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THE ASIA FOOD CHALLENGE

Achieving Prosperity Through Water Technology and Investment

BACKGROUND AND INTRODUCTION

In this fourth edition of The Asia Food Challenge, we focus on the critical nexus between agri-food and water, highlighting the growing water stress across Asia and its profound economic, environmental, and social implications.

Asia remains an agriculture-heavy region. With 1.7 billion hectares of agricultural land, Asia accounts for more than 50% of global crop production. Rising populations and food demand are placing increasing pressure on already-constrained water resources. The region withdraws over half of the world's groundwater, yet more than 500 million people still lack access to basic water supplies, underscoring the imbalance between water use and water security.

Agriculture is by far the largest consumer of water in Asia, responsible for over 80% of withdrawals, but the adoption of water-efficient management practices lags behind other regions. At the same time, Asia is already the world's most disaster-affected region from weather, climate, and water-related hazards, with floods and droughts striking with increasing frequency. Without more sustainable water management, these pressures are set to intensify, placing escalating strain on both food security and water availability in the decades ahead.

This report explores the scale of Asia's water challenge, the central role of agri-food in driving water stress, and the key barriers to change. It identifies promising technologies and practices that can improve agricultural water efficiency, as well as the potential benefits (including significant financial returns and savings) that could be unlocked if solutions already demonstrated globally were more widely adopted in Asia. At the same time, it recognises that in addition to technology adoption, collaboration between governments, private sector actors, farmers, and financiers will be essential to build the enabling conditions for change.

This report focuses on the region of Asia, defined as the main regions of Central Asia, Eastern Asia, Southeastern Asia, Southern Asia, Western Asia, and Oceania.

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EXECUTIVE SUMMARY

Asia is home to 60% of the world's growing population and produces more than 50% of the world's crops. However, water, a key resource in the production of food, is at a critical juncture. The water crisis in Asia is worsening and is expected to intensify in the coming years.

Water stress in Asia is accelerating and is expected to get worse, as it is projected to increase three times faster over the next 10 years. As global water demand is set to outpace supply by 40% by 2030, according to the United Nations (UN), the water crisis will only intensify. At current projected rates of growth of water stress, together with climate change, approximately one billion more people in Asia will become water stressed.

With agriculture being the largest user of freshwater withdrawals in Asia, accounting for more than 80% in the region, water scarcity disrupting food production will place even more people in the region under food insecurity, adding to the billion people in Asia already facing some level of food insecurity.

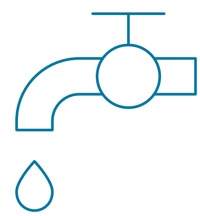
Action to protect Asia's food security and maintain a sustainable source of water must and can be taken now. Given agriculture's heavy dependence on water, the increased demand for food from Asia's growing population will exacerbate the already-strained freshwater systems. Climate change and sudden shocks such as drought-related disasters will only add to Asia's water crisis, making the supply of water more volatile and less predictable, damaging crop yields and thereby further impacting Asia's food supply.

However, Asia's increasing water stress can be mitigated through readily available technologies and practices to improve water use efficiency and reduce water usage. The significance of agriculture to water suggests that small changes can have a large impact.

The projected increase in water stress levels can be slowed through adopting these technologies, with an approximately

10% DECREASE IN WATER USE

slowing the growth in water stress by more than 2%.



These include more water efficient irrigation methods, together with precision agriculture technologies, protecting and regenerating our soils, maintaining water infrastructure, and making changes to our food consumption behaviours. Greater adoption levels can even provide more significant change, such as reaching the water efficient irrigation levels of Europe or North American, which would provide an additional 5% to 10% savings in water.

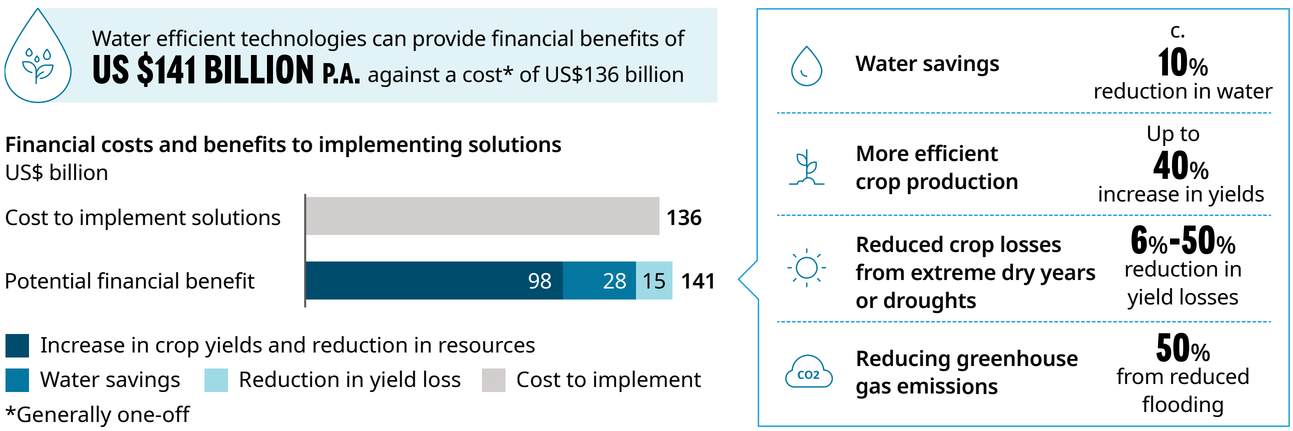
At the same time, these technologies can bring along greater crop yields for less inputs of water and fertiliser, providing farmers with greater profits. Farmers are also more resilient to climate shocks, limiting the impact of crop loss to disaster events. Environmentally, adopting these technologies can also cut down on agricultural emissions.

Financially these savings and benefits are significant (c.$141 billion p.a. in total) vs costs (generally one-off) of $136 billion.

The majority of these benefits (c.70%, $98 billion) come from an increase in crop yields and a reduction in resources needed to grow (e.g. less fertilizers), which can be very significant benefits for smallholder and large-scale farmers, helping drive profitability. c.20%, $28 billion, comes from the potential value of the water itself (far smaller than the uplift but this is down to the low economic value currently attributed to water). Lastly c.10%, $15 billion comes from avoiding yield loss through extreme weather event. Here we have taken a conservative and average amount over time - this could be far higher when drought or flooding is very severe and we expect to see that increase as climate change takes its toll.

These benefits significantly outweigh the costs (especially as benefits are per annum vs the costs being generally one off to implement) and hence highlight the financial benefits in investing in water technology, on top of the food security considerations.

Exhibit 1: Water saving technologies can provide both economic and environmental benefits, on top of reducing water use in agriculture



Sources: Oliver Wyman analysis

However, with that said, this requires the efforts of every stakeholder, from governments and investors to industry and farmers. Bringing these technologies to Asia, convincing and supporting farmers to use them, the initial investment and implementation are all hard, with limited activity to date.

We therefore propose a five-principle framework that cuts across the value chain, acknowledging that water stress is a systemic problem, requiring multi-stakeholder alignment to drive change.

Ultimately, the future of Asia's food security hinges on our collective actions today, while also safeguarding our water resources for the next generations.

ASIA'S ESCALATING WATER CHALLENGE

Asia is entering a critical era of water stress. Already home to some of the most water-stressed regions globally, the situation is projected to worsen under the combined weight of rising demand and declining supply. By 2030, global water demand is forecast to outpace supply by nearly 40%, as highlighted by the UN, as rising population and development drives food and water needs amidst a backdrop of deteriorating natural freshwater systems due to climate change and environmental degradation. Asia, in particular, will be more vulnerable due to the region accounting for more than 50% of global crop production, with heightened water demands from hosting about 60% of the world's population, as well as being home to just one third of the world's renewable water resources.

This challenge is not limited to gradual scarcity. Sudden shocks are also multiplying: the number of drought-related disasters globally has risen 29% since the turn of the century, crippling food systems, damaging livelihoods, and creating long-lasting ecological scars. Freshwater reserves such as China's Yangtze River and Poyang Lake, and the Himalayan foothill rivers, are shrinking, while aquifers in key agricultural belts are being depleted far faster than they can recharge. Rainfall patterns across the Asia region have undergone notable shifts over the past decade too, with implications for agricultural water availability that vary by sub-region and season.

The water challenge cannot be viewed in isolation, as it sits at the heart of the water-food-energy-environment nexus. Freshwater supplies are already under severe strain from overuse, climate change, and population growth, with unequal distribution and rising pollution further limiting what is usable. Agriculture, which consumes roughly 70% of global withdrawals, is the most exposed as water shortages reduce yields, weaken livestock health, and threaten food security, while inefficient irrigation entrenches over-extraction and makes farming systems less resilient.

The energy and environmental dimensions of the crisis deepen the complexity. Hydropower and thermal power plants rely on stable water flows, yet declining levels have already curtailed generation in many regions. Meanwhile, extracting, treating, and distributing water itself consumes significant energy, reinforcing a negative feedback loop. On the environmental side, rivers, wetlands, and aquifers are being degraded by excessive withdrawals and pollution, eroding biodiversity and natural processes, such as climate regulation and groundwater recharge. Runoff and untreated wastewater from agriculture and industry compound the damage, highlighting how poorly managed water destabilises ecosystems and amplifies climate risks. These underscore how water stress is no longer just an isolated concern but a systemic economic risk.

AGRICULTURE AT THE HEART OF THE CRISIS

Agriculture dominates water use in Asia, accounting for over 80% of freshwater withdrawals in many countries. Globally, the region represents more than half of agricultural production and nearly 90% of the world's rice output. This makes Asia not only a global source of food, but also a major hotspot of embedded "virtual water trade."

The impacts of this are apparent, with multiple markets already facing acute pressures on their water systems. In India's Punjab, groundwater is being extracted at 150% of annual recharge, while in Indonesia, over-reliance on groundwater in Java has caused land subsidence of up to 20 centimetres annually, threatening urban infrastructure and rural water supplies. Without coordinated interventions, these pressures risk undermining both agricultural sustainability and broader regional growth.

STRUCTURAL DRIVERS OF AGRI-WATER STRESS

Water stress in agriculture has been the outcome of deeply entrenched structural issues. Agricultural production across the region is dominated by water-intensive crops such as rice, wheat, sugarcane, cotton, and alfalfa. Historical diets, cultural preferences, and state-backed subsidies have locked farmers into practices that extract beyond ecological limits. Water-intensive crops are often subsidised, making them economically attractive but ecologically costly. In India, for example, free electricity and procurement support have entrenched rice paddy cultivation in Punjab, where groundwater is now being extracted at more than 150% of annual recharge. Export-oriented crops, including cotton and avocados, add further stress through “virtual water trade,” embedding scarce resources into global supply chains.

Capital flows also play a role in this imbalance. Subsidies and financial markets reward output rather than efficiency, while water risks remain systemically unpriced. Investment continues to gravitate towards high-water-use crops, leaving water-smart technologies underfunded and out of reach for smallholder farmers, who account for nearly 80% of production. As a result, projects that could improve efficiency often struggle to achieve bankability, constraining both innovation and adoption.

These dynamics are compounded by governance gaps. Water policy is often fragmented across ministries and tiers of government, with agriculture, energy, and urban authorities pursuing separate mandates that neglect the bigger picture. This siloed approach not only distorts allocation decisions but also contributes to chronic underinvestment. Irrigation and drainage networks, many built in the mid-20th century, now operate with heavy conveyance losses, sedimentation, and inadequate upkeep. Pakistan’s Indus Basin, where canal seepage can swallow up nearly half of withdrawals, illustrates the scale of inefficiency created by decades of deferred maintenance. Weak monitoring and water accounting compound the problem, as few countries reliably track withdrawals or enforce penalties for over-extraction.

Beyond human-level drivers, environmental externalities such as physical water scarcity, climate volatility, and soil or land degradation also exacerbate the region’s water stress, with their intensity and frequency varying widely across sub-regions. Groundwater tables are sinking below viable extraction depths, eroding the natural buffer that once safeguarded against surface water shortages, while rivers and reservoirs no longer provide reliable flows to meet agricultural demand. These physical scarcities are intensified by a backdrop of climate volatility, as rainfall becomes less predictable, droughts extend longer, and extreme flooding events become more destructive. At the same time, soil and land degradation is steadily weakening the foundation of agricultural productivity. Erosion strips away fertile topsoil, infiltration capacity is lost through deforestation and land clearing, and rising salinity reduces the ability of plants to take up water, undermining yields.

THE TECHNOLOGY AND INVESTMENT LANDSCAPE

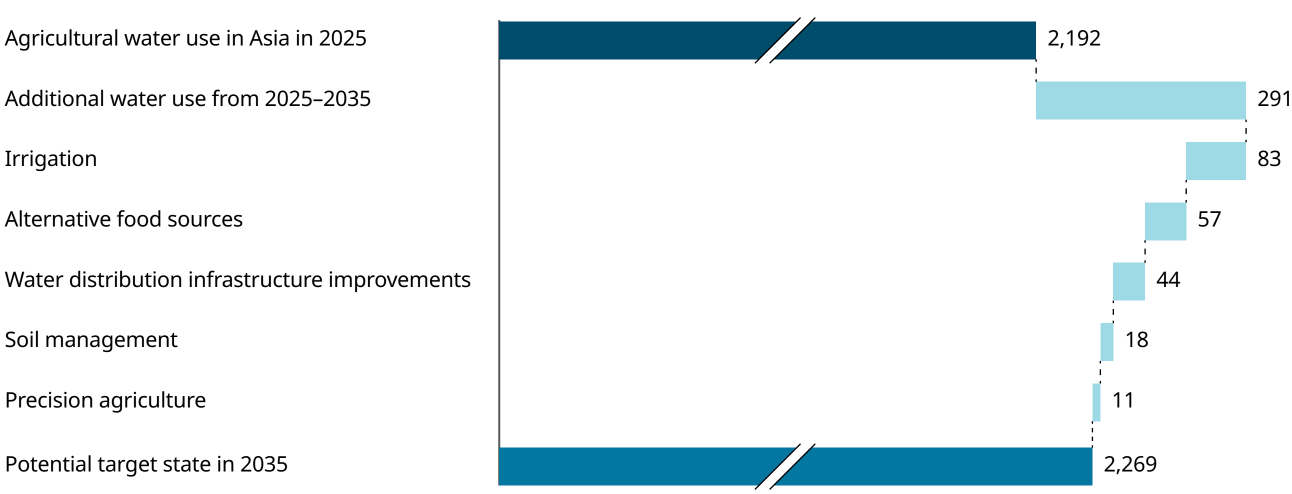
Technology is rapidly becoming a cornerstone of water efficiency, resilience, and stewardship. A growing array of innovations now spans the entire water cycle, offering new capabilities to enhance production, distribution, use, and reuse of water resources.

