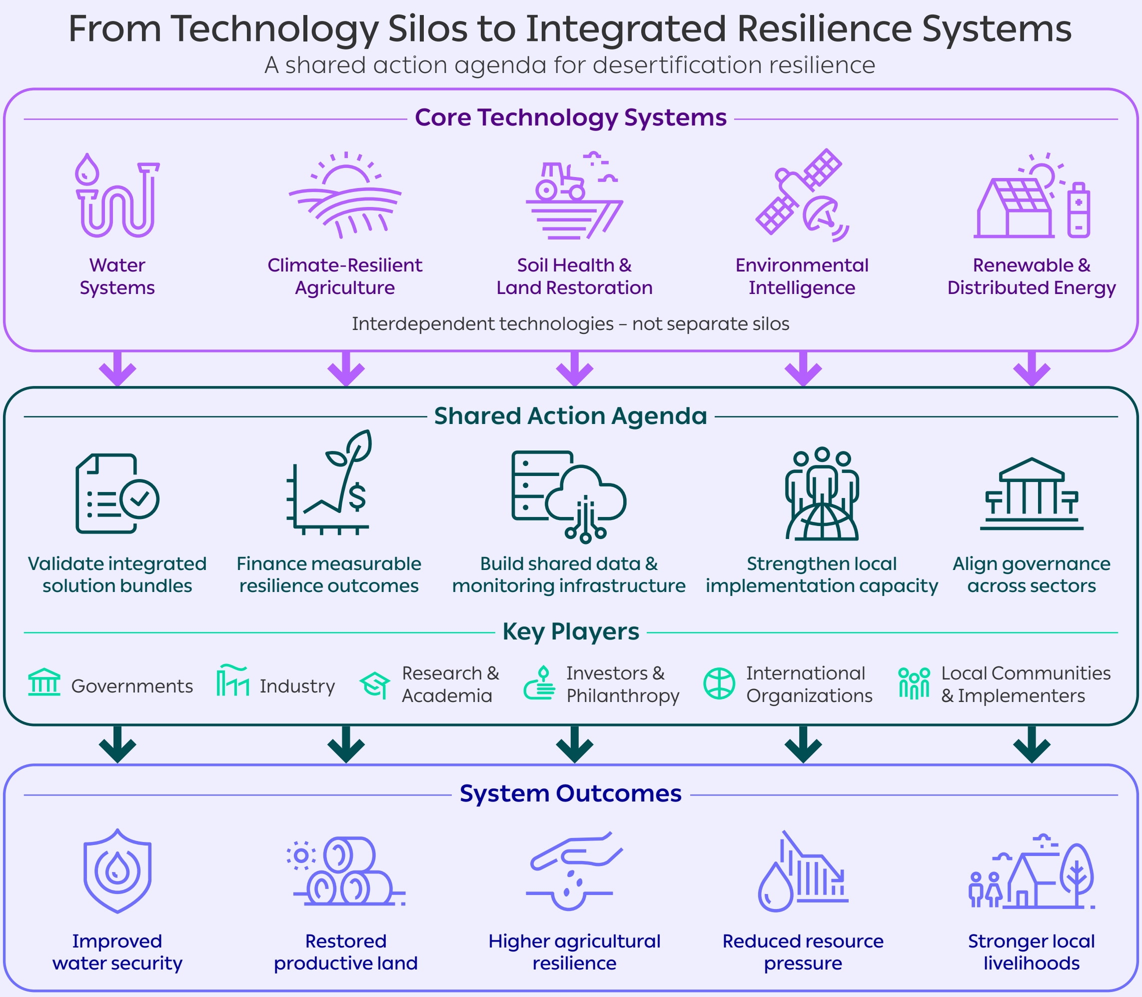


FIGURE 7: INTEGRATED DEPLOYMENT MODELS FOR CLIMATE RESILIENCE IN DRYLANDS

3 Enablers Beyond Technology

Advanced technological innovations offer unprecedented opportunities to combat desertification and restore arid ecosystems. Their impact can be amplified when deployed alongside enabling policies, innovative financing mechanisms, and strong local partnerships. Recent advances in water management, climate-resilient agriculture, land restoration, renewable energy, and environmental monitoring have created a growing portfolio of solutions for arid and semi-arid regions.

The growing availability of innovative solutions has shifted attention from technology development to effective deployment, adoption, and scaling. Realizing their full potential for long-term, commercially viable climate resilience depends on a supportive ecosystem that helps reduce risk, mobilize investment, strengthen local capabilities, and foster sustainable market demand.

Experience from both developed and emerging economies suggests that the impact of climate resilience initiatives can be strengthened when innovation is supported by effective governance, enabling financing mechanisms, institutional capacity, and skilled human capital. Three enabling pillars can help accelerate deployment, adoption, and long-term impact:

- Governance and Policy Frameworks: Regulatory certainty, long-term planning, public procurement mechanisms, and integrated resource management can create enabling conditions for private sector participation and support the scaling of innovative solutions.

- Financing and Investment Models: Innovative financing structures, blended finance mechanisms, and development capital can help mobilize investment and facilitate the transition from proven technologies to scalable infrastructure projects. This is especially important for deep-tech solutions, where the 'valley of death' between technology validation and commercial scale can be particularly difficult to bridge, requiring innovative financing tools.

- Local expertise, institutional capacity, workforce development, and international knowledge exchange can strengthen the ability to deploy, operate, and sustain innovative solutions over time.

3.1
Governance and Policy Frameworks

Technological innovation alone will not provide a sufficient response to desertification and land degradation. Technologies for water reuse, precision irrigation, soil restoration, drought-resilient crops, and climate-smart agriculture can be powerful tools; yet their success depends on the policy environment surrounding them. Without regulation, long-term planning, research support, infrastructure, financing, and implementation capacity, many promising solutions remain local experiments rather than scalable systems.

This is especially true for desertification-related technologies. Their effectiveness depends on soil type, climate, water availability, farming practices, and land-use patterns. A solution that works in the Negev may not work in the Sahel, Rajasthan, or northern Kenya without adaptation. Results can often be evaluated only after several agricultural seasons or through long-term monitoring of soil, vegetation, and water conditions. Many benefits are also public, including reduced erosion, restored land, improved groundwater management, healthier ecosystems, and greater food security. These benefits are real, but they are not always captured as direct profit by the farmer, company, or local authority that adopts the technology. Public policy therefore has a central role in reducing adoption and implementation risks.[85,86]

To build a coherent policy framework for slowing and managing desertification, governments need to address both the incentives of land and resource users and the practical tools available to them. Farmers, utilities, municipalities, and private firms often make decisions based on immediate costs and risks, while the broader damage from groundwater depletion, salinity, erosion, and ecosystem loss is borne by society over time. A comprehensive policy framework must therefore operate in two directions: encourage actions that mitigate desertification by making better alternatives available, affordable, and credible, while discouraging actions that accelerate desertification by means of regulation or financial actions.

> “The central policy challenge is not only to develop better technologies, but to create conditions under which effective solutions can move from isolated pilots to scalable, locally adapted systems.”

Nadav Bachar
Researcher ,National Institute for Climate Policy Research, Ben-Gurion University of the Negev

Structural mitigation and aligning public-private actions in light of Desertification

The first task is to guide land and resource users away from practices that accelerate desertification. This requires pricing mechanisms that accurately reflect the true cost of resource use. Water extraction, pumping energy, and land degradation should not be viewed solely as private production expenses, as their impacts extend far beyond individual users, contributing to declining aquifers, soil salinization, biodiversity loss, and reduced resilience to drought.

Australia’s Murray–Darling Basin offers a relevant agricultural example. Irrigation water is governed through tradable entitlements and seasonal allocations, while prices respond to scarcity and demand under basin-level limits on total extraction.[87,88] This is not a case in which water prices precisely internalize all environmental externalities. However, the model remains useful because it allows water scarcity to be reflected in prices and enables trading that can shift water toward higher value uses or users are better able to use the available water efficiently.

Israel provides a complementary example of regulated water pricing in a water-scarce context. While Israeli water tariffs do not fully internalize all environmental externalities, they are largely based on cost-recovery principles; however, cross-subsidies remain, and agricultural water prices are still subsidized.[89]

The second task is to support the adoption of tools that can reduce pressure on land and water systems. Many desertification-related technologies face significant adoption challenges because early users bear high risks before public benefits are proven. Policy can respond through four main mechanisms: direct subsidies, market creation, regulation, and risk reduction.

1. Direct subsidies can lower entry costs for farmers adopting water-saving irrigation, treated wastewater systems, or soil restoration practices.

2. Market creation can be achieved through public purchasing, quality standards, and long-term targets that provide confidence in sustained demand. For example, India's Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) promotes micro-irrigation systems such as drip and sprinkler irrigation through subsidies, national targets, and implementation frameworks, helping create a more stable market for suppliers while encouraging farmers to adopt water-efficient technologies.[90]

3. Regulation can translate policy goals into enforceable standards for quality, safety, and environmental performance. By setting clear minimum requirements, governments create predictable demand for compliant technologies and prevent weak or unsafe solutions from becoming the default.

4. Risk reduction can be achieved through field trials and extension services that test technologies under local conditions before farmers are asked to rely on them. Israel's regional agricultural R&D centers are valuable in this regard, as they test crops, irrigation methods, and agricultural technologies in collaboration with farmers under specific climatic and soil conditions.[91]

The third task is to ensure the availability of a strong and diverse portfolio of technologies capable of slowing and managing desertification. Because desertification is driven by multiple interacting processes, no single solution is sufficient. Governments should actively promote and incentivize the development and deployment of breakthrough technologies such as bio-solutions for soil health and increased crop yield, precision and optimized irrigation, drought-resilient crops and state-of-the-art decision-making systems. Public support for research and development is essential, but working in a coordinated manner with the private sector is no less imperative for the successful adaptation and scaling of emerging technologies. These tools can include shared funding and investment models, as described in the following chapter; creating regulatory sandboxes and testing regulatory approaches; creating innovation communities that leverage knowledge, opportunities and challenges between the private and public sectors, for an effective discussion and bridge-building, as private actors may be reluctant to invest under uncertainty.

This Innovation policy is needed to turn promising technologies into scalable solutions. In desertification policy, this means creating clear pathways from research and validation to scale-up and implementation, commercialization, and international adaptation. Israel's experience in desalination and wastewater reuse illustrates how sustained policy support, infrastructure investment, and clear demand signals can accelerate innovation and adoption, helping reduce water scarcity as a constraint on economic and population growth.

Structural adaptation and an enabling public framework

In addition to private-sector engagement, a comprehensive desertification strategy must include a complementary governmental apparatus to manage efforts and public resources. This section outlines the required governance framework, financial resource management, and the necessary monitoring and measurement systems.

A coherent framework suggests a governmental overview, aligned with partnerships to align budget, regulation, spatial planning, and implementation across sectors. Desertification should be addressed through an integrated nexus approach, recognizing the links between water, agriculture, biodiversity, energy, land use, infrastructure, tourism, and local communities. Without such coordination, water policy may encourage one outcome while agricultural subsidies, infrastructure development, or land-use planning encourage another. Governments should therefore establish inter-ministerial mechanisms or dedicated agencies that can align targets, monitor progress, and balance cross-sector priorities. Spatial planning is essential in this context, as land-use decisions shape the distribution of agriculture, infrastructure, urban development, conservation areas, and water systems, and can either reduce or intensify pressure on vulnerable soils and ecosystems.

Spain offers a useful example, as its National Strategy to Combat Desertification treats the issue as a cross-sectoral policy challenge requiring mapping, monitoring, and coordinated action.[92] The Atlas of Desertification in Spain strengthens this approach by compiling national-scale information on climate, land use, water resources, groundwater conditions, and other variables that support land degradation neutrality planning.[93] At the global level, tools such as Trends.Earth demonstrate how satellite and geospatial data can support national monitoring of land degradation.[94] Trends.Earth is a free and open source tool to understand land change, and allows users to draw on the best available information from across a range of sources - from globally available data to customized local maps. It was produced by a partnership of Conservation International, Lund University, and the National Aeronautics and Space Administration (NASA), with the support of the Global Environment Facility (GEF), and is further developed through partnerships with universities and global organizations.

Effective monitoring and measurement systems are essential for managing desertification over time. Governments need reliable data on soil health, water availability, and land-use changes to evaluate policies, detect early signs of degradation, and adjust interventions. This requires a combination of satellite data, field measurements, and standardized indicators that can be tracked consistently across regions. Without such systems, it is difficult to assess whether investments in technology and policy are delivering real improvements or merely shifting problems elsewhere.

Finally, some resources require dedicated local management frameworks that can operate over time. Israel's water and sewage corporations provide one structural example, as they operate within a closed financial framework in which water revenues are used to finance service provision and reinvestment in infrastructure.[95,96] For desertification policy, the broader point is that infrastructure cannot be treated as a one-time installation. Meters, treatment plants and soil monitoring systems, require ongoing maintenance, financing, and institutional responsibility beyond the pilot phase.

Some of these functions have no substitute for government. Pricing resource use, regulating water quality, defining land rights, and enforcing extraction limits require public intervention and investment. Other functions, however, can be advanced through international cooperation. The World Economic Forum, for example, could help establish a regional or international desertification solutions hub: a shared platform linking governments, researchers, investors, technology providers, and field sites in arid regions. Such a hub could coordinate demonstration sites, test technologies across different soils, climates, and farming systems, publish comparable results, and reduce risk for investors and public buyers.

In conclusion, technologies addressing desertification cannot be treated as standalone solutions. Their impact depends on the governance systems that discourage unsustainable resource use, reduce adoption risks, support innovation, and provide institutions capable of monitoring and adapting over time. The central policy challenge is not only to develop better technologies, but to create conditions under which effective solutions can move from isolated pilots to scalable, locally adapted systems.

"Technology opens new possibilities, but it is policy that creates the environment where those possibilities become a reality. Good policy brings together clear regulations, strong institutions, long-term investment, public trust, and visionary leadership. That is when innovation and pilots can move beyond ideas to strengthen resilience."

Tamar Zandberg
Head, The National Institute for Climate and Environmental Policy,
Ben Gurion University of the Negev.

3.2 Financing and Investment Models

While many technologies capable of addressing desertification already exist, expanding their impact will require financing mechanisms that support deployment, adoption, and long-term operation on a scale.[97] Financing plays an important role not only in providing capital, but also in enabling climate resilience by helping innovative solutions reach broader markets and applications.[98] A combination of public, private, and multilateral capital can mobilize investment, reduce investment barriers, and create sustainable pathways for growth.

In desertification innovation, specialized investors are playing an increasingly important role in early-stage financing. Alongside capital, they often bring sector expertise, strategic networks, validation environments, and market access, helping innovative solutions advance from development to commercialization and market adoption.

Solution Snapshot: OKO Finance – Parametric insurance for smallholder resilience

Climate risk is one of the main barriers to investment in smallholder agriculture. When a drought or flood hits, farmers lose their harvest, agro-industries lose their supply and lenders lose their repayments. [OKO Finance] designs and distributes automated parametric crop insurance that protects the whole value chain: agro-industries secure a more resilient supply base and stronger farmer loyalty, while banks and microfinance institutions de-risk their agricultural lending and can extend credit to farmers they previously excluded. To reach the last mile, OKO has developed its own distribution and payment solutions, using mobile money and mobile wallets so that farmers with no internet access, smartphone or bank account can be insured and receive automated payouts within days of an adverse weather event. Combined with agro-weather advisory services, this gives farmers both the protection and the information they need to invest in climate-resilient practices.

Source:
OKO Finance website

Public Funding and Investment De-risking

Public funding can play a catalytic role in advancing technologies that address water scarcity, land degradation, and climate adaptation challenges. Many desertification-related solutions require significant upfront investment and real-world validation before reaching commercial maturity. In this context, public support can help promising innovations progress from research and pilot stages toward broader market readiness.

Key public financing mechanisms include a portfolio of complementary instruments, such as non-dilutive R&D grants, public-private innovation platforms, and beta sites and demonstration facilities.

Israel's experience in desalination and wastewater reuse illustrates how sustained policy support, infrastructure investment, and clear demand signals can accelerate innovation and adoption, helping reduce water scarcity as a constraint on economic and population growth.