Investment trends reflect this momentum, though unevenly. Global venture capital (VC) funding for water technology grew more than 1,300% from 2013 to 2023, reaching US$1.2 billion, with water treatment and resource management companies attracting the largest share. Importantly, maturity levels of technology are also rising with over half of funding since 2021 going to later-stage companies, signalling a more established and investable sector. Yet, water remains a small fraction of overall climate technology funding, just 1.3% to 2.2% compared to the dominant energy and transport verticals. Moreover, most capital is concentrated in North America and Europe, accounting for over 90% of VC funding, despite Asia facing some of the highest water stress levels globally. This capital mismatch highlights both an urgent need and a major opportunity for greater investment in Asia.

The opportunity to transform agricultural water use in Asia is immense, with a handful of technologies and initiatives holding the potential to deliver savings at scale. If adopted more widely, these solutions could cut agricultural water use by as much as 10% across the region by 2035, significantly easing pressure on overstretched water systems while sustaining productivity. With greater adoption levels of global peers, additional water savings of about 5% to 10% can be achieved.

The respective solutions are detailed below:

Exhibit 2: Potential impact of selected technologies and practices on water consumption in Asia
Billion cubic metres



Sources: FAO, Oliver Wyman analysis

Irrigation efficiency offers the single largest opportunity. Today, on average, fewer than 10% of farms across Asia use modern systems such as drip or sprinkler irrigation, compared with global adoption rates of about 21%. Even a modest increase to close the gap to global levels could save an estimated 83 billion cubic metres by 2035, as shown by programmes in the region, such as India's adoption of automated systems in Karnataka

Complementing these shifts, **alternative food sources and seed innovation** can further reduce demand: substituting just 2% of rice, wheat, and maize with water-efficient crops such as millets, and replacing 2% of conventional meat with cultivated or plant-based proteins, could yield approximately another 57 billion cubic metres in savings

Improving water distribution infrastructure can also support the efficiency of water use in agriculture. Poor or degraded infrastructure results in significant water loss during the conveyance of water from source to field, before the water is even used. By lining 16% of the unlined agricultural canals in Asia, an estimated 44 billion cubic metres of water can be saved

Soil management can regenerate degraded soil, improving water retention and reducing the need for irrigation. Applying these practices to 22% of degraded land in Asia by 2035 could save about 18 billion cubic metres, while also enhancing resilience

Precision agriculture can deliver about 11 billion cubic metres in savings by applying technologies such as IoT sensors, greenhouses, and controlled environment agriculture to just under 1% of irrigated land. China's Beidahuang Group, which deploys smart monitoring across its farms, illustrates how digital tools can optimise inputs and reduce waste

The combined savings of about 214 billion cubic metres of water would be enough to sustain Singapore almost 300 times or fill

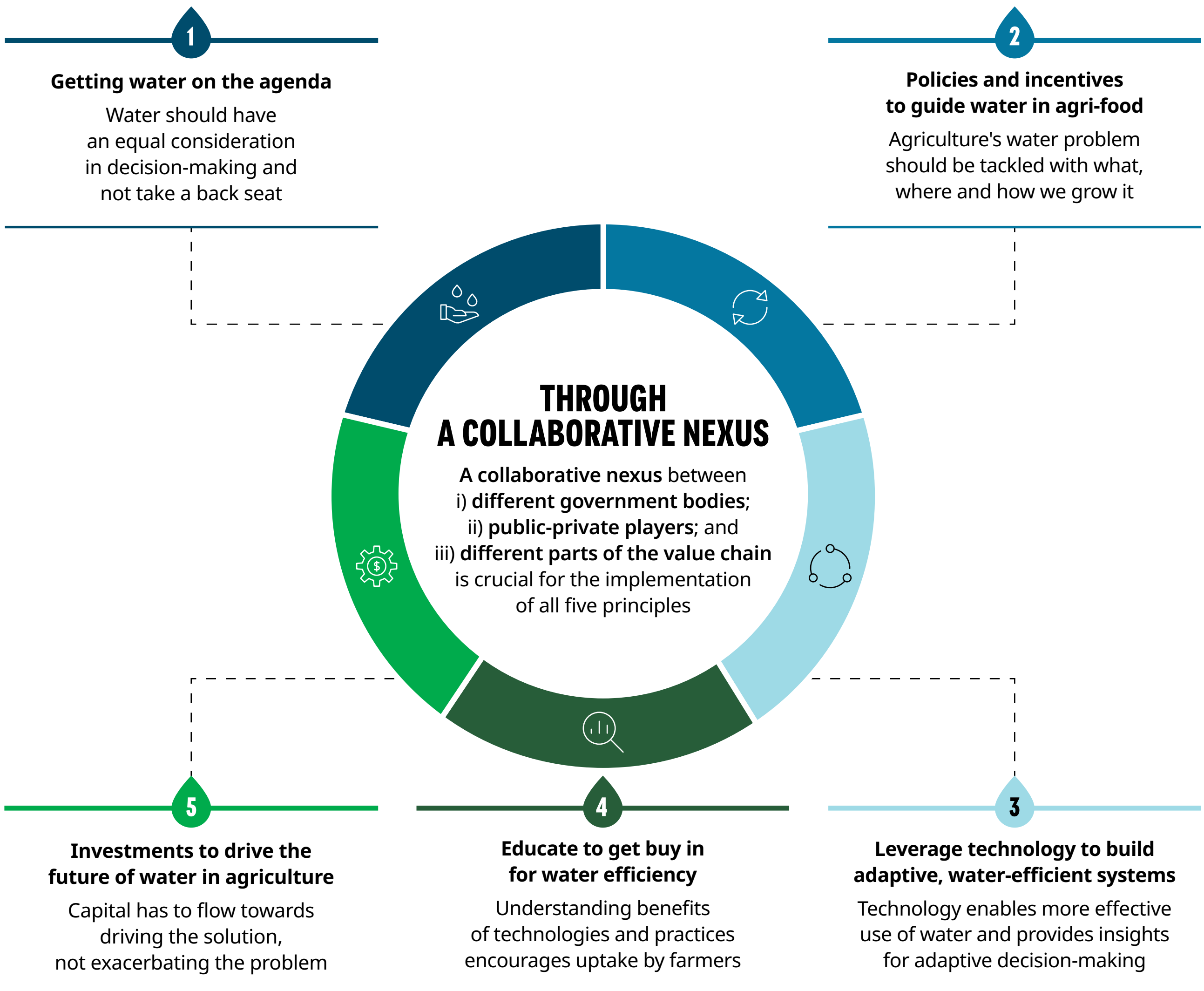
85 MILLION OLYMPIC-SIZED SWIMMING POOLS.

These technologies can further enhance crop yields, with more targeted application of water and nutrients to crops, while also reducing the use of resources like water and fertiliser. Irrigation also allows farmers to be more prepared for climate events, helping them maintain water application to crops and reducing crop yields by 6% to 50%. From an environmental perspective, the use of water-efficient technologies also reduces the use of paddy field flooding in parts of Asia, cutting down on a significant source of methane emissions.

A FRAMEWORK FOR ACTION

Solving Asia's agri-food water crisis requires systemic change, not piecemeal fixes. We propose a five-principle framework that cuts across the value chain, aligning governments, industry, financiers, and smallholders around shared solutions. The principles focus on putting water first in decision-making; policies and incentives to reward efficiency rather than extraction; building and developing infrastructure with the help of technologies; sharing knowledge and educating stakeholders; and investing in water-smart crops and technologies.

Exhibit 3: A systematic view of the Five-principle Framework



Source: Oliver Wyman analysis

Addressing Asia's water challenge will demand bold choices and coordinated action. The scale of the problem is immense, but so too is the opportunity. By reshaping incentives, mobilising finance, and deploying proven technologies, the region can secure water for its people, its food systems, and its economies. The chapters that follow set out the scope of the challenges in detail, highlight interventions that can make the greatest impact, and illustrate enablers for building a more water-resilient future.

CHAPTER 1

THE ROLE OF AGRI-FOOD IN ASIA'S WATER CRISIS

Asia is facing a serious and worsening problem around water usage and scarcity, with agriculture accounting for most of the water usage in the region.

1.1 ASIA'S WATER CRISIS WILL ONLY CONTINUE TO INTENSIFY OVER TIME

Asia's water stress levels have consistently risen. With the supply of freshwater declining and total water use set to increase, the region is expected to face even greater water stress levels in the future.

Globally, water stress levels have been rising, but the stress levels within key hotspots in Asia are markedly higher. Water stress, as defined by the United Nations (UN), is "the ratio of total freshwater withdrawn to the total renewable freshwater resources within a specific region, after considering environmental flow requirements."

Over the past 10 years, water stress in Asia has risen by about 1%, triggering widespread water scarcity in key hotspots and causing significant environmental degradation across the region. The higher water stress equates to approximately 120 billion cubic metres of additional water being drawn per year, roughly the volume of 48 million Olympic-sized swimming pools. Over the next 10 years, Asia's water stress is expected to worsen and could reach more than 3%, not to mention the climate conditions that could potentially further exacerbate this situation.

Climate conditions, such as droughts, worsen water stress and the water crisis, by affecting the predictability and consistency of water to communities. Asia has been facing an increasing frequency of acute water stress through these events. Between the first and second decades of the 21st century, the number of drought-related disasters in Asia has risen 29%.

On top of that, Asia is experiencing shorter wet periods and longer dry periods, with both being more intense. The IPCC highlights that moving forward, South, Southeast and East Asia is projected to experience more intense and more frequent heavy and intense precipitation. At the same time, Southeast Asia and regions in China are projected to experience longer annual consecutive dry days. The increased volatility of weather and climate conditions will add further strain to water supplies in Asia. These climate conditions make water scarcer for longer periods during the year, while also making the supply of water more unpredictable.

Since 1900, humanity's water consumption has quintupled, imposing an enormous environmental burden. Yet, water demand is only set to grow, with global freshwater demand expected to outstrip supply by 40% by 2030,[1] according to the UN.

On the flip side, water supply will only decrease, with global warming and environmental decline inevitably reducing freshwater availability. Globally, there are less renewable water resources per person now than at the turn of the century, with total renewable water resources per capita declining from about 6,400 cubic metres in 2000 to about 5,300 cubic metres at present, according to the Food and Agriculture Organisation of the UN (FAO). Regionally within Asia, Central and Western Asia have seen the most decrease, with water resources declining by about 30% and 37%, respectively, since 2000.

Natural systems that once drove Asia's freshwater supplies are also in widespread ecological decline. Examples include the following:

- The Aral Sea has shrunk over 80% since the 1960s due to upstream diversion.[2]
- China's Yangtze River has experienced significant drying following a drought in 2022, which saw water levels at nearby monitoring points falling by six metres,[3] and rainfall in the Yangtze River drainage area falling by about 30%.[4]
- China's Poyang Lake has increasingly seen early starts to its dry season, with the lake's dry season in 2022 starting 100 days earlier than the historical average.[5] This situation is expected to worsen as global temperatures continue to rise.
- Water levels of the Caspian Sea fell by about two metres from 2006 to 2024,[6] and they are expected to continue to decline. The decline has been driven by climate change, changes in river inflows, and desalination, among other factors.
- The rivers within the Himalayan foothills have seen a decline in the areas capable of holding water, shrinking by 2,900 acres from 1985 to 2024, as a result of increased human activity and the higher population in the region.[7]

Rainfall patterns across Asia have also undergone notable shifts over the past decade, with implications for agricultural water availability that vary by sub-region and season.

Asia is already feeling water stress impacts, with regional stress levels reaching 33%, among the highest rates globally. Today, in many Asian hotspots, water stress has escalated to acute crises and deficits. It is also important to note that water resources, such as all-natural resources, are not equally distributed across the globe.

Of the approximately 55 billion cubic metres of total renewable water resources globally,

ONLY ABOUT A THIRD ARE FOUND IN ASIA

despite being home to about 60% of the global population.

In 2022, the renewable water resources per capita in Europe and the United States (US) were both about 9,000 cubic metres. In comparison, such resources per capita in most Asian regions ranged from about 1,200 to 3,000 cubic metres, with Southeast Asia having the most at about 7,000 cubic metres. These numbers highlight not just the disparity in availability of water resources globally, but also regionally, putting certain Asian regions at an even greater risk of water scarcity.

Beyond scarcity, agriculture is emerging as a major driver of water quality decline in Asia, with the FAO noting it as the single-largest contributor of non-point-source pollution to surface water and groundwater. Expanding crop and livestock production increases the use of fertilisers, pesticides, and agrochemicals, while intensive livestock operations generate nutrient-rich effluents.

These inputs often leach into groundwater or run off into rivers and lakes, leading to nitrate contamination, algal blooms, and ecosystem degradation. In many parts of South and Southeast Asia, irrigation return flows also carry high concentrations of salts, degrading soils and polluting downstream water supplies. These, paired with industrial discharge and seawater intrusion, are contaminating groundwater sources, particularly in peri-urban and coastal zones, adding further stress to the already-worsening water demands.