> "Behind every DeepTech breakthrough is the support that helps it grow. The right financing can turn promising innovations into scalable solutions for desertification and climate resilience."
>
> **Libat Weiss**
> Program Manager, Climate Tech Department, Growth Division,
> Israel Innovation Authority

Public-private innovation platforms provide access to infrastructure, testing environments, technical expertise, and industry networks that can accelerate commercialization and strengthen innovation ecosystems. In Israel, the InNegev incubator illustrates how such ecosystems can support climate-tech, water, and desert agriculture startups on their path toward market readiness. InNegev builds and invests in top-tier early-stage Israeli DeepTech startups, leveraging the Negev innovation ecosystem, and providing a 360° startup support system.

Beta sites and demonstration facilities enable real-world validation of technologies, generating operational data, building confidence among investors and partners, and supporting adaptation to local conditions. For instance, Israeli government-backed company "Energy Infrastructures" was recently selected by the Israel Innovation Authority to build an innovation demonstration facility for renewable and green energy sources in the Negev. This creates a mutually beneficial model, the company gains exposure to breakthrough technologies and can assess their potential application at the national level, and the startups gain an effective demonstration site, providing them with real-world testing on how to effectively demonstrate deployment at scale.

Together, these mechanisms strengthen pathways from innovation to commercialization, complement private investment, and support the scaling of climate resilience solutions.

Philanthropic and Catalytic Capital

Climate technology innovation depends not only on scientific breakthroughs and entrepreneurial capacity, but also on an enabling ecosystem that supports experimentation, deployment and scale. Governments play a central role in funding research and establishing regulatory frameworks, while the private sector drives commercialization and growth. Philanthropic capital can complement both by addressing strategic gaps that neither public nor commercial actors are always well positioned to fill.

One important role for philanthropy is strengthening the early-stage innovation pipeline. Grants, prizes, fellowships and non-dilutive funding can help attract entrepreneurs and researchers into climate technology and support promising ventures before they are ready for conventional investment. Initiatives such as the Climate Solutions Prize demonstrate how philanthropic awards can provide direct funding while also increasing visibility, attracting investors and creating wider ecosystem momentum. Similar support mechanisms can include accelerators, bootcamps and ecosystem-building programs that help early-stage companies strengthen their technical, commercial and partnership capabilities.

Philanthropy can also support the broader infrastructure required for innovation to scale. Many barriers to climate technology adoption are systemic rather than technological, including fragmented stakeholder networks, limited coordination, regulatory uncertainty and knowledge gaps. Philanthropic funding can therefore be directed toward public goods such as knowledge platforms, multi-stakeholder partnerships, communities of practice, leadership development and international collaboration. These investments can help create the institutional conditions needed for technologies to move from isolated pilots toward wider deployment.

A relevant example is the Israel Agrivoltaics Forum, established by the PAI Foundation, Yad HaNadiv and Jewish Climate Trust in collaboration with the Israeli Ministry of Agriculture, and coordinated by the Heschel Center for Sustainability and GrowingIL. Agrivoltaics, which combine agricultural activity and solar energy generation on the same land, hold significant potential for land constrained and climate-vulnerable regions. However, their deployment requires coordination across technical, regulatory and commercial domains.

The Forum brings together government agencies, researchers, farmers, industry and civil society to address these barriers collaboratively. Its activities have supported regulatory development, the establishment of a National Agrivoltaics Knowledge Center, publication of a national sector report and the launch of the Global Agrivoltaics Alliance to strengthen international knowledge exchange. This type of intervention illustrates how philanthropic actors can act not only as funders, but also as conveners and ecosystem builders that reduce implementation barriers and help prepare the ground for public and private investment.

A further role for philanthropy lies in de-risking technologies during demonstration and scale-up. Many climate solutions encounter a financing gap between successful research and commercially bankable deployment. First-of-a-kind projects, pilot infrastructure and early commercial demonstrations can involve technical, market and execution risks that exceed the appetite of traditional investors.

Philanthropic capital can help address this gap through flexible and patient financing instruments such as grants, concessional capital, guarantees and first-loss structures. It can also support technical assistance, regulatory navigation, knowledge dissemination, commercialization strategy and international partnerships. These interventions can reduce perceived risk, strengthen project readiness and enable larger pools of public and private capital to participate.

Philanthropy is not a substitute for commercial investment. Its value lies in its catalytic role: helping technologies progress from promising ideas to validated solutions, from pilots to investable projects, and ultimately from individual projects to scalable deployment models.

> **"True climate impact requires more than funding technology; it demands building the collaborative networks, policy frameworks, and financial models that allow those solutions to survive and mature."**

Nigel Savage
CEO JCT

Key tools for philanthropy to accelerate climate technologies:

- Non-dilutive R&D matching alongside public innovation grants to accelerate technical milestones.
- Concessional loans, guarantees and catalytic first-loss capital to de-risk first-of-a-kind projects and attract private investors.
- Pilot and demonstration funding to validate technologies under real-world conditions.
- Technical assistance and ecosystem support, including regulatory navigation, international partnerships and commercialization strategy.
- Mission-aligned venture philanthropy and blended finance vehicles that combine financial discipline with measurable climate and societal impact.

Blended Finance Architecture

Building on these public financing mechanisms, blended finance provides a framework to mobilize additional sources of capital and support technologies as they progress toward commercialization and broader market adoption.

Blended finance can play a catalytic role in scaling desertification technologies by combining public, philanthropic, and private capital. This approach is particularly relevant for innovations that require extended field validation, long development cycles, and significant upfront investment.[99]

By aligning public funding with private investment, blended finance helps bridge the transition from early-stage validation to market deployment, enabling technologies to move beyond pilots and demonstration sites toward broader implementation at scale.

Private Capital

As technologies mature and demonstrate commercial viability, private capital becomes increasingly important for enabling large-scale deployment and long-term impact. Institutional investors, infrastructure funds, and commercial financial markets play a central role in financing this transition.

A range of market-based instruments supports this scale-up phase. Venture capital and private equity provide growth financing for commercialization and international expansion, while green and blue bonds mobilize long-term capital for water infrastructure, ecosystem restoration, and climate resilience projects. Sustainability-linked loans incentivize measurable environmental performance by linking financing conditions to sustainability outcomes, and carbon and biodiversity credits create additional revenue streams by recognizing the value of ecosystem restoration and natural capital.

Together, these financing mechanisms strengthen market readiness, mobilize private investment, and enable the deployment of scalable solutions across arid and semi-arid regions.

Structural Recommendations

1. Establish Standardized Performance Metrics: Clear and comparable metrics for water efficiency, soil health, and land productivity are essential to measure adaptation impact, strengthen investor confidence, and expand sustainability-linked financing.
2. Develop Pooled Investment Vehicles: Aggregating regional adaptation projects into diversified portfolios can attract institutional investors and mobilize larger-scale capital for water, agriculture, and ecosystem restoration.
3. Strengthen Enabling Policy Frameworks: Supportive regulatory and fiscal incentives can improve project bankability and encourage greater private investment in climate adaptation.

Financing is an enabling pillar of the broader desertification resilience ecosystem. While technology, governance, infrastructure, and human capital drive innovation, financial mechanisms enable solutions to scale beyond pilot projects. Effective financing supports not only innovation, but also adoption, implementation, and long-term resilience.

3.3 Talent, Skills, and Knowledge Transfer

People, skills, and knowledge play a central role in translating desertification technologies into long-term impact. As solutions continue to evolve, strengthening human capital and fostering knowledge exchange can help accelerate adoption, support local implementation, and enhance resilience across diverse regions.

> "Addressing desertification requires more than developing solutions within national borders. International collaboration can accelerate learning, connect innovation ecosystems, and enable proven approaches to be adapted and scaled across diverse dryland regions."

Shani Dayan
Head, C4IR Israel, Israel Innovation Authority

Capacity Building and Technical Skills Development

The adoption of precision agriculture, advanced water systems, remote sensing, and AI-enabled environmental monitoring is reshaping workforce needs. In response, workforce development is expanding across several complementary areas, including:

- Digital and Precision Agronomy: Building capabilities in the use of IoT sensors, satellite data, and AI-enabled decision-support tools for more efficient resource management.
- Advanced Water Infrastructure: Strengthening expertise in decentralized desalination, wastewater reuse, and circular water systems.
- Restoration Ecology and Soil Science: Expanding knowledge in soil restoration, ecosystem rehabilitation, and nature-based solutions.
- AI and Optimization: Developing skills in AI-enabled modeling, analytics and optimization for climate and resource-management systems.