Without stronger safeguards, rising food demand will not only heighten water withdrawals but also compound water stress through widespread pollution, undermining both human health and agricultural productivity in the long term. All of this is in addition to rising water demands from other users of water, with expanding industries such as data centers and semiconductor manufacturers increasingly demanding water for cooling and cleaning, putting even further stress on the already-fragile water supply.

CASE STUDY

JAKARTA[8, 9, 10, 11]

Rapid urbanisation and development of Jakarta has resulted in increased water stress levels. Moreover, with the lack of infrastructure and piping, the population has become over-reliant on groundwater to supply its needs, resulting in severe land subsidence.

Jakarta, a megacity located on the island of Java, is facing severe water stress levels beyond 80%. Of the city's population, 67% have access to piped water, and only

15% HAVE ACCESS TO ADEQUATE SAFE DRINKING WATER AT HOME.

Java is home to around 57% of Indonesia's population but only holds around 10% of its water resources. Per-capita water availability in Java is expected to reach less than 500 cubic metres per year in 2040, indicating absolute scarcity based on UN thresholds and far below the ideal amount identified by the Indonesian government of 1,600 cubic metres per year. This may result in poor households spending large proportions of their income on water from informal vendors.

Jakarta's water problems have been driven by growing demand for water from rapid urbanisation, as well as over-reliance on groundwater due to limited piped coverage around the city. This has led to groundwater over-extraction, and further resulted in land subsidence of up to 20 centimetres in some areas.

Monsoon variability has also exacerbated Jakarta's water stress levels, with increasing variability leading to longer dry seasons and heavier rainfall events.

With a strong growing population and no clear signs of widespread improvements to infrastructure, per-capita water availability may continue to worsen, and lead to North Jakarta seeing 95% of its land area below sea level by 2050 due to subsidence.

Jakarta's water stress has been worsened by the failure of water privatisation to invest in Jakarta's infrastructure. The privatisation of water in Indonesia as a whole failed to meet the key target of 98% of service coverage, only reaching 59% in 2015.

To combat Indonesia's water stress and resulting land subsidence, the government re-nationalised the water industry in 2023 with a target of 100% piped coverage by 2030. The city has also further banned groundwater extraction in key zones by owners of buildings larger than 5,000 square metres in area. These restrictions are set to strengthen by 2027, when households and legal entities extracting at least 100 cubic metres of ground or river water per month must apply for a permit to do so.

In parallel, coastal defences and water storage projects, such as the Giant Sea Wall, are also being developed to reduce flooding specifically in North Jakarta.

1.2 THE IMPACTS OF RISING WATER STRESS AND THE WATER CRISIS ARE FELT BOTH ECONOMICALLY AND ENVIRONMENTALLY

The intensifying water challenge is set to deepen pressures on populations already living under significant scarcity, with wide-ranging environmental and economic consequences across Asia. Today, an estimated 12% of the region's population lacks reliable access to clean water, highlighting a persistent state of chronic stress. This baseline is expected to worsen, with global freshwater demand projected to exceed supply by 40% by 2030.

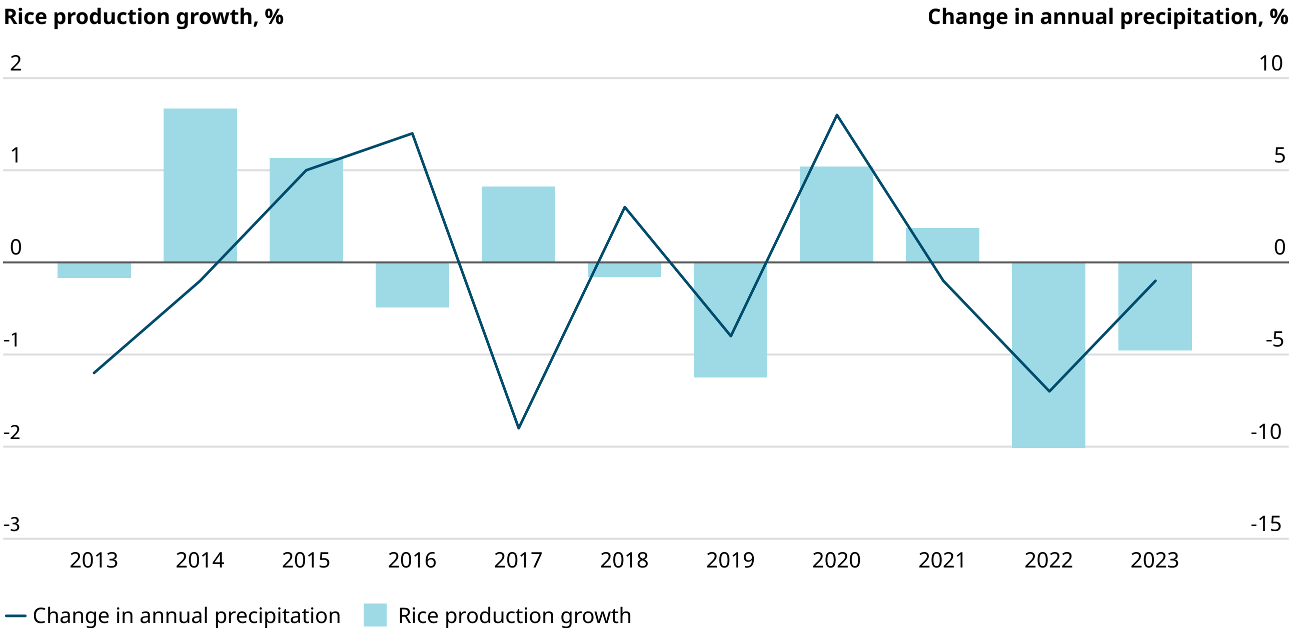
Water stress is not evenly distributed globally. In some parts of the Middle East, stress levels have risen above 80%. Other parts of Asia may face levels of more than 70%, driven by competing demands across agriculture, urban consumption, and industry, with technology-focused industries driving significant growth in water demand. Such pressures have direct implications for food security, as water scarcity is a critical driver of reduced agricultural productivity and, in turn, rising food insecurity across Asia, adding to the already bad situation in Asia.

At present, more than one billion people in the region are already under moderate or severe food insecurity. However, with global food supplies potentially declining by up to 14% by 2050 under intermediate scenarios of climate change,[12] this would place an additional one billion people at risk of food insecurity.

This is further exacerbated by increased volatility and less predictability of weather conditions. The increasing intensity of weather events, such as rainfall and dry periods, will reduce crop yields and worsen the economic conditions of countries in Asia. For example, Thailand is expected to experience increasingly volatile seasonal rainfall and a decline in overall rainfall,[13] leading to rice yields potentially declining more than 10% by 2050.

Furthermore, disaster events, such as droughts, can reduce yields of rice and wheat by about 25% to 28%.[14] At the same time, deficits in water requirements of crops can result in approximately 10% to 30% loss of yield.[15] For example, from 2013 to 2023, China saw correlation between the annual mean precipitation and their rice production, with lower precipitation levels resulting in lower rice production. India also saw significant loss in crops from 2015 to 2021, with 33.9 million hectares lost to excess rains and floods, and another 35 million hectares due to drought.

Exhibit 4: Historical relationship between precipitation and rice production in China
2013–2023



Sources: World Bank, FAO, Oliver Wyman analysis

Moving forward, crop yields in countries across Asia are projected to decrease as a result of climate conditions, sudden shocks and temperature increases. For example, India is projected to see a reduction in wheat yields by about 6% to 23% by 2050, compared to average yields in the early 2000s, as a result of climate change.[16] South Asian countries are also projected to see wheat yield declines by 16% by 2050.[17]

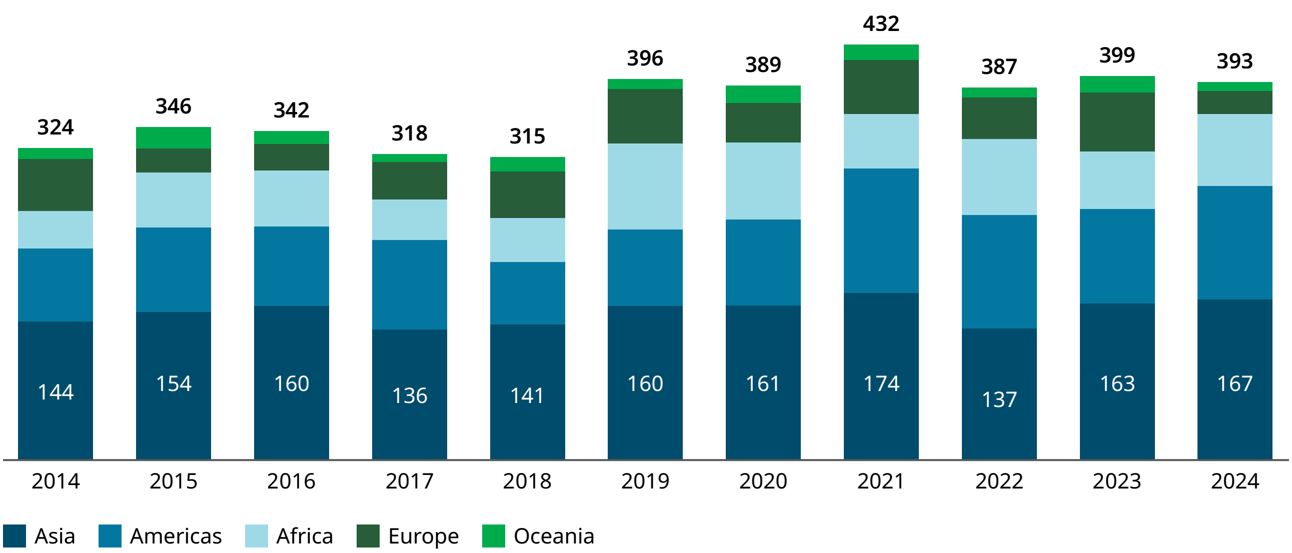
As crop yields and food production decline, they put upward pressure on prices, increasing crop prices by about 5% to 20%.[18] For example, in September 2025, Pakistan and India were hit with floods, severely affecting their basmati rice crops, with conservative estimates of 20% of the rice grown in Pakistan being damaged. This resulted in the prices of basmati rice rising by US$50 per metric ton,[19] equating to a 5% to 6% increase. This will disproportionately hit developing countries the most, where a large proportion of the population already faces water stress.

The World Bank also projects that the growth of gross domestic product (GDP) in water-scarce regions could fall by as much as 6% by 2050, underscoring the systemic economic toll caused by heightened water stress. This also adds to other economic impacts of water scarcity in agriculture. According to the UN, the average annual loss from disasters in the region is US$924 billion, with drought-related losses accounting for 44% or US$404 billion.[20] The FAO also estimates that average annual crops and livestock production loss due to disasters is US$123 billion, with Asia accounting for approximately 45% of this.[21]

The impacts on water and food from climate-related events are only going to intensify, with the World Meteorological Organisation (WMO) highlighting that Asia remains the world's most disaster-hit region, with more than 85% of the extreme events due to floods, storms, or extreme temperatures. From 2020 to 2024, Asia had a higher number of natural disasters compared to the global average, and almost 68% of people impacted by such disasters were in Asia.

Exhibit 5: Number of disaster events globally by region

2014–2024



Sources: EM-DAT, Oliver Wyman analysis

With greater volatility of weather conditions, and increasing frequency and intensity of climate events, this will dampen the food independence of Asian countries, as well as threaten the export of water-intensive products. As Asia accounts for over 50% of global agricultural production and about 90% of the world's rice,[22] any disruptions to Asia's ability to produce crops will result in disruptions to the global food supply chain. Countries reliant on imports, in particular, will be disproportionately impacted.

As resources become scarcer, conflicts over water across national borders are also expected to intensify. Tensions and political conflicts already exist to secure water supply and will likely increase amongst nations sharing natural bodies of water, and as countries increasingly view water in the broader nexus encompassing water, food, energy, and the environment.

1.3 THE WATER PROBLEM IS SYSTEMIC AND SO REQUIRES INTEGRATED SOLUTIONS

The water challenge extends far beyond water itself, shaping the entire water-food-energy-environment nexus due to its critical role across all domains:

Water

Freshwater supplies are increasingly constrained by overuse, climate change, and population growth. Unequal distribution and rising pollution further reduce the portion of water that is usable for people, farms, and industry.

Food

Agriculture is the largest consumer, accounting for around 70% of global freshwater withdrawals.[23] Water shortages directly lower crop yields and livestock health, threatening food security and rural incomes. Wasteful irrigation practices magnify scarcity, locking farmers into a cycle of over-extraction and reduced resilience.

Energy

Energy production is heavily water-dependent. Hydropower requires reliable river flows, while thermal power plants use large volumes of water for cooling. Declining water levels can shut plants down and reduce generation capacity. At the same time, the extraction, treatment, and distribution of water are energy-intensive, creating a feedback loop between the two sectors. On top of that, energy demands are increasing. With artificial intelligence (AI) being an area of increasing interest today, energy-intensive sectors such as data centers will continue to demand large volumes of energy, putting further pressure on energy production.

Environment

Natural ecosystems, from rivers, to wetlands, to aquifers, are degraded by over-extraction and pollution, undermining biodiversity and the natural processes that regulate climate and recharge water systems. While agricultural runoff and untreated wastewater add to the burden, poor water management also accelerates climate change impacts by destabilising hydrological cycles.

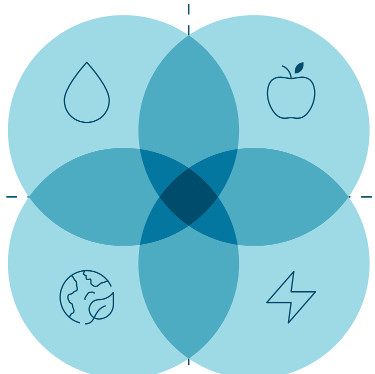
Exhibit 6: The water crisis affecting the water-food-energy-environment nexus[24, 25]

Water

- Limited freshwater availability due to overuse, climate change and population growth
- Unequal spatial and seasonal distribution
- Water pollution reduces usable supply

Food

- Agriculture accounts for 70% of global freshwater withdrawals
- Water shortages reduce crop yields and livestock health, threatening food security
- Wasteful irrigation exacerbates scarcity



Environment

- Overextraction and pollution degrade habitats such as rivers, wetlands and aquifers which support natural cycles
- Agricultural runoff and lacking wastewater treatment harm the environment
- Poor water management can worsen climate change and water cycles

Energy

- Energy generation requires large amounts of water
- Low water levels can force power plants offline and reduce output
- Extracting, treating and distributing water is energy intensive

Sources: FAO, Javan et al. (2024), Ghosh et al. (2024), Oliver Wyman analysis

CASE STUDY
PUNJAB'S WATER STRESS AND THE IMPACT ON CROPS[26, 27, 28]

Given the state-level economy heavily centred around agriculture, Punjab is facing difficulties from groundwater depletion, inefficient irrigation methods, and climate change. Efforts are now focused on incentivising the growth of other crops and monitoring groundwater extraction.

Punjab contributes up to about 13% of rice and 15% of wheat production in India. About 98% of Punjab's cultivated area is irrigated, with about 75% of the irrigation water coming from groundwater.

Punjab's groundwater extraction is alarmingly high, reaching around 150% of its annual recharge, the highest amongst Indian states. As a result, water tables can decline up to a half to one metre per year, with some wells in Central Punjab now needing to reach depths of 150 to 200 metres.

Demand for groundwater in Punjab has been driven by choice of crops and poor water use efficiency. Rice and wheat, both highly water-intensive crops, dominate up to 85% of the crop area, driving further irrigation demand. Punjab also experiences high evapotranspiration and low water use efficiency, such as heavy use of flood irrigation for crops.

Free electricity for agriculture has also encouraged over-pumping, with groundwater tubewells expanding from 190,000 in 1980 up to 1.48 million by 2019.

If conditions continue to persist, Punjab could exhaust usable groundwater within the upcoming decades, and its water tables could fall by up to

300 METRES BY 2039 IN OVER-EXPLOITED ZONES.

Climate change will continue to exacerbate rainfall variability, evapotranspiration, and result in higher crop water demand. Increasing average temperatures may reduce yield of all major crops in Punjab by about 10% by 2050.

To combat the water stress situation, the Punjab Water Regulation and Development Authority (PWRDA) was established in 2020 to oversee groundwater regulation. Punjab has also provided subsidies for drip irrigation and pushed for the restoration of canal systems. Beyond encouraging efficient water use, Punjab has introduced a Crop Diversification Programme, designed to reduce paddy areas and provide financial incentives to farmers switching to alternative crops.

Tackling the water crisis in this manner requires systemic dialogue among all stakeholders, including governments, corporates, investors, farmers, and consumers, to align priorities and coordinate action. The water crisis is a systemic issue that cannot be solved through sector-specific actions alone. It demands coordinated, cross-sector dialogue and integrated solutions to effectively address its complex challenges.

1.4 AGRICULTURE IS BOTH THE MAIN DRIVER OF WATER USE IN ASIA, AND THE MOST VULNERABLE TO WATER SCARCITY

In Asia, water is consumed across agriculture, industry, and municipal needs, with agriculture dominating by a wide margin. Agriculture in Asia alone accounts for 55% of global freshwater withdrawals, and within the region, represented 81% of total freshwater use in 2022. In contrast, agricultural water withdrawals in Europe and North America account for just 30% and 38%, respectively.

Exhibit 7: Water use within Asia

2022, billion m³/year

Core use cases (non-exhaustive)

Agriculture	• **Irrigation for crops** — Water applied to fields to support the growth of staples such as rice, wheat, maize, and fruits/vegetables • **Livestock water use** — Drinking water for animals and water for cleaning stables, pens, and milking facilities • **Aquaculture** — Water in ponds, tanks, and coastal farms to raise fish and shrimp
Industrial	• **Manufacturing processes** — Water used directly in production (e.g. electronics cleaning, paper pulping etc) • **Energy generation** — Water for steam generation and cooling in coal, gas, and nuclear power plants, as well as reservoir storage in hydropower • **Mining and resource extraction** — Water used to separate minerals from ore, wash materials, and suppress dust • **Industrial cooling** — Water circulated to remove heat in steel, cement, chemical plants, and refineries
Municipal	• **Domestic consumption** — Water for drinking, cooking, bathing, laundry, and cleaning • **Public services and businesses** — Water used for commercial and public services (e.g. sanitation in buildings, fire fighting, street cleaning) • **Urban infrastructure and amenities** — Water used for landscaping, public recreation, street cleaning etc

Sources: FAO, Oliver Wyman analysis

This dominance reflects not only the inherently water-intensive nature of crops such as rice and sugarcane, but also the deep inefficiencies that persist across the agricultural value chain.

Exhibit 8: Illustration of agricultural life-cycle

0. Cropping patterns
Selection and arrangement of crops within a given area over time, including decisions on crop types, rotations, and planting sequences

1. Water extraction and sourcing
Withdrawal of water from natural sources such as rivers, lakes, reservoirs, and groundwater aquifers to meet agricultural needs

2. Storage and conveyance
Collection and movement of water from its source to farms, using infrastructure such as reservoirs, tanks, canals, pipelines, and distribution channels

3. On-farm delivery and irrigation
Delivery of water onto farms and application to crops, using technologies from pumps, pipes, and sprinklers to drip irrigation and open channels

4. Return flows and drainage disposal
Movement of water out of fields after use, which may occur as surface runoff, subsurface drainage, or seepage back into surrounding water systems

Phase of lifecycle	Key challenges
0. Cropping patterns	In much of Asia, farmers cultivate highly water-intensive crops such as rice, wheat, and sugarcane in regions where water is already scarce, locking in unsustainable demand. District-level synchronised sowing cycles, common in South Asia, exacerbate stress especially when thousands of smallholders plant simultaneously, resulting in aquifers and canals facing overwhelming, concentrated withdrawals. Further inefficiencies arise from the misalignment of cropping calendars with natural water availability. Compressed crop seasons, or planting cycles that ignore rainfall and river flow patterns, force farmers to rely on heavy irrigation at precisely the times when water is least abundant. These structural mismatches between crop planning and hydrology are among the most fundamental sources of inefficiency in the agri-water system.
1. Water extraction and sourcing	Overdrafting of shallow and deep aquifers has driven groundwater tables to alarming lows. In some regions, pumps now need to reach hundreds of metres, raising both water and energy costs. Over-reliance on fragile surface water diversions, such as the Mekong or Ganges basins, creates further vulnerability, especially when seasonal surges in extraction coincide with declining natural recharge. These inefficiencies are compounded by the absence of coordinated management. Farmers often withdraw water independently of basin-wide availability. Without mechanisms to synchronise extraction with natural replenishment cycles, water is taken faster than it can be renewed, leaving less for future seasons and downstream users.
2. Storage and conveyance	In much of Asia, storage infrastructure remains inadequate to buffer seasonal extremes. Irrigation tanks and reservoirs overflow during monsoon peaks, only to run dry in the lean season, leaving farmers reliant on groundwater pumps to fill the gap. Losses mount during conveyance. A significant share of Asia's canal networks is unlined, poorly maintained, or decades old, leading to seepage and evaporation losses that can exceed 30% to 40% before water even reaches the farm gate. While some seepage can recharge local aquifers, in practice much of it represents wasted delivery and diminished reliability.
3. On-farm delivery and irrigation	Across Asia, flood irrigation forms the main method for irrigation delivery, essentially inundating fields to ensure coverage. This practice is deeply ingrained, tied not only to tradition but also to pest management and weed control. Yet it is also highly inefficient as large volumes are applied with little control over how much crops actually absorb, while the rest evaporates or goes beyond the root zone. Modern techniques such as drip and sprinkler irrigation can deliver water directly to plants with far greater precision, often cutting usage by 30% to 50%. However, adoption remains low due to high upfront costs, limited technical know-how, and cultural inertia.
4. Return flows and drainage disposals	Even after crops have absorbed what they need, much of the applied water does not stay in the field. Excess irrigation runs off as surface water or seeps below the root zone into drains and aquifers. While some of these "return flows" can be captured and reused downstream, they often carry fertilisers, pesticides, and salts, degrading both surface and groundwater quality. This is compounded as many parts of Asia have limited infrastructure or incentives to develop effective drainage and treatment, resulting in return flows not being captured or reused effectively.

Sources: World Bank, UN, IFC, Ingrao et al. (2023), Jain et al. (2021), Oliver Wyman analysis

Looking ahead, demand is set to intensify. Crop and livestock production in Asia is projected to grow by roughly 20% over the next decade, further increasing water requirements. This challenge is compounded by structural factors in the region, where nearly 80% of farming is carried out by smallholders, who often lack access to efficient irrigation technologies and are highly exposed to environmental shocks.

At the same time, agriculture is also the most exposed sector to the consequences of water scarcity. Irrigation accounts for the vast majority of agricultural withdrawals at 80%, yet efficiency levels remain low compared to global best practices.

In many Asian countries, surface irrigation continues to dominate, with about

90% OF LAND EQUIPPED WITH SURFACE IRRIGATION

compared to the global average of about 79%, with efficiency rates of just 50% to 60%.

By contrast, more advanced systems, such as drip irrigation, can achieve efficiencies of up to 90%, but adoption remains limited due to several drivers, such as cost and the lack of financing access. This leaves a large portion of production vulnerable to even modest shifts in rainfall or groundwater availability.

Finally, water scarcity in agriculture amplifies interconnected risks across the broader economy. Competition for limited resources is intensifying between farmers, industries, and cities, particularly in fast-growing urban areas. This raises the potential for trade-offs that pit food security against industrial growth and urban development. Without coordinated action, these pressures could undermine long-term sustainability in both agriculture and the wider regional economy.

CHAPTER 2

THE AGRI-WATER ECOSYSTEM AND ITS KEY CHALLENGES IN ASIA

We have identified three main drivers behind agri-food-water stress, which is further compounded by the externalities of environmental factors.

The three drivers identified as the underlying forces that lead to water-inefficiency and systemic failure of self-correction are: crop selection and incentives; public and private market distortions; and gaps in collaborative governance. These drivers are compounded by environmental externalities.

2.1.1 CROP SELECTION AND INCENTIVES

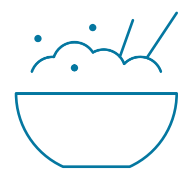
Historical crop selection and crop-soil mismatch continue to drive water-stress in Asia, and government incentives have only catalysed stress growth.

Crop choices across Asia are often misaligned with local water realities, reflecting a mix of historical patterns, consumer demand, and policy intervention. Staples such as rice, wheat, and sugarcane are deeply embedded in diets, cultures, and economies, but are also among the most water-intensive crops globally.

For example, rice alone accounts for approximately

30% OF THE WORLD'S FRESHWATER WITHDRAWALS[29]

and about 90% of rice production occurs in Asia.



Despite its high water footprint, rice remains central due to both consumer stickiness and policy support designed to ensure food security.

These structural misalignments are further reinforced by economic incentives. Governments, seeking to protect farmer incomes and ensure food affordability for the masses, have historically provided subsidies and minimum support prices (MSPs) for water-heavy crops such as rice in India or sugarcane in Pakistan and Thailand. While well-intentioned, these policies have entrenched cultivation patterns that are often at odds with local hydrological conditions. In India, for instance, MSPs for rice have driven paddy cultivation into water-stressed states such as Punjab and Haryana, where groundwater tables have dropped alarmingly.

Beyond staples, export-oriented crops also contribute to stress. Cash crops, such as cotton, avocados, and nuts, often command high global demand, incentivising farmers to shift land and water resources away from more climate-resilient alternatives. This trend has expanded the "virtual water trade," where large volumes of scarce water resources are effectively embedded within crops for export, often at significant cost to local ecosystems and communities.

Exhibit 9: Examples of types of crops by water usage[30]

	A Water-intensive staples	B Export-oriented highvalue crops	C Traditional resilient crops
Water usage	Around 800–1200mm of water per season (on-average)	Around 1000–1200mm per season (on-average)	Around 300–600mm per season (on-average)
Crops	Rice, wheat, sugarcane, animal feed[1] (maize, alfafa, soybean)	Cotton, avocado, nuts	Millet, pulses, beans
Challenge(s)	• Grown in ecologically unsuited zones, leading to external water inputs and system-wide amplification of water stress • Where conditions allow, scaled beyond sustainable land and water share — pushing water systems into imbalance.	• High-value crops are expanding into arid and semi-arid zones where water availability is structurally low	• In decline, even though usually climate-resilient i.e., they require 60–80% less water than staples and have evolved to thrive in low-rainfall, marginal or degraded soils. – Millet cultivation area in India has decreased by over 50% between 1966 to 2016

1. Animal feed crops are primarily water-intensive crops in Asia, but are crops often grown in export-oriented contexts — they also account for almost 30-40% of all water usage in agriculture regionally.