Partnerships between academia, industry, vocational training providers, and governments can help accelerate workforce development through applied learning and industry-oriented training.[100]

Source:
Wolfgang Motzafi-Haller

Cross-Border Knowledge Sharing, Adaptation and Technology Transfer

As desertification affects diverse regions, international collaboration can help accelerate learning and support the adaptation of solutions to local contexts. Several collaborative models are gaining momentum, including[101] :

- **Joint International Research Initiatives** that promote shared expertise and collaborative innovation. For example, the Horizon Europe-funded LILAS4SOILS project brings together partners across several countries to test and scale carbon farming and soil-health practices through a network of Living Labs. Israel participates through the RAGILL - RegenAg Israeli Living Lab, led by MIGAL with regional agricultural partners, enabling knowledge exchange and adaptation of soil-resilience practices across different climatic and agricultural contexts.

- **International Demonstration and Pilot Sites** generate practical evidence under diverse environmental and market conditions. Drawing on Nura Global Innovation Lab's experience supporting companies entering low- and middle-income countries, the organization highlights the importance of structured market adaptation and localized pilot validation. This may involve adapting the product, business model and operational approach to local conditions. In Colombia, EZPack piloted an off-grid, solar-powered water purification system in La Guajira, validating field deployment, remote assembly and long-term water quality. In South Africa, Solidrip repurposed an automated irrigation system originally designed for urban green walls for use in urban farming in Soweto, validating both technical and operational feasibility. These examples show how pilots can validate not only technology performance, but also product-market fit and pathways toward future scale.

- **Fellowship, Leadership and Exchange Programs** that strengthen technical capabilities, cross-sector leadership, and professional networks. For example, Israel's Climate Tech Fellows Program brings together researchers, entrepreneurs, investors, industry leaders and policymakers to develop climate-tech leadership, work on real-world challenges, and connect participants with international organizations, experts and global markets.

Long-term partnerships across governments, academia, industry, and local communities can further strengthen knowledge exchange and implementation capacity.

Key Takeaways

- Invest in multidisciplinary skills through collaboration between academia, industry, and vocational training.

- Strengthen international knowledge networks to support technology transfer and shared learning.

- Build local implementation capacity by combining global expertise with regional knowledge.

Human capital and knowledge exchange are important enablers of climate resilience, supporting the long-term deployment and scaling of technologies addressing desertification.

4 Pathways for Replication, Adaptation, and Implementation

4.1 Israel and the Negev as a Living Lab for Climate Resilience

Climate change is increasing the frequency and severity of challenges that Israel has confronted for decades: water scarcity, land degradation, extreme heat, and the need to produce more with fewer resources. As a result, Israel's experience offers valuable insights for countries seeking practical approaches to climate resilience and sustainable development.

Israel's innovation prowess lies not only in strong individual technologies, but in the highly integrated system that enables ideas to move rapidly from research and development to real-world implementation. The Negev Desert represents the clearest expression of this model as it relates to climate solutions.

Covering more than half of Israel's land area and characterized by extreme heat, limited rainfall, water scarcity, and challenging environmental conditions, the Negev functions as a national-scale living laboratory for climate resilience innovation. It is a place where technologies can be tested, validated, and deployed under conditions that resemble those increasingly faced by communities and industries across the globe.

The Negev as a Living Laboratory for Climate Innovation

Unlike controlled research environments, the region provides authentic operating conditions that allow technologies to be tested under real-world stresses, including prolonged drought, extreme temperatures, salinity, and resource scarcity. These conditions create opportunities to validate solutions designed for climate adaptation and resilience before deployment in international markets.

At the same time, the region offers access to a diverse network of pilot and demonstration sites across agriculture, water, energy, industrial operations, and critical infrastructure. This enables innovators to move beyond laboratory testing and evaluate performance at operational scale.

The region's innovation capacity is further strengthened by the concentration of academic, industrial, governmental, and entrepreneurial actors. Research institutions, led by Ben-Gurion University of the Negev, provide world-class scientific expertise and research infrastructure. Industrial operators, agricultural producers, and municipal institutions offer opportunities for pilot deployment and commercialization. Government agencies, investors, and ecosystem organizations contribute financing, policy support, and market access.

The integration of these actors is exemplified by Ben-Gurion University of the Negev (BGU), which anchors the regional ecosystem through its Jacob Blaustein Institutes for Desert Research (BIDR) encompassing specialized centers for agriculture, water, and energy – and the Goldman Sonnenfeldt School of Sustainability and Climate Change. BGU bridges academia and entrepreneurship through its Yazamut 360° center, which runs the Oazis deep-tech venture builder and Cactus Capital, Israel's first student-run venture fund with over $40 million in investment.

This academic foundation is closely linked with applied public research and industrial leaders. Applied agricultural research is conducted on-site by regional MOP (R&D) centers like the Ramat Negev Desert Agro-Research Center (RNDARC), which specializes in brackish water irrigation and agrivoltaics, and the Volcani Center's southern extension, the Gilat Research Center, which develops cultivation protocols for intensive agriculture under arid conditions.

Furthermore, mature industrial entities act as commercialization partners. Multinational crop protection company Adama hosts its global R&D Center at Neot Hovav to bridge advanced agrochemical research with industrial application, while drip-irrigation pioneer Netafim directly partners with Negev farmers and local research hubs to pilot smart IoT precision farming systems. Additionally, Haifa Group is setting up innovative research and training farms in the Tkuma and Arava regions to connect young farmers with agtech startups, and ICL Group operates the Planet Startup Hub to provide early-stage agrifood startups with capital, global R&D infrastructure, and testing sites.

From Innovation to Deployment: The Israeli Scaling Model

One of the greatest challenges facing climate technologies is not invention and testing, but adoption and scaling. Governments, utilities, agricultural producers, and industrial operators often require evidence that solutions will perform reliably under real-world conditions before committing significant resources to their adoption.

The Negev serves as a practical platform for this process by providing the infrastructure, partnerships, and governance mechanisms necessary to support technology validation and deployment. Dedicated pilot programs, accelerators, innovation communities, testing environments, and deployment opportunities enable technologies to advance from early-stage development toward commercial readiness.

Testing under conditions of heat, drought, salinity, and resource scarcity generates the performance data needed to support investment decisions and commercial deployment. As a result, the region functions not only as a center for innovation, but also as a mechanism for reducing risk and accelerating implementation.

This validation model is already actively demonstrated by several concrete initiatives on the ground:

- The Be'er Sheva Innovation District & Synergy7: Operating as Israel's first urban innovation district, this ecosystem is spearheaded by Synergy7, a strategic hub backed by a NIS 25 million Israel Innovation Authority investment. Partnered with BGU, Soroka Medical Center, and corporate giants like Dell and Elbit, Synergy7 provides advanced R&D facilities and proof-of-concept validation in cybersecurity, indoor robotics, and biotechnology.
- AgroNegev Platform: Serving the Western Negev, AgroNegev acts as an integrative hub funded by the Israel Innovation Authority, Ministry of Agriculture, and Ministry of Economy. It connects agricultural producers with early-stage startups to implement precision agtech directly in the field, run on-site agronomic observations, and build unified agricultural data infrastructures.
- Eilat-Eilot Renewable Energy & Transboundary Cooperation: In the southernmost Negev, the Eilot region serves as a specialized research hub for off-grid energy, water treatment, and hyper-arid agriculture. This regional work is supported by institutions like the Arava Institute for Environmental Studies, which fosters transboundary environmental cooperation across Middle Eastern borders, researching sustainable solar energy and transboundary water management

Beyond validation within domestic boundaries, the ultimate promise of the Negev model lies in its capacity to export these climate-adapted solutions to the most climate-vulnerable regions worldwide. This transition from local proof-of-concept to international market deployment can be exemplified by the "Water in Rural Africa" challenge – a joint initiative led by the DeserTech & Climate Innovation Center and the non-profit organization Innovation: Africa.

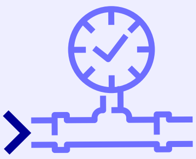
- The Orchestration Partners: As an Israeli innovation community, DeserTech coordinates the development, adaptation, and commercialization of sustainable technologies for arid climates, turning Be'er Sheva and the Negev into a prominent global entrepreneurial hub. For this initiative, DeserTech partnered with Innovation: Africa, a non-profit dedicated to delivering Israeli solar, water, and agricultural innovations to off-grid African villages. Since its establishment in 2008, Innovation: Africa has completed over 850 solar and water projects. By pumping clean water and providing solar power to schools and medical centers, the organization has impacted nearly 4 million people across 10 countries – including Uganda, Malawi, Tanzania, Zambia, South Africa, Eswatini, Cameroon, DRC, Ethiopia, and Senegal.