Sources: FAO, UN, ICAR, Oliver Wyman analysis

CASE STUDY

PUNJAB'S WATER STRESS AND THE IMPACT ON CROPS[31, 32, 33]

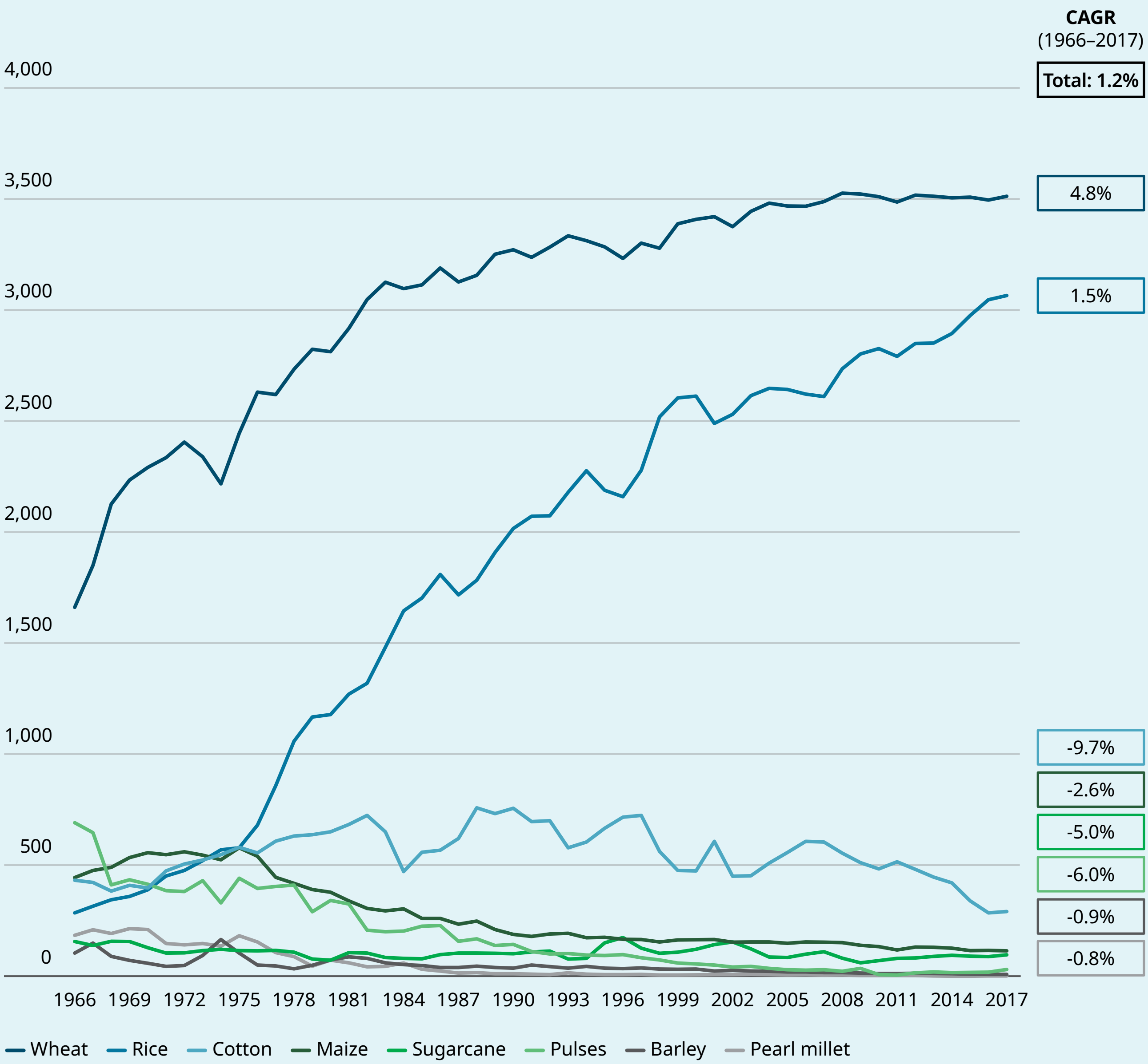
Punjab is often called India's breadbasket, but ecologically it is a semi-arid region with limited surface water availability. Rainfall is seasonal and uneven, and natural groundwater reserves were already under stress before large-scale policy interventions. Historically, farmers grew less water-intensive crops, such as millets, pulses, and oilseeds, better suited to the local climate.

In the 1960s and 1970s, the Indian government introduced MSPs and large-scale procurement policies for cereals, particularly rice and wheat, to ensure national food security during and after the Green Revolution. These guaranteed purchase prices, combined with subsidised electricity for irrigation and fertiliser support, made it economically rational for farmers to switch from traditional dryland crops to rice paddies.

Farmers responded by dramatically expanding paddy cultivation. By the 1980s, rice had grown to cover more than 80% of Punjab's kharif (monsoon) cropped area. However, Punjab's natural rainfall could not meet the high water demands of rice paddies, forcing farmers to rely heavily on groundwater extraction. Tube wells proliferated, powered by subsidised electricity, locking farmers into unsustainable irrigation practices.

Exhibit 10: Evolution of crop area in Punjab

1966–2017, 1000 hectares



Source: International Crops Research Institute for Semi-Arid Tropics (ICRISAT)

The mismatch between crop choice and water availability quickly became critical.

Punjab is now India's highest extractor of groundwater, with agriculture accounting for

97% OF WITHDRAWALS, LARGELY FOR RICE.

Annual pumping exceeds sustainable limits by roughly 70%, and aquifers are declining at an average of a half metre per year. With the current trend, Punjab is expected to exhaust its groundwater reserves by the late 2030s.

Recognising the scale of the crisis, Punjab and the central government have been focused on a range of interventions to date. These include the following:

- **Water recharge structures:** Nearly 3,960 recharge structures are currently being proposed to drive rainwater harvesting and replenish Punjab's groundwater levels. Rooftop rainwater harvesting has also been made mandatory in new large buildings.
- **Increased regulation:** Regulations such as the Punjab Preservation of Subsoil Water Act (2009) and Punjab Water Resources Management and Regulation Act serve to provide greater groundwater governance.
- **Crop diversification incentives:** Pilot programmes to shift farmers away from rice paddies to less water-incentive crops are currently underway. For example, farmers have been encouraged to shift from rice to maize through financial incentives of ₹17,500 per hectare and by distributing free maize seeds.

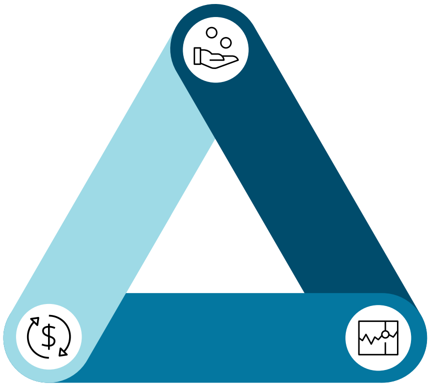
2.1.2 PUBLIC AND PRIVATE MARKET DISTORTIONS

Public and private market distortions drive inefficient water use, as they encourage farmers to make the best economic decision and overlook water-efficiency.

Globally, market signals see distortions, such as inefficiencies in or the absence of water pricing, or the lack of consideration of water costs in trade. At the same time, there is market failure to prioritise water-efficient investments, leading to low adoption of water technologies and solutions. These distortions are also reflected regionally in Asia, with limited investment in technologies and a mismatch in terms of subsidies.

There are three main constraints which collectively drive these market distortions. The constraints work together collectively and can be visualised in the following struggle:

Exhibit 11: Public and private market distortions drive inefficient use of water and make the best economic decision for farmers overlooking water-efficiency



Constraint 1

Public pricing and subsidy distortions

Constraint 2

Private market incentives and market structures

Constraint 3

Investment-level distortions

Source: World Bank, Oliver Wyman analysis

Constraint 1

PUBLIC PRICING AND SUBSIDY DISTORTIONS

Distortions can be driven by government interventions, such as free or flat-rate electricity driving unlimited tube-well pumping in groundwater-dependent zones. As farmers are shielded from actual water prices, they underinvest in technologies.

For example, in the Rangpur region of Bangladesh, the right to irrigate for the entire season is based on a per-acre fee that farmers pay and is not based on the volume of water consumed.[34] Farmers are not encouraged to conserve water, as compared to those who pay by volume.

Constraint 2

PRIVATE MARKET INCENTIVES AND MARKET STRUCTURE

The private market sends profit-driven economic signals that encourage the heavy production of water-intensive crops, without government nudging.

Global market demand and price signals for water-intensive crops, such as cotton, almonds, and avocados, have skyrocketed, while orientation to create export-focused crops does not incorporate water into pricing. Private investors treat farmland as a water-backed asset, and do not factor water into their decision-making.

Constraint 3

INVESTMENT-LEVEL DISTORTIONS

A fundamental barrier to advancing water efficiency in agriculture is the systemic misallocation of capital. Investments continue to flow into high-water-use crops and intensive production models because existing incentives reward yield above efficiency. As a result, capital is diverted away from sustainable alternatives, while innovation skews towards volume-driven systems rather than water-smart solutions.

Water risks remain largely unpriced in financial markets, making efficiency-focused projects appear less bankable despite their clear long-term value. Critically, there are currently few dedicated financing mechanisms or cheaper credit structures linked to water-saving key performance indicators (KPIs), leaving projects that deliver measurable efficiency gains at a disadvantage compared with conventional models.

This distortion is further compounded by the structure of farming in the region. With the majority of producers being smallholder farmers, fragmented and dispersed operations make it difficult to respond effectively to market signals or regulatory frameworks. Without targeted interventions, such as performance-linked finance, outcome-based subsidies, or aggregation models, capital will continue to overlook the very investments most critical for long-term water security.

2.1.3 GAPS IN COLLABORATIVE WATER GOVERNANCE

Governance-level issues drive a significant portion of the water stress challenge within Asia's agri-food-water-environment nexus. While water scarcity is often framed as a resource or technology problem, governance gaps on how decisions are made, funded, and enforced are just as critical.

SILOED DECISION-MAKING

Key decision-makers across water allocation, irrigation service delivery, energy pricing (for pumping), agriculture support, and urban supply are often governed by different ministries or tiers of government. These policymakers often operate in silos, approaching water from the narrow lens of their own sectors rather than as part of an integrated strategy.

AGING INFRASTRUCTURE

Irrigation infrastructure across Asia reflects decades of deferred investment, largely because water rarely ranks high on political or budgetary agendas. As a result, large canal systems which were mainly constructed in the mid-20th century are now outdated, suffering from high conveyance losses, sedimentation, and poor maintenance. Routine monitoring and infrastructure upkeep are consistently deprioritised, leaving water delivery, storage, and drainage systems outdated and increasingly unfit for today's demands.

In **Pakistan's Indus Basin**, one of the world's largest irrigation networks, seepage losses from main and distributary canals are severe, reducing water delivery efficiency and causing downstream waterlogging and salinity. Water losses from the irrigation supply have been reported to be up to 40% to 50% of the total water withdrawals.

LACK OF PROPER WATER GOVERNANCE

Asia also suffers from a lack of robust water accounting and enforcement. Few countries have consistent systems to track how much water is withdrawn, by whom, and for what purpose. Without reliable monitoring, diversions are under-reported, over-extraction is rarely penalised, and adaptive planning is nearly impossible.

2.1.4 ENVIRONMENTAL EXTERNALITIES

Environmental externalities exacerbate the water-stress concern, but these constraints differ by sub-region with varying levels of intensity and frequency.

Environmental externalities include underlying environmental issues, such as climate volatility, rainfall variability, and extreme weather events. These externalities exacerbate the water stress problem and are in turn compounded by human-level drivers. The three main externalities focused on here are physical water scarcity, climate volatility, and soil and land degradation.

EXTERNALITY 1: PHYSICAL WATER SCARCITY

Physical water scarcity can be broken down into two main buckets of groundwater scarcity and surface water scarcity. Groundwater scarcity arises from significantly lowered water tables below economic extraction depths, impacting the buffer against surface supply. Surface water scarcity is the natural constraint that arises when water bodies fail to maintain reliable flow volumes for sufficient agricultural needs.

EXTERNALITY 2: CLIMATE VOLATILITY

Climate volatility refers to the growing unpredictability and intensity of weather patterns that disrupt agriculture and water systems. It captures a range of phenomena, such as irregular rainfall, shifting seasonal cycles, prolonged droughts, and extreme flooding events. These fluctuations reduce the reliability of water supply, damage crops at critical growth stages, and make it harder for farmers to plan planting and harvesting. In short, climate volatility erodes both agricultural productivity and water efficiency, amplifying risks to food security.

EXTERNALITY 3: SOIL AND LAND DEGRADATION

Soil and land degradation stems from multiple processes, most notably erosion, declining infiltration, and salinisation. Erosion and infiltration loss occur when topsoil is stripped away and the soil's ability to absorb and retain water diminishes, often as a result of deforestation, over-cultivation, or the removal of protective vegetation cover. This reduces fertility, increases runoff, and heightens vulnerability to both droughts and floods.

Soil salinisation, on the other hand, arises when salts accumulate in the soil, commonly due to poor irrigation practices, seawater intrusion, or rising groundwater tables. Elevated salinity restricts plants' ability to absorb water, impairs nutrient uptake, and can permanently reduce long-term yields if unmanaged. Together, these processes degrade the productive capacity of land, threatening agricultural output, food security, and ecosystem health.

Exhibit 12: Severity of these externalities in a tabled Harvey-ball format

Illustrative

		South Asia (incuding India)	Southeast Asia	East Asia (including China)	Middle East	Central Asia	Oceania (including Australia)
Externality 1: Physical water scarcity	A. Groundwater scarcity • Significantly lowered water tables below economic extraction depths, impacting the buffer against surface supply	Full	1/2	1/2	3/4	3/4	1/4
	B. Surface-water scarcity • Natural constraint that arises when water bodies fail to maintain reliable flow volumes for sufficient agricultural needs	3/4	1/2	1/2	Full	Full	1/4
Externality 2: Climate volatility	Umbrella term for a series of unpredictable climate behavior that causes damage to the agricultural landscape, and in turn water efficiency. (e.g., irregular precipitation, seasonal timing shifts, droughts, extreme flooding events)	Full	3/4	3/4	1/2	1/2	3/4
Externality 3: Soil and land degradation	A. Erosion and infiltration loss • Degradation of topsoil and loss of soil's capacity to absorb water • Driven by rampant deforestation and clearing of nearby plants	3/4	3/4	1/2	1/4	1/4	1/4
	B. Soil salinization • The level of soil salinity in the water inhibits water uptake by plants and damages long-term yields	1/2	1/4	Full	1/4	1/4	1/2

Lower severity ←→ Higher severity

Sources: FAO, UN, IPCC, WRI, Oliver Wyman analysis

2.2 THE WAYS IN WHICH THESE DRIVERS MANIFEST REGIONALLY

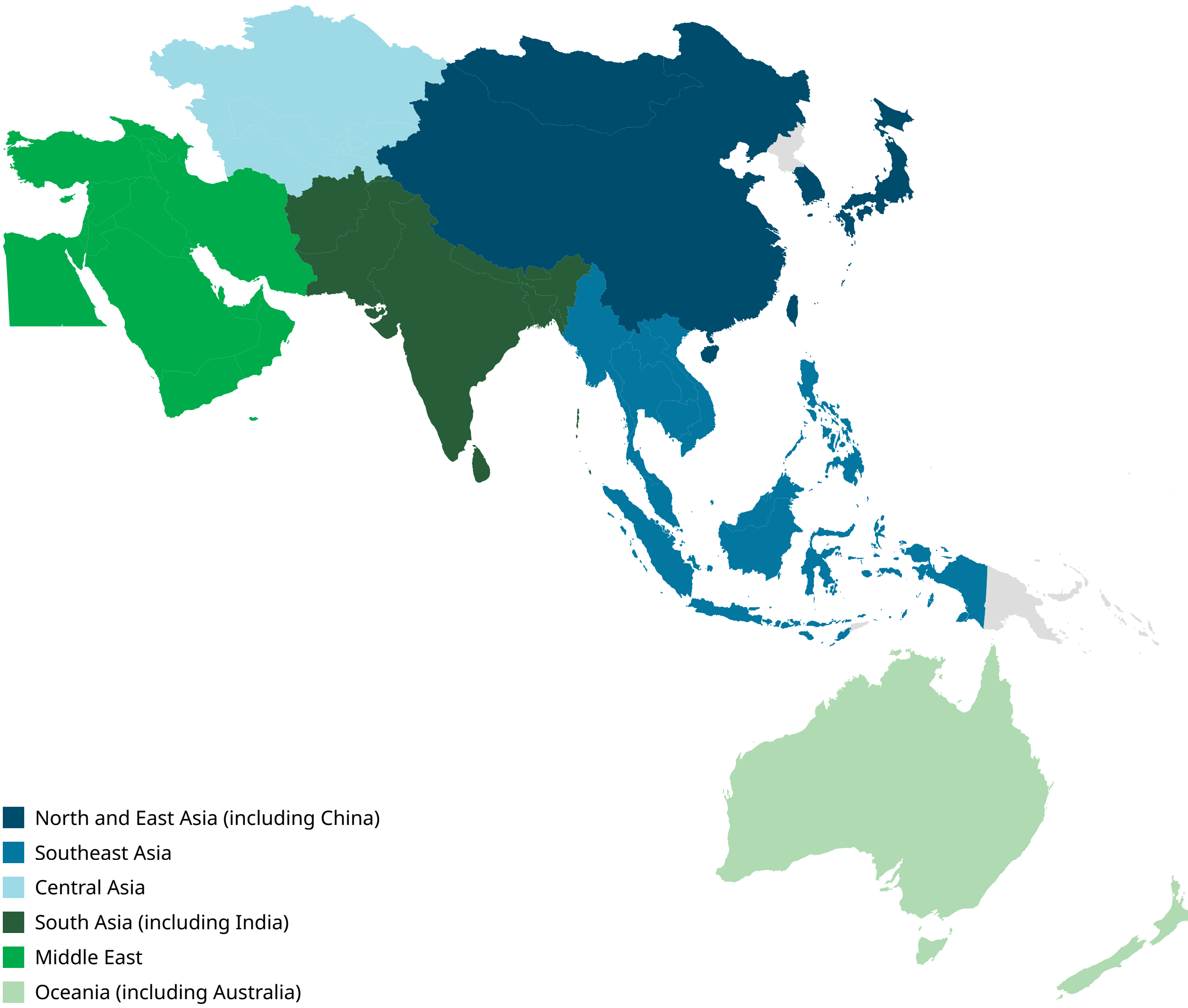
The water crisis is a shared challenge across Asia but manifests in highly localised ways; its severity and characteristics vary across sub-regions.

East and South Asia, particularly China and India, have faced issues of physical water scarcity, with strong demand for water and continued extraction of groundwater having depleted resources. China and India are also the countries that have the biggest areas irrigated by groundwater, accounting for more than 55 million hectares.

Regions with drier climates, such as the Middle East, are also facing water scarcity. On top of the dry nature of the region, over-extraction of water for agriculture has exacerbated the water stress. As a result, countries have looked to policies to support their water use and agriculture.

Oceania has also struggled with water scarcity, but the countries there have taken steps to address the root causes of their water depletion, such as Australia establishing the Basin Plan for the Murray-Darling Basin. While a step in the right direction, additional steps need to be taken to ensure the sustainability of water resources in the region.

Exhibit 13: Aligned sub-regional divisions



Sub-region	Hotspot country identified	Rationale
North and East Asia	China	• Agricultural heartlands suffer severe freshwater scarcity and water diversion projects struggle to keep pace with growing demand • Legacy water allocation inefficiencies and industrial competition continue to drive agricultural water stress • Increasing frequency of extreme climate events (floods, droughts)
Southeast Asia	Indonesia	• Smallholder systems remain trapped in outdated irrigation models, lacking incentives for efficient water use • Watersheds are under pressure from upland land-use change and pollution • Significant exposure to volatile climate cycles like El Nino

Sub-region	Hotspot country identified	Rationale
Central Asia	Kazakhstan	• High dependence on inherited irrigation systems built for different climactic and political realities lead to systemic water loss and inefficiency • Complicated governance systems due to both internal governance problems and transboundary politics
South Asia	India	• Highest absolute agricultural water use in the world; with over 80% of freshwater withdrawals going to farming • Heavy dependence on monsoon variability and declining groundwater tables • Rapid groundwater extraction driven by incentives and distorted pricing continues to outpace natural recharge rates
Middle East	Saudi Arabia	• Past policies incentivized unsustainable expansion of desert agriculture and large-scale depletion of aquifers • Hyper-arid conditions make Saudi Arabia an interesting case for management of water resources as traditional rainfall-management strategies are less helpful
Oceania	Australia–Murray Darling Basin	• Largest country in the Oceania region from an agriculture perspective • Climate variability is structural — requiring continuous recalibration and adaptive mechanisms to address

Source: Oliver Wyman analysis

REGIONAL DEEP DIVE: A BASIN SYSTEM AT THE BRINK OF ECOLOGICAL COLLAPSE[35, 36, 37]

By the early 2000s, Australia's Murray-Darling Basin, a system supporting about 40% of the country's agriculture, was in ecological collapse.

The Murray-Darling Basin spans over one million square kilometres across five states, irrigates 70% of Australia's total irrigated land, and contributes about 40% of the national agricultural output, from rice and cotton, to wine grapes and citrus products. In more ways than we can count, it is the lifeblood of the Australian agriculture ecosystem.

From the 1970s, the basin has experienced massive extractions of water, as the area of irrigated crops has continued to grow. This has resulted in river wetlands and ecosystems coming under stress, with water becoming scarcer and salinity increasing.

The basin was further hit by the Millennium Drought, which impacted the country from the late 1990s. The basin saw historically low river flows, with regions seeing riverbeds exposed. This placed great pressure on agricultural communities.

Rice production in the basin dropped to just 18,000 metric tons in 2008, more than 90% less than pre-drought levels. Production of cotton also shrank dramatically, with thousands of farming families forced to abandon or severely scale down operations.

As Australia's domestic production fell during droughts, global prices spiked. From 2007 to 2008, a sharp drop in basin output contributed to **food inflation,** revealing how a localised water crisis could have wider economic effects.

The combination of the years of over-allocation and Australia's longest drought highlighted the importance of sustaining the basin for the future. In response, Australia established the Basin Plan in 2012 for the sustainable management of water use and the protection of the health of the basin.

CONNECTING IT TO THE THREE STRESS DRIVERS AND ENVIRONMENTAL EXTERNALITIES

Crop selection mismatch: Some of the driest parts of the Murray-Darling Basin, such as southern Queensland and New South Wales, see large-scale cultivation of water-intensive crops, such as rice and cotton. These crop choices have been enabled by historical irrigation infrastructure and water rights systems that did not factor in long-term hydrological sustainability. Some legacy entitlements have enabled continued planting of crops, even in drought years, despite sharp declines in river flows.

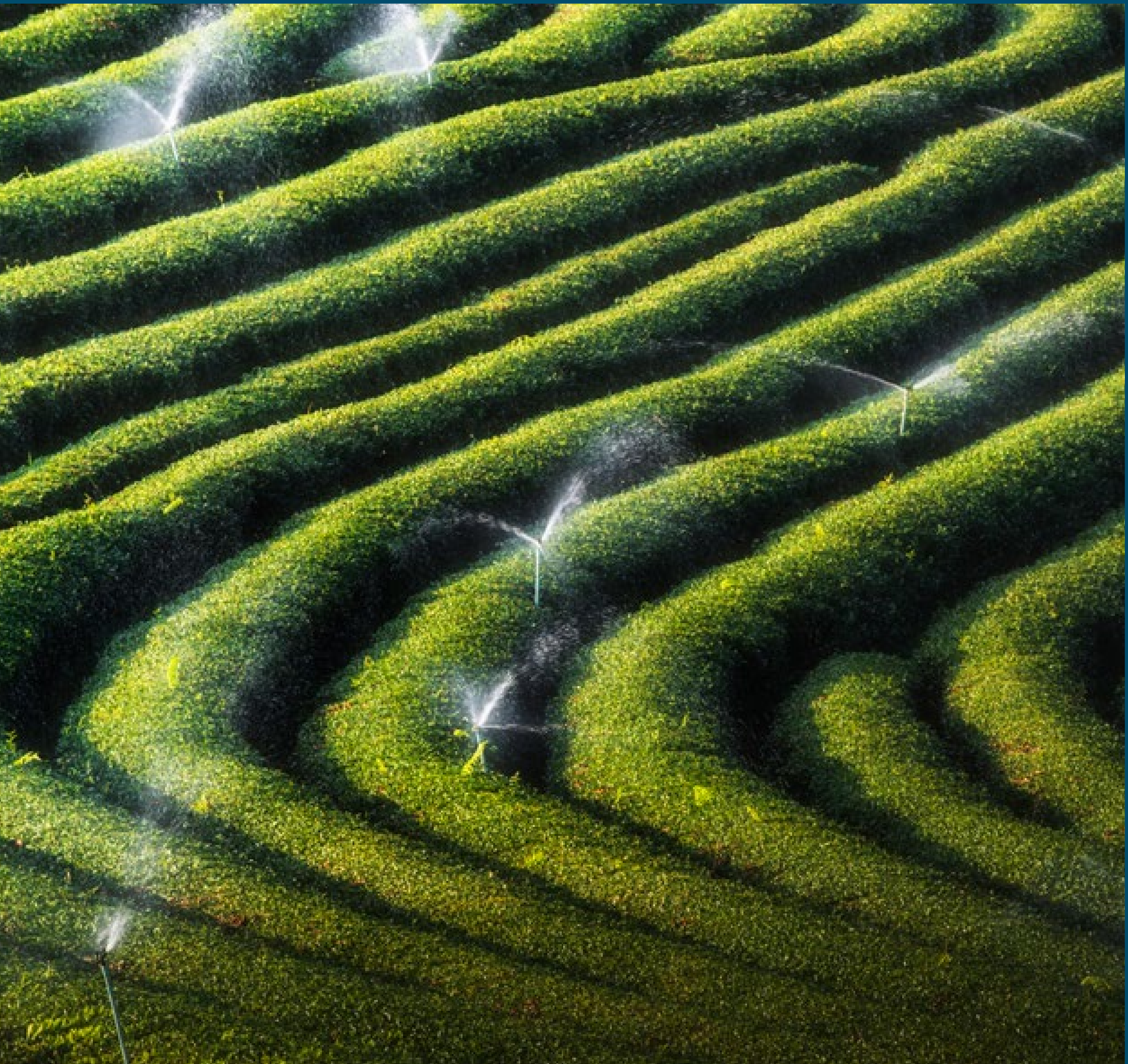
Market and policy distortions: Water rights were historically over-allocated, with water extracted exceeding environmentally sustainable levels for some catchments. Furthermore, the early water trading system lacked safeguards to prevent market concentration or ecological harm. This resulted in an uneven playing field between smallholders and large agribusinesses, which could better leverage trading tools and infrastructure support.

Collaborative water governance gaps: The Murray-Darling Basin spans five states and territories, each with differing legal frameworks, water pricing systems, and political priorities, with each jurisdiction managing its own portion of the basin. Prior to the 2007 Water Act, federal involvement in water was limited to cooperative agreements, with no binding federal coordination. This resulted in a "free-for-all" dynamic, where upstream states extracted heavily at the expense of downstream ecosystems and users.

Environmental externalities (natural stressors, not outcomes of mismanagement): The Murray-Darling Basin is an intrinsically water-scarce region, with long-term average rainfall far below global agricultural norms. Climate models suggest this volatility will intensify, reducing average flows by up to 20% by 2050. At the same time, issues of soil salinity exacerbate the issue, particularly in irrigated zones, where high evaporation and poor drainage lead to salt buildup that degrades arable land over time.