- Targeting Operational Gaps: Rather than deploying untested prototypes, the challenge established a highly structured pipeline to match Israeli dryland innovations with acute, real-world needs. The competition explicitly sought off-grid, low-maintenance Israeli technologies that could be seamlessly integrated into Innovation: Africa's independent, solar-powered water piping networks across three critical operational domains where water quality and long-term system durability are vital.

- Systemic Risk Reduction: By routing early-stage technologies through local pilot sites and matching them with Innovation: Africa's extensive field operations – which aim to complete 1,200 additional projects to reach 10 million people over the next five years—the challenge provides a reliable mechanism to bridge the "deployment gap". Of the three "Water in Rural Africa" challenge winners, two successfully progressed through this pathway, with field validation in an international market contributing to their subsequent growth and reducing the uncertainty associated with wider-scale deployment.

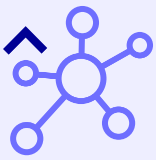
Ultimately, this collaborative ecosystem framework dramatically reduces technology and execution risks for international investors, governments, utilities, and corporate partners who demand verified performance data before funding large-scale climate adaptation initiatives. This case study illustrates how ecosystem intermediaries can systematically connect locally validated technologies with clearly defined international needs, creating pathways for entrepreneurs to scale their solutions while delivering tangible benefits to communities in drought-impacted regions

This example illustrates how ecosystem intermediaries can connect technologies developed for arid conditions with clearly defined international needs, supporting adaptation, validation, and deployment in climate-vulnerable regions.



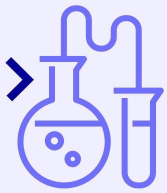
Water Quality Monitoring

Solutions for measuring and monitoring the water quality in real time, detecting changes and contamination from a biological or chemical source.



Water Disinfection and Treatment

Solutions that can purify or remove various elements from the water, such as microbiological contamination, metals, Nitrate and Fluoride.



Groundwater Desalination

Solutions for effective brackish groundwater desalination and safe brine disposal. The typical groundwater salinity encountered in Innovation: Africa's search for water is in a TDS range of 1,200 – 5,000 ppm.

FIGURE 8: 3 KEY DOMAINS

"What makes the Negev unique is the convergence of climate extremes, scientific excellence and innovation - creating a real-world laboratory for solutions that can strengthen resilience far beyond the desert."

Sivan Cohen Shachari
CEO, DeserTech & Climate Innovation Center

Lessons for Climate-Vulnerable Regions

Desertification, water scarcity, extreme heat, and other climate pressures: environmental constraints can become assets for innovation when they are matched with the institutions and infrastructure needed to turn local experimentation into deployment.

The model does not depend on replicating the Negev's specific technologies or institutions. Rather, it highlights several principles that can be adapted to local conditions:

Regional Orchestration and Coordination

A defining characteristic of the Negev model is the presence of organizations and partnerships that connect actors who traditionally operate independently: research institutions, startups, corporations, government agencies, investors, and infrastructure operators. These coordinating mechanisms help identify regional priorities, facilitate collaboration, align incentives, and accelerate implementation.

Financing the Deployment Gap

Many climate technologies face a critical challenge between successful pilot projects and large-scale adoption. The Negev model highlights the importance of financing mechanisms that support this transition, combining public support, private investment, industry participation, and outcome-oriented funding approaches to reduce risk and accelerate deployment.

Creating Markets for Climate Resilience Solutions

Innovation scales most effectively when supported by real demand. Industrial facilities, agricultural operations, water systems, and public infrastructure serve not only as testing environments but also as early adopters and reference customers. This creates feedback loops that improve technologies while generating the market confidence necessary for wider deployment.

The most transferable element of the Negev model is not a particular technology, but the system that enables technologies to move from local need, to real-world validation, to investment and deployment. While no two regions share identical circumstances, the underlying principles are broadly applicable: creating strong connections between research and implementation, developing mechanisms to finance the deployment gap, and creating markets in which climate solutions can be tested, adopted, and scaled.

For regions confronting desertification and climate change, this offers a practical starting point. Environmental constraints can become catalysts for innovation when they are matched with the institutional capacity, partnerships, infrastructure, and financing needed to act on them. The experience of the Negev suggests that building climate resilience is therefore not only a question of developing better technologies, but of creating the systems that allow those technologies to move from experimentation to measurable impact.

4.2
Regional Cooperation: From Fragmented National Responses to Regional Implementation Capacity

In this report, regional cooperation should not be understood as a formal political framework, but as a practical and voluntary implementation model for scaling desertification and climate-resilience solutions across countries and institutions facing similar environmental constraints. The core challenge is not only that climate risks cross borders. It is also that fragmented policies, regulations, standards, data systems, financing tools, and procurement frameworks create artificial borders that limit the ability to respond at scale.[102]

> "The region does not lack promising solutions to desertification. What it lacks is the shared infrastructure: data, standards, finance and a regional implementation framework, that allows these solutions to move beyond isolated pilots and deliver lasting impact across the region and beyond."

Dr. Lee Recht
Strategic Director, National Institute of Climate and Environment Policy, Ben Gurion University of the Negev; Managing Director, Table of Choices

In MENA, this logic is particularly relevant because countries across the region face overlapping structural conditions, including severe water scarcity, land and water-resource constraints, rising climate stress, pressure on agriculture, and growing demand for resilient infrastructure.[103,104] The World Bank identifies MENA as highly vulnerable to climate change, including extreme heat, desertification, water scarcity, degraded coastal and marine ecosystems, and air pollution.[105] Yet responses often remain nationally designed, financed, and implemented. This creates duplication, slows learning, limits market formation, and prevents successful solutions from being adapted across similar climate geographies.[106]

A regional approach offers a different logic. Rather than treating each country as an isolated market or policy environment, MENA can be viewed as a shared climate-resilience region: diverse in income levels, governance systems, and infrastructure capacity, but connected by overlapping environmental constraints and implementation needs. This creates an opportunity to leverage regional scale, accelerate applied innovation, reduce deployment risk, and build collective implementation.[107,108]

Regional cooperation can add value in three practical ways:

1. Reduce policy and regulatory fragmentation. Many desertification-related solutions depend on enabling regulation: treated wastewater reuse, brackish-water irrigation, desalination, soil-health monitoring, land restoration, climate-smart agriculture, digital advisory tools, and renewable-energy-powered water systems.[109,110] When standards, permitting processes, quality requirements, safety rules, and monitoring systems differ across countries, companies and public-sector actors must redesign implementation models for each national context. Regional alignment does not require full harmonization, but it can create common principles, comparable standards, shared terminology, and mutual learning between regulators.[111] This would make it easier for proven solutions to move from one MENA country to another.

2. Strengthen shared evidence, testing, and adaptation. Desertification and climate-resilience planning require comparable data on land degradation, drought, soil health, water availability, evapotranspiration, vegetation cover, groundwater stress, and agricultural productivity.[112,113] Today, data availability, quality, and accessibility differ across the region.[114,115] Regional platforms for data sharing, remote sensing, early warning, and applied analytics could support more consistent risk assessment, intervention design, and investment targeting.[116,117] Regional demonstration sites and applied research networks can also help assess how solutions perform under different soil conditions, water sources, crop systems, energy prices, and institutional capacities, supporting adaptation to specific implementation contexts.