CHAPTER 3

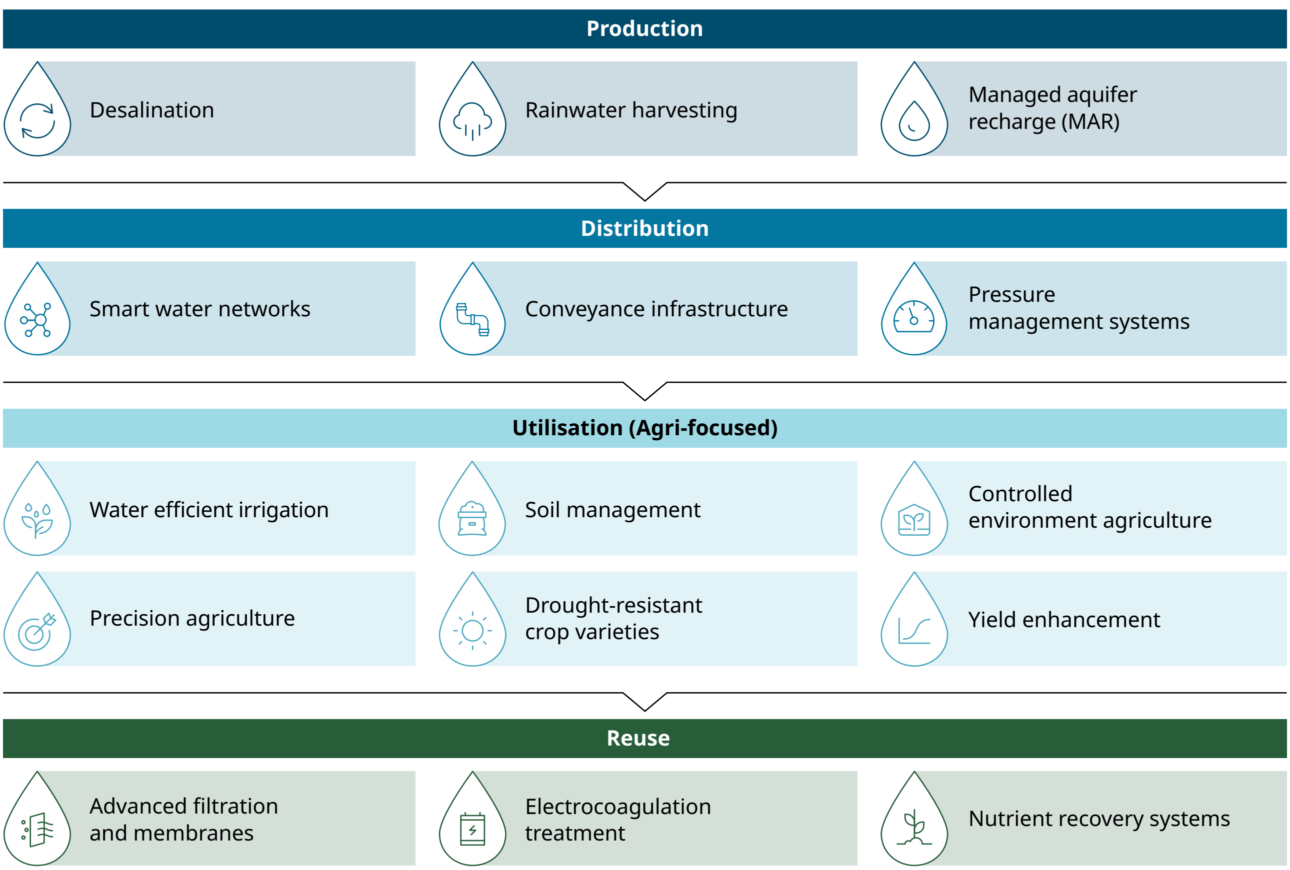
THE TECHNOLOGY AND INVESTMENT LANDSCAPE



3.1 WATER TECHNOLOGY INVESTMENT LANDSCAPE

Water scarcity is no longer merely a question of supply, but of how intelligently that supply is managed across the entire cycle, from production and distribution to utilisation and reuse. From production to reuse, technologies are emerging that promise to reduce waste, stretch limited resources, and embed efficiency into systems long plagued by loss and leakage. With regard to production, desalination and rainwater harvesting are expanding available supply beyond traditional sources. Distribution efforts, such as smart water networks, upgraded pipes, leak detection, and renewable-powered pumps, are improving reliability and efficiency. For utilisation, precision agriculture, soil management, water efficient irrigation, and drought-resistant crops are enabling smarter, more resilient water use in agriculture and industry. Finally, for reuse, advanced filtration, membranes, and electrocoagulation offer new ways to recycle and purify water with fewer inputs.

Exhibit 14: Examples of technologies for each stage of the water value chain



Source: Oliver Wyman analysis

Taken together, these innovations mark a shift from a resource-extraction mindset to one of stewardship, placing technology at the heart of a new water economy.

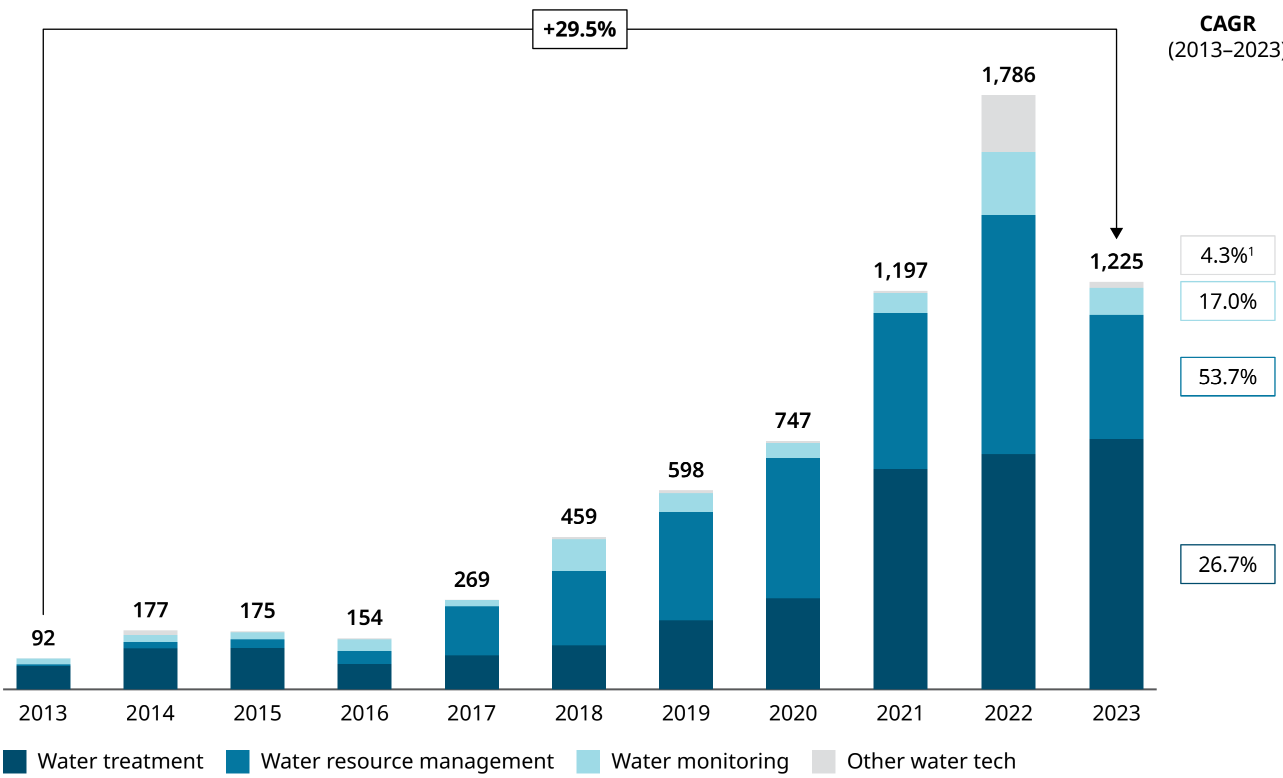
Exhibit 15: Examples of technologies supporting water resilience across the water value chain

Technology	Description	Value chain stage
Desalination	Converts seawater into freshwater through processes like reverse osmosis or thermal distillation to expand water supply	Production
Rainwater harvesting	Captures and stores rainwater from rooftops, land surfaces, or catchments to reduce dependency on groundwater or piped supplies	
Managed aquifer recharge (MAR)	Infiltration basins, recharge wells, and aquifer injection using stormwater or treated wastewater to store water underground for subsequent use	
Smart water networks	Digital systems using sensors, IoT, and analytics to monitor and manage water distribution in real time to reduce leaks, optimize flows, and improve system efficiency	Distribution
Conveyance infrastructure	Systems and technologies for the transportation of water from its source to the point of use, including main canals and irrigation pipes	
Pressure management systems	Smart valves and control systems regulate water pressure across the network, thus reducing the likelihood of pipe bursts or leakage	
Water efficient irrigation	Technologies such as sprinkler, drip or subsurface drip irrigation that supports more efficient use of water, allowing more targeting application of water to crops and reducing overirrigation	Utilization
Precision agriculture	Sensors, IoT tools, and soil moisture probes track water use, soil conditions, and crop water needs in real time, allowing farmers to apply only the amount of water required, improving irrigation efficiency, preventing overuse, and protecting yields under variable climate conditions	
Soil management	The strategic use of cultivation practices and technologies to improve the health, structure and moisture retention of soils to enhance productivity	
Drought-resistant crop varieties	Genetically engineered or selectively bred crops that need less water and withstand dry conditions to reduce water demand while maintaining yields	
Controlled environment agriculture	Greenhouses or vertical farms where water use is tightly managed and recycled	
Yield enhancement	Advances in agronomy and digital farming (e.g. bio-stimulants, crop modelling) helps farmers produce more output per hectare thus reducing the water required per unit food produced and lowering the "water footprint" of agriculture	
Advanced filtration and membranes	Membrane technologies such as ultrafiltration, nanofiltration, or reverse osmosis to treat and recycle water	Reuse
Electrocoagulation treatment	Uses electrical currents to destabilize and remove contaminants from wastewater, thus reducing chemical inputs in the reuse process	
Nutrient recovery systems	Technologies that recover nitrogen and phosphorus from livestock wastewater or food processing effluent (e.g., struvite crystallizers), creating both irrigation water and fertilizer inputs	

Source: Oliver Wyman analysis

The desire for increased water resilience has been matched with increased investments in water technology over the years, with water treatment and water resource management forming major focus areas of investment. From 2013 to 2023, global venture capital (VC) investment into water technology grew from US$92 million to US$1.2 billion, an increase of more than 1,300%.

Exhibit 16: Breakdown of global VC investment in types of water technology[38]
2013–2023, USD million

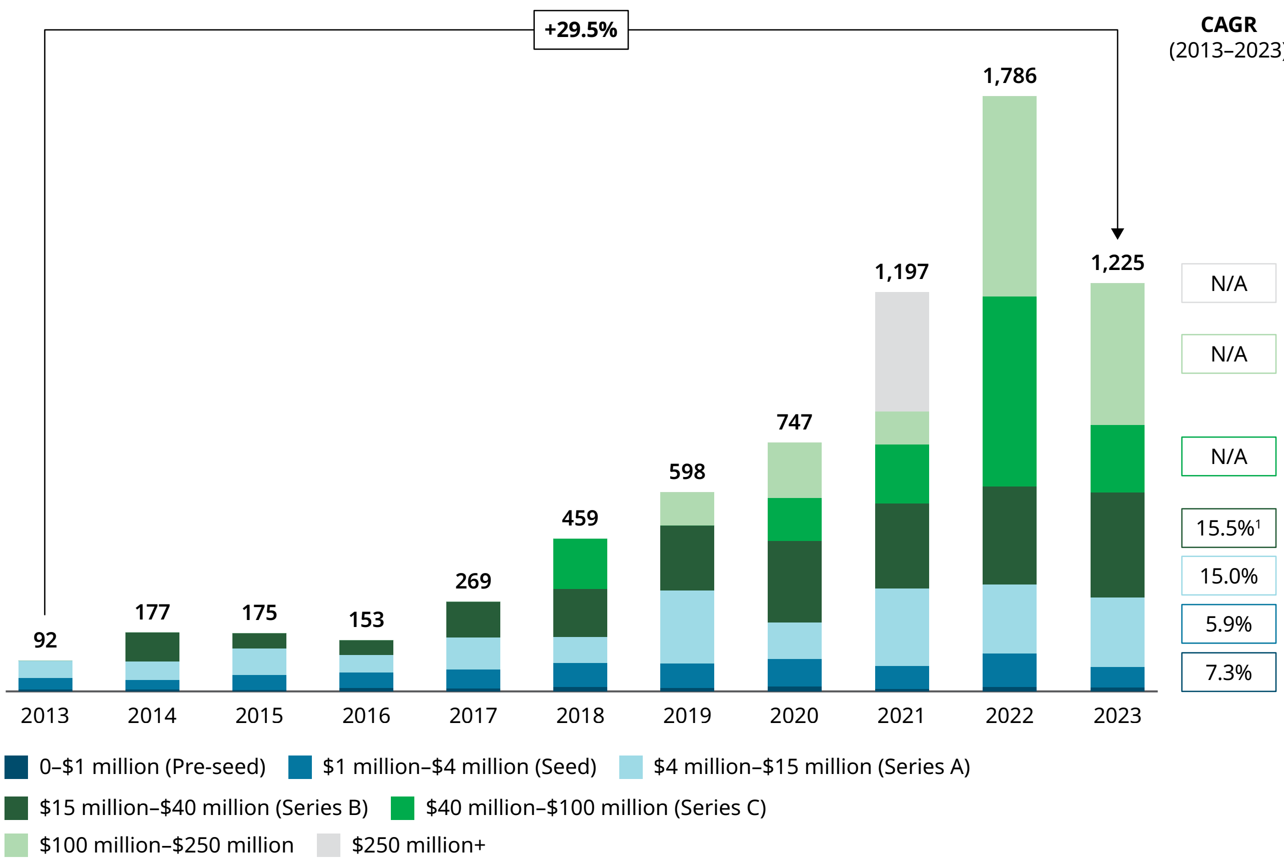


1. CAGR for other water tech from 2014–2023, as no recorded investment in 2013.
Sources: Dealroom.co, Oliver Wyman analysis

Water treatment accounted for about 61% of water technology VC funding in 2023, which aligns with emerging regulations globally on treatment of wastewater. At the same time, funding for water resource management companies, such as irrigation and precision agriculture companies, is supported by the increasing digitalisation of agriculture.