3. Strengthen regional implementation capacity and expand markets for climate-resilience solutions. Many technologies relevant to desertification can remain trapped between pilot and scale when national markets are small, fragmented, or difficult to enter. Regional procurement frameworks, challenge funds, blended-finance facilities, shared investment platforms, and common standards could aggregate demand and make deployment more attractive for companies and investors.[118] Cooperation can also support the professional capacity needed for implementation: trained regulators, municipal planners, water authorities, agricultural extension services, engineers, financiers, researchers, and local implementers.[119,120]

Several existing initiatives show that regional cooperation mechanisms already exist and can serve as building blocks. FAO's Water Scarcity Initiative for the Near East and North Africa focuses on water governance, coordination between water and agriculture, non-conventional water resources, drought resilience, and tools for monitoring water consumption, productivity, and efficiency.[121,122] The Union for the Mediterranean's Water Agenda includes a Policy Framework for Actions 2030 and a financial strategy for implementation, with areas of work that include the water-energy-food-ecosystems nexus, water and climate change adaptation, desalination, wastewater reuse, groundwater recharge, stormwater harvesting, and renewable energy use in groundwater abstraction.[123] ICARDA, as a CGIAR research centre, delivers science-based solutions for dry areas, including work on agricultural water-use efficiency, water and land management, rangeland management, and dryland farming systems.[124] Regional energy cooperation is also reflected in the Pan-Arab Renewable Energy Strategy 2030 and its roadmap for implementation, developed with support from IRENA, the League of Arab States and RCREEE.[125] These initiatives are not a complete regional architecture for desertification resilience, but they show that cooperation can be organized around practical sectors, technical capacity, and shared resource constraints.

However, existing regional cooperation mechanisms still face barriers to scale. Policy and regulatory systems differ across countries, data is often incomplete or not interoperable, institutional capacity varies, and financing mechanisms are usually organized nationally rather than regionally.[126,127] Political sensitivities can also limit formal cooperation, even where technical needs are shared. Without such pathways, regional initiatives risk remaining focused on knowledge exchange or pilot activity rather than joint implementation, procurement, financing, or scale.

The recommended model is therefore not a broad political framework, but a practical regional implementation architecture for desertification resilience. Such an architecture should focus on the enabling conditions that allow solutions to move across contexts: shared evidence, comparable standards, coordinated testing, implementation finance, and professional networks. It should be designed around missions rather than declarations, with each mission defining a desertification-related challenge, measurable outcomes, relevant implementation partners, financing needs, and mechanisms for learning across countries.[128] In this sense, regional cooperation is not only about managing shared risks. It is about unlocking shared capacity. For MENA, the strategic opportunity is to move from fragmented national responses toward a regional implementation ecosystem capable of scaling desertification and climate-resilience solutions faster, reducing costs, and strengthening the region's capacity to respond to land degradation, water stress, and climate vulnerability.

4.3

Climate Vulnerability as a Governance Challenge:

Groundwater Depletion, Water Security, and Resilience in the Era of Desertification

Many communities across the world are experiencing the impacts of climate change in profound and increasingly disruptive ways. From extreme heat and prolonged droughts to destructive floods, mega fires, and rising seas, climate change is wreaking havoc across communities, ecosystems, and economies.[129] Yet these impacts are not felt equally and often experienced through water: too much, too little, or too polluted.[130]

These experiences are often most acute in vulnerable regions with limited or weak institutional, social, civic, and infrastructure capacities and where communities have fewer resources to prepare for, respond to, and recover from climate-related shocks and disruptions.[131] In these contexts, climate vulnerability is not only about exposure to hazards but about the capacity of systems to manage those hazards over time.

Too often, climate vulnerability is framed solely as an environmental challenge. In reality, it is equally a governance and development challenge.[132] The devastating consequences of climate change arise not only from the magnitude of the hazard itself, but also from the interaction between climate hazards and underlying social, economic, and institutional vulnerabilities. Drought becomes a humanitarian crisis when water governance systems fail. Floods become disasters when communities lack resilient infrastructure and recovery mechanisms or live in hazardous places due to poor land-use and zoning plans. Heat waves become deadly when social safety nets and public health systems are inadequate.[133]

Even in regions with relatively strong institutions and resources, climate extremes are exposing the limitations of existing governance systems, institutional and infrastructure set up. One such region is California's Central Valley, the food basket of the United States and one of the most productive agricultural regions in the world. While California, if counted as a stand-alone economy, would rank as the fourth largest economy in the world, it is also home to some of the most economically disadvantaged and climate-vulnerable communities in the nation.[134]

> "This report brings together a diverse collection of climate-related challenges and resilience solutions from around the world, creating a valuable opportunity for cross-pollination of ideas and peer-to-peer learning as we navigate the growing impacts of climate volatility and extreme weather events."

Dr. Newsha Ajami
Director, Governance for Risk, Resilience, and Recovery
Stanford Doerr School of Sustainability, Stanford University

Core Challenge

With that backdrop, the Central Valley is an epicenter of where poor governance meets climate vulnerability. California is home to one of the most complex water infrastructure systems in the world, moving water from water-rich regions to areas with more limited water resources and enabling population growth and one of the world's most productive agricultural economies despite being inherently water constrained.

Yet the same infrastructure and governance systems that facilitated economic growth have also created new vulnerabilities and exacerbated existing inequities. In the Western United States including California, surface water is partly allocated through antiquated and out of proportion appropriative water rights systems, while groundwater is largely treated as a property right tied to landownership.[135,136] For decades, this fragmented water governance structure has created a dynamic in which surface water shortages are routinely offset by increased groundwater pumping.

Over time, this has led to declining groundwater levels and severe land subsidence, which in part motivated the development of California's two major water projects: the Central Valley Project[137] in the 1930s and the State Water Project[138] in the 1960s. Despite both these significant investments, groundwater levels have continued to decline due to weak groundwater governance and increasing reliance on groundwater during prolonged drought periods that have become more frequent and severe as a result of climate change and aridification (Figure 9).[139]

In 2014, California passed the Sustainable Groundwater Management Act (SGMA), a historic attempt to address decline of groundwater levels and manage the unintended consequences. It requires local agencies to form Groundwater Sustainability Agencies, develop sustainability plans, and achieve sustainable yield over a defined timeline. It is, in essence, an attempt to retrofit governance onto a resource system that was never governed in a coordinated way. This required a strong coalition building and significant compromises across sectors.

However, while SGMA provides an important framework, implementation challenges remain. Due to prolonged dry conditions, recurring severe droughts, lack of comprehensive monitoring systems, and the absence of strict enforceable caps on use, groundwater levels in the Central Valley have continued to decline (Figure 9).[140] This has had a significant impact on disadvantaged communities in the region, with over 650 households reporting dry wells and losing their only source of running water between 2023 and 2024, and increasing water quality concerns.[141]

SGMA implementation illustrates a broader lesson for regions facing desertification: broad definitions of sustainability, deployed through polycentric governance regimes, may not result in sustainable outcomes for groundwater users in general, and for vulnerable users in particular.[142] The core challenge is always the same: how do you build the governance architecture for sustainable resource management after decades of unmanaged extraction have already locked in structural risk?

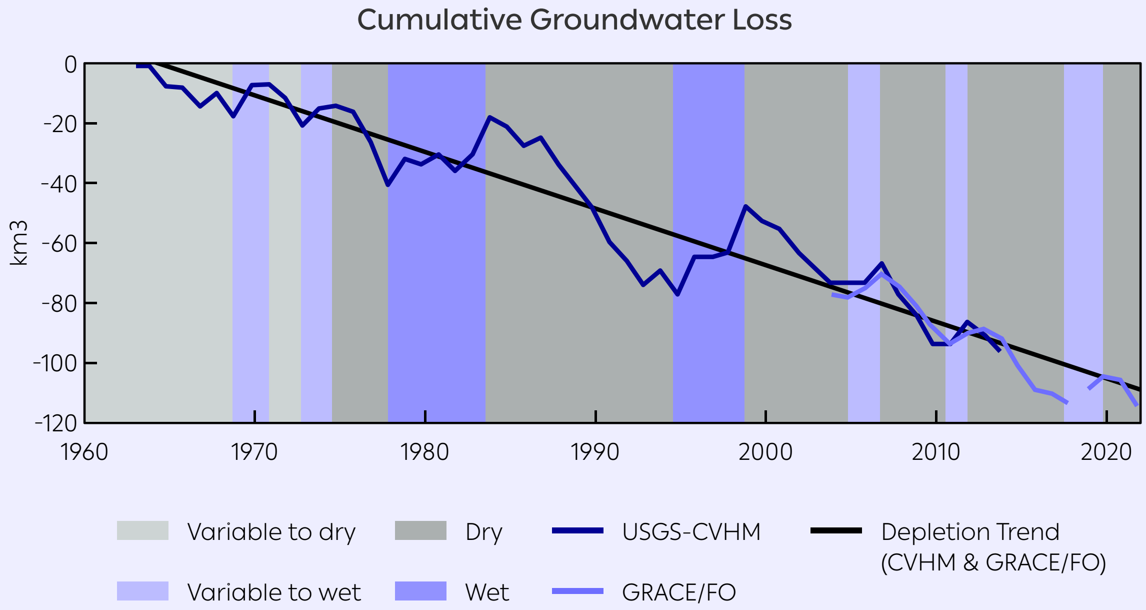


FIGURE 9: OVERALL GROUNDWATER LOSSES IN THE CENTRAL VALLEY, CALIFORNIA, USA SINCE 1962[143]

Priority Solution Areas

Addressing desertification and climate vulnerability in water-stressed regions requires action across three interconnected solution areas that must be pursued simultaneously.

Integrated water governance reform: Fragmented water management systems, siloed regulatory authorities, and the absence of coordinated groundwater management are the root conditions that convert drought into crisis.[144] Groundwater has long been an "out of sight, out of mind" resource, poorly measured and poorly governed, especially in semi-arid and arid regions where periodic droughts have historically masked the scale of depletion.

Over time, pumping technology has enabled extraction from deeper aquifers, often in the absence of regulatory regimes or enforceable sustainability targets and thresholds. Building governance frameworks that manage surface water and groundwater as a single integrated system, that account for ecological flows and community water security alongside agricultural and industrial uses, and that create enforceable sustainability obligations rather than voluntary aspirations, is foundational to long-term water security.

Data infrastructure for adaptive management: Data is a key element in proper and transparent resource management. Regions facing aridification frequently lack the monitoring systems, reporting requirements, data integration capabilities, and institutional capacity to track what is happening to their water resources in real time.[145] Without this visibility, governance becomes reactive rather than adaptive.

Building robust data infrastructure including groundwater monitoring networks, soil moisture systems, remote sensing,and interoperable data platforms, is not simply a technical investment. It is a governance investment that enables adaptive management, supports regulatory action, and creates transparency and accountability.[146]

Community-centered resilience investment: The communities most exposed to aridification such as smallholder farmers, rural communities, indigenous peoples, are typically the least represented in governance processes and the least resourced to adapt independently. Investment in community-level resilience capacity such as diversified water sources, drought-resistant agricultural transitions, and economic diversification must be a core component of any long-term resilience strategy.

Adaptation Requirements

Translating these priorities into durable outcomes requires investments in enabling systems that work in concert.

First, there must be a shift from fragmented governance to coordinated, basin-scale institutions capable of managing interconnected surface and groundwater systems. Second, robust data infrastructure and monitoring systems are needed to support transparent and adaptive management and to enable accountability. Third, sustainability must be defined through enforceable thresholds, such as extraction limits or ecological minimums tailored to each region and community based on local environmental and hydrologic conditions rather than broad aspirational goals.

Equally important, adaptation requires integrating land-use planning and water governance, since settlement patterns, agricultural expansion, and zoning decisions directly shape hydrologic stress. Finally, governance systems must explicitly incorporate equity considerations, ensuring that vulnerable users are not disproportionately burdened by transition costs or system failures.

Scaling Pathway

Scaling from localized interventions to systemic transformation requires a phased approach. The first phase involves piloting integrated monitoring and governance systems in high-risk basins, coupled with the development of foundational data infrastructure. The second phase focuses on institutionalization including embedding monitoring requirements, enforcement mechanisms, and financing structures into formal governance systems. The third phase expands coordination across regions, enabling basin-to-basin learning and the development of interoperable governance frameworks that can be adapted to other arid and semi-arid systems globally.

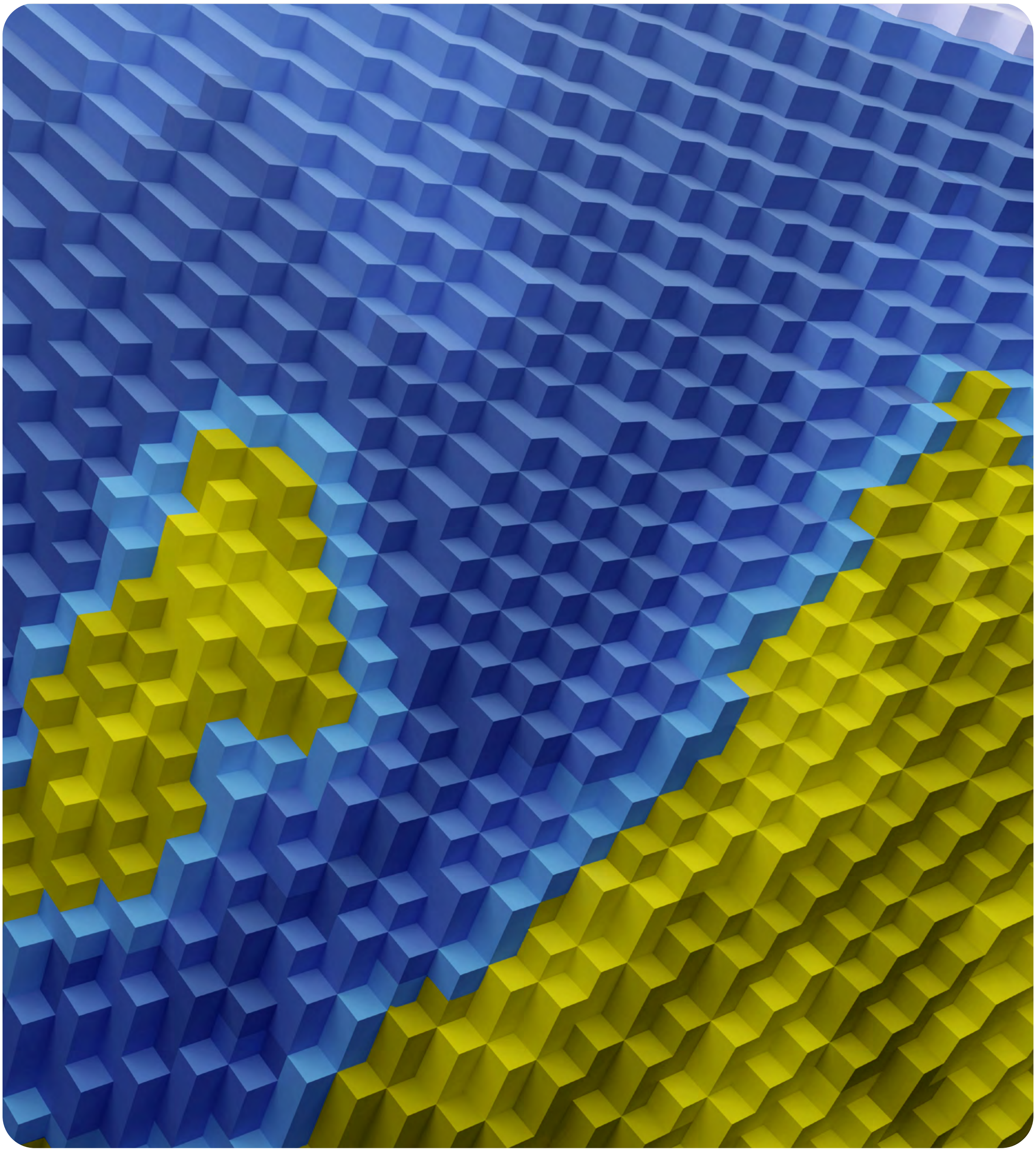
This progression is essential because desertification is not a static condition but an accelerating process shaped by feedbacks between climate stress and governance capacity. It is also important to keep in mind that implementation boundaries, if possible, should map into natural/hydrological boundaries, otherwise the governance will remain fragmented and misaligned with the very systems it is meant to manage.

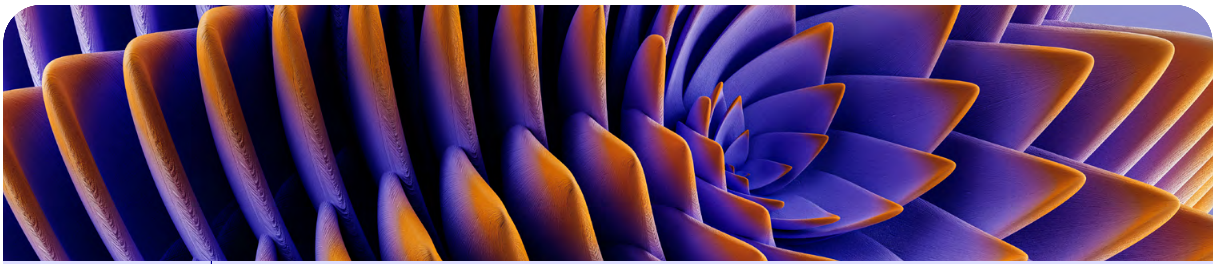
Operational Recommendations

Climate shocks can also serve as windows of opportunity for institutional transformation. California's repeated droughts and groundwater crises created the political momentum necessary for the passage of SGMA. Similarly, periods of disruption in other climate-vulnerable regions can provide opportunities to reform governance systems, build new institutions, and make investments that reduce future risks rather than simply restoring pre-existing vulnerabilities. Recovery should therefore be viewed not as an endpoint, but as a catalyst for long-term adaptation and resilience. Building back to the status quo often means rebuilding the very conditions that created vulnerability in the first place.

In regions with limited water governance structure, there is an opportunity to start the process with a strong interconnected and integrated governance framework established on data and transparency. Land-use is one of the most important parameters that impact sustainable and resilient water quality and quantity management across systems. Denmark's integrated approach, despite being water rich, to nitrate management and groundwater protection, built on mandatory monitoring, land-use regulation, and basin-scale governance, demonstrates that even heavily agricultural economies can achieve sustainable groundwater outcomes when governance frameworks are comprehensive and enforceable. When reimagining existing governance structures like California's, the starting point must be a rigorous understanding of the hydrological, governance, economic, and social realities of affected communities, because without that foundation, political support and community buy-in will remain out of reach. Ultimately, building data infrastructure, establishing clear regulatory targets, creating transparent and accountable processes, and developing resilience-centered business models are essential to achieving long-term water security and resilience.

The Central Valley's experience demonstrates that climate vulnerability and desertification are not inevitable outcomes of living in arid environments. They are, in large part, the product of governance choices, institutional arrangements, and investment decisions accumulated over time. Building resilience in climate-vulnerable regions therefore requires moving beyond isolated technical interventions toward integrated systems that manage risk, strengthen resilience, and leverage recovery as an opportunity to reduce future vulnerability and enable long-term adaptation.





5 Call to Action: From Innovation to Impact

Desertification is no longer a distant environmental concern. It is a systemic resilience challenge affecting water security, food production, land productivity, energy systems, economic development and social stability. The solutions needed to respond to this challenge are increasingly available. Across water systems, climate-resilient agriculture, soil and ecosystem restoration, environmental intelligence, and distributed energy, technologies and implementation models are already being tested and deployed in arid and climate-vulnerable regions.

The central challenge is therefore not only to develop new technologies, but to create the conditions that allow proven and emerging solutions to move from fragmented pilots to scalable, locally adapted systems. This requires a shift from isolated innovation projects to integrated deployment pathways that combine technology, governance, finance, local capacity and international cooperation.

"Desertification is a growing resilience challenge, but it is also an opportunity to rethink how we use our most limited resources. Israel's experience shows how constraints can drive innovation – and how technologies developed in response to water and climate challenges can become solutions for regions facing similar pressures. The task ahead is to turn this innovation into impact at scale."

Ronit Eshel
Head of ClimateTech, Israel Innovation Authority

The next phase of desertification resilience should be guided by five priorities.

1. **Build integrated desertification resilience systems**

Governments and implementation partners should move beyond sector-specific responses and design integrated systems that connect water, land, agriculture, energy and data. Desertification is driven by interactions between water scarcity, soil degradation, unsustainable land use, food insecurity and climate stress. Addressing these pressures separately limits impact. Integrated planning can help ensure that water reuse supports agriculture, distributed energy powers irrigation and treatment systems, environmental intelligence guides land restoration, and soil recovery strengthens long-term food and water security.

2. **Create real-world validation environments**

Technologies designed for arid and climate-vulnerable regions must be tested under real-world conditions before they can be deployed at scale. Governments, research institutions and innovation agencies should support living labs, regulatory sandboxes, demonstration sites and field-validation platforms in dryland environments. These environments can reduce risk for public buyers, investors, utilities, farmers and industry partners by generating evidence on performance, cost, resilience outcomes and local adaptability.

The Negev and other arid innovation ecosystems demonstrate the value of testing solutions under conditions of water scarcity, extreme heat and resource constraints before adapting them for wider deployment. A structured pathway from research and development to pilot testing, performance verification and commercial deployment can help accelerate global replication.

3. **Finance the full deep-tech pathway, from R&D to FOAK deployment**

Many desertification-related solutions require significant upfront investment, long validation cycles and adaptation to local conditions. This is especially true for deep-tech solutions, where research and development is not a short preliminary phase, but often extends through field validation, demonstration and first-of-a-kind deployment. Continued investment in R&D is therefore essential, alongside financing models that recognize the longer timelines, higher capital needs and technical risks involved in bringing breakthrough solutions from the lab to real-world use.

Public funding, blended finance, concessional capital and risk-sharing instruments should help bridge this pathway without diverting attention from the importance of early-stage innovation. They can support demonstration facilities, FOAK projects, farmer and utility adoption, restoration outcomes and long-term operation. Investors and public finance institutions should also develop financing models linked to measurable outcomes, including water savings, soil health improvement, avoided land degradation, reduced emissions, ecosystem restoration and increased agricultural productivity.

4. **Develop environmental intelligence as shared infrastructure**

Effective desertification resilience depends on the ability to monitor, anticipate and respond to environmental stress before degradation becomes irreversible. Countries and regions should invest in environmental intelligence infrastructure, including Earth observation, soil and water sensors, AI-enabled analytics, drought early-warning systems, digital soil mapping, and decision-support tools.

Such systems should be treated as public-good infrastructure for climate adaptation. Open datasets, interoperable platforms, shared monitoring standards and transparent measurement, reporting and verification frameworks can support better policy decisions, improve targeting of investments, and enable more credible restoration and resilience finance.

5. **Strengthen local capacity and cross-regional replication**

Technologies cannot be transferred successfully without local adaptation. Scaling desertification solutions requires local technical skills, trusted implementation partners, knowledge exchange and institutional capacity. Governments, universities, vocational training providers, companies and international organizations should invest in multidisciplinary skills across water management, agronomy, soil science, restoration ecology, data science, AI, renewable energy and project finance.

International cooperation can accelerate this process by connecting regions facing similar dryland challenges. Cross-regional demonstration networks, shared learning platforms and technology-transfer partnerships can help adapt solutions to different regulatory, climatic, economic and social contexts. The goal should not be to export a single model, but to create adaptable implementation pathways that can be replicated across diverse arid and climate-vulnerable regions.

Table 4: SUGGESTED ADAPTABLE IMPLEMENTATION PATHWAYS

Stakeholder	Strategic Priority	Illustrative Approaches	Contribution to System Resilience
Governments & Policymakers	Create enabling policy environments	Green public procurement; adaptive regulatory frameworks; regulatory sandboxes; targeted fiscal incentives.	Reduces barriers to technology deployment, strengthens market confidence, and creates stable conditions for long-term investment.
Institutional Investors & Financial Institutions	Finance full deep-tech pathway	Blended finance mechanisms; pooled investment vehicles; standardized adaptation metrics.	Expands access to commercial capital and supports investment in resilient infrastructure and climate adaptation technologies.
Industry & Technology Providers	Develop and scale locally adapted technologies	Integrated system design; user-centered innovation; cross-sector partnerships; technologies designed for local operating conditions.	Accelerates the development, deployment, and adoption of resilient technologies tailored to diverse environmental conditions.
International Organizations	Strengthen global collaboration and knowledge exchange	Demonstration networks; capacity-building programmes; technology transfer frameworks; cross-border partnerships.	Facilitates knowledge exchange, strengthens local capabilities, and supports the global diffusion of climate adaptation solutions.

Looking Ahead

The path from innovation to impact requires treating desertification resilience as a systems challenge. Water technologies, climate-smart agriculture, soil restoration, environmental intelligence and distributed energy each play a critical role, but their greatest value emerges when they are deployed together through supportive governance, targeted finance, local capacity and international cooperation.

The call to action is clear: move from fragmented pilots to integrated resilience systems; from technology development to real-world deployment; and from isolated national responses to cross-regional implementation capacity. By aligning innovation, policy, finance and partnerships, arid and climate-vulnerable regions can transform desertification from a growing systemic risk into an opportunity for resilient, sustainable and inclusive development.

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