Across water technology, the level of maturity is also increasing, with growth in funding seen across all funding stages. More investments are flowing to later-stage and more mature companies. Since 2021, Series C and later-stage companies have received more than 50% of funding for water technology.

Exhibit 17: Breakdown of global VC investment by company funding stage[38]
2013–2023, USD million



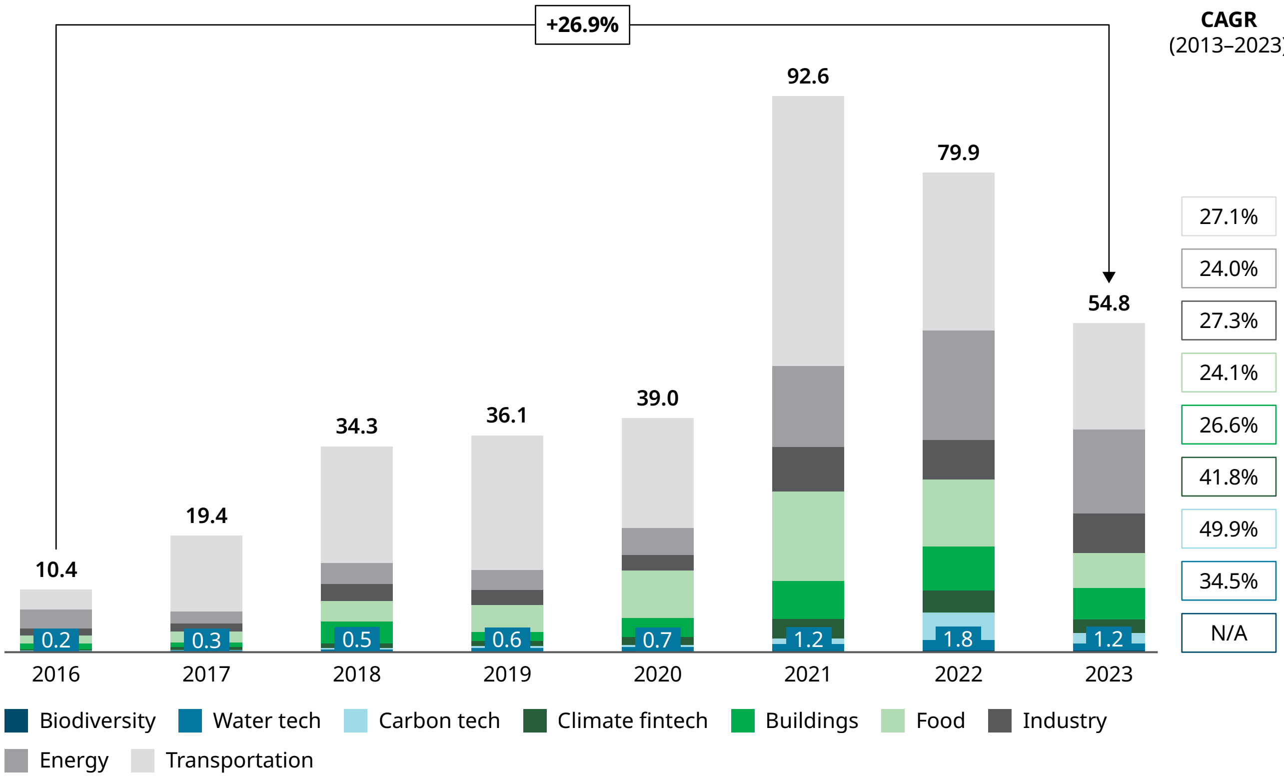
1. CAGR for Series B segment from 2014–2023, as no recorded investment in 2013.
Sources: Dealroom.co, Oliver Wyman analysis

The increased funding for later-stage companies suggests the maturing of water technology, both in terms of importance and capabilities. There is also further room to grow in the water technology ecosystem, with most of the value of water startups contributed by companies established since 2010.

However, while investment in water technology has been increasing, it remains relatively underinvested compared to the wider climate technology space. Climate technology saw investment growth of greater than four times from 2016 to 2023, with peak funding occurring in 2021. Transportation and energy accounted for about 63% of the total funding in 2023. The decline in funding for climate technology in 2022 and 2023 mirrored the overall VC funding landscape at the time.

Exhibit 18: Breakdown of global climate technology VC funding by segments[38]

2016–2023, USD billion



Sources: Dealroom.co, Oliver Wyman analysis

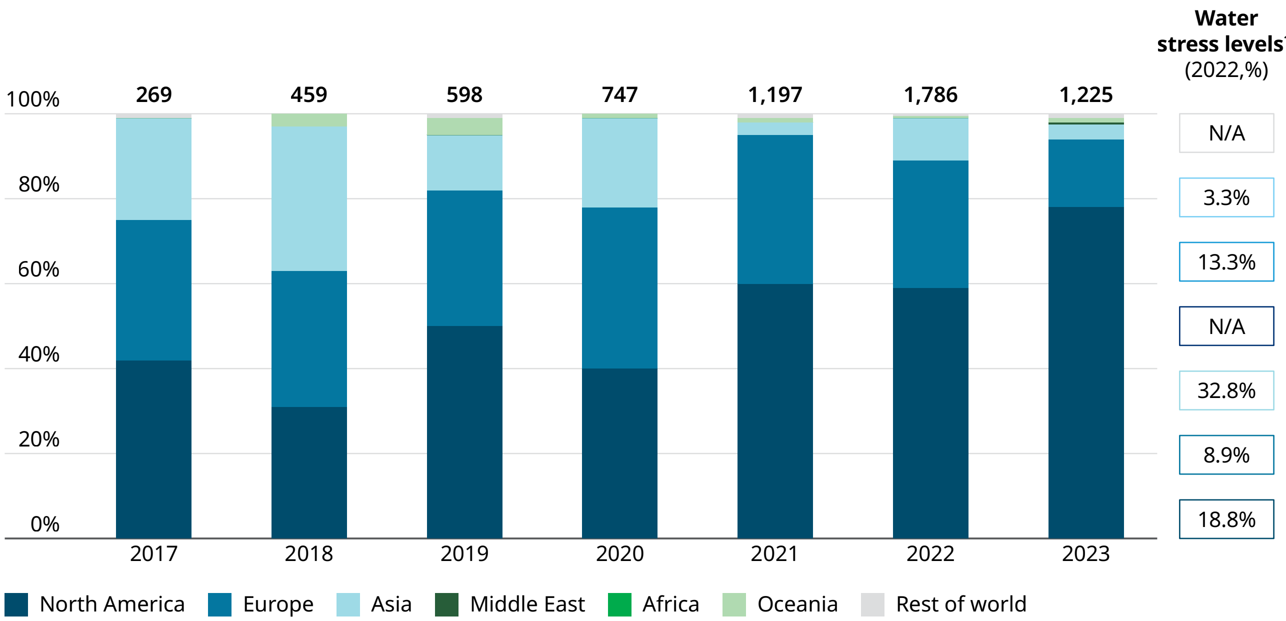
While the amount of funding for water technology has grown, it still receives only from about 1.3% to 2.2% of the overall funding. This is mirrored in the overall private capital funding towards water, with the ERM Sustainability Institute highlighting that funding towards water accounted for just 0.7% to 1.3% of total climate technology funding from 2020 to 2023. Furthermore, while funding for food technology, such as alternative proteins and agri-technology, has grown, it has declined in terms of the proportion of climate technology funding since 2020.

This trend of water investment lagging behind the rest of climate technology comes down to several factors, including the fact that water is rarely prioritised over other needs for government spending and development finance. Companies also often prioritise goals such as carbon and greenhouse gas emissions, which are more commonly discussed commercially and among consumers. Lastly, unlike energy or carbon, water innovation lacks strong regional platforms for knowledge exchange, joint investment, or technology transfer, adding to the gap in investment towards water today.

Focusing on Asia, water technology remains relatively poorly funded despite the region having relatively high water-stress levels.

Exhibit 19: Share of water tech VC deal value and water stress levels by region

2017–2023, USD million



1. Calculated based on FAO SDG 6.4.2 Water Stress formula — 100*[Total freshwater withdrawal]/([Total renewable water resources]-[Environmental Flow Requirements]). Only countries that have complete data required for the calculation were included.

Sources: FAO, Pitchbook, Oliver Wyman analysis

While funding for water technology has been on an upward trajectory, it has been concentrated primarily in North America and Europe, accounting for more than 90% in 2023. This reflects the maturity of their venture ecosystems, but it also results in a skewed distribution of capital towards regions with relatively lower water stress.

In contrast, Asia faces some of the highest water stress levels globally, driven by agricultural dependence, rapid urbanisation, and industrial demand. Despite this acute need, the region continues to attract disproportionately little investment in water technology. VC investment in water technology in Asia also declined from 2017 to 2023.

While Asia's water problem highlights the urgent need for greater investment into water technology, there have been barriers and challenges that have led to Asia remaining relatively underfunded compared to North America and Europe.

From a regulatory and policy perspective, government commitment has supported commercial investment in water technology, providing encouragement that the space will continue to mature. For example, in 2025, the European Investment Bank committed €15 billion over two years to protect water resources in the European Union (EU).[39] Asia, on the other hand, sees similar investments from Multilateral Development Banks (MDBs) of about US$9 billion to US$13 billion annually,[40] despite having a population that is more than six times in size.

North America and Europe also see less fragmented policies around water, with regulatory support such as the US Water Infrastructure Act and the EU Water Framework Directive. Comparatively, while some countries like Japan and South Korea have well-developed water governance frameworks, Asia still faces challenges in fragmented policies, which may deter some investors.

Wider adoption of less sophisticated solutions, such as water efficient irrigation methods, have also promoted investment in water technologies, with technologies such as precision agriculture building on the existing infrastructure. The smaller scale of drip and sprinkler irrigation in Asia relative to North America and Europe may also serve to limit the innovation of water technologies in the region.

At the same time, venture ecosystems in North America and Europe are comparatively more mature than Asia, with North America and Europe accounting for more than 70% of global VC funding in 2024.[41] This provides an easier platform for investors to source and invest in promising startups in the water space.

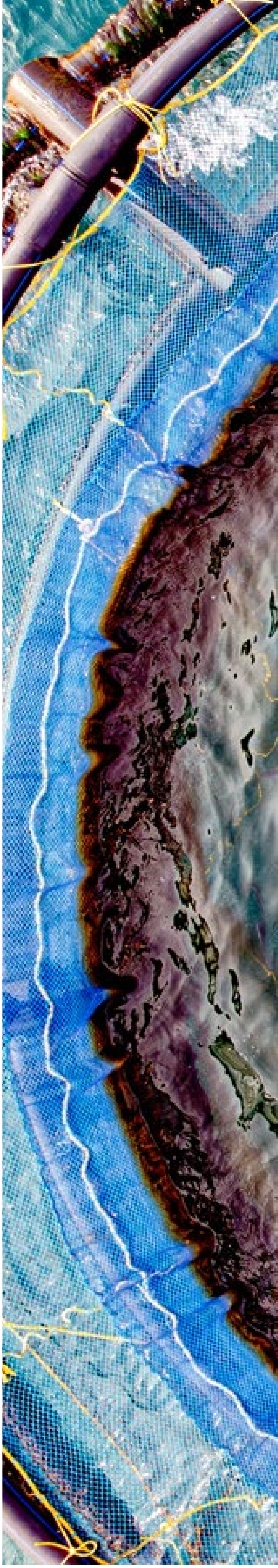
Not limited to venture capital, private equity markets also see similar trends. Total assets under management in 2023 for North America and Europe were US$3.4 trillion and US$1.1 trillion, respectively, and were significantly larger than that of Asia's tally of US$611 billion.[42]

The mismatch in water stress and funding in Asia underscores a strong case for unlocking greater capital flows into high-stress regions such as Asia, where the impact potential is highest and the need for scalable solutions is most urgent.

On top of improving water resilience and supporting the sustainable development of water resources, water technologies present a strong investment opportunity for investors, with the increasing demand and supply gap projected in the future. With water a finite resource and water demand only going to increase with the growing population, solutions to reduce water usage or provide an alternative source of water become increasingly important and vital.

At the same time, demand for water solutions is not limited to agriculture, with demand from industrial activities as well. Competition for water is increasing as industries such as technology, AI, and semiconductors continue to consume large volumes of water for cooling and cleaning. This scenario presents an even greater potential return for investors.

The investment opportunity in water technology will be driven by increasing willingness of corporations to pay for water, both within and outside of agriculture, continued public investment in water, and regulations on water quality and safety.



Corporations are increasingly taking steps to maintain sustainable water resources in their operations, in particular, technology companies. Due to the heavy use of water in cooling and cleaning, technology companies are increasingly investing in water to mitigate business risks.

For example, Microsoft launched their water replenishment programme in 2020 to become water positive by 2030.[43] The programme prioritises investment in regions which have high water stress while also having high operational water consumption, presently focusing on 40 priority locations. The programme also serves to manage business risks, with the need for water for their data centres, as well as the potential increased costs from water security issues.

Governments have also identified the demand gap, with increasing public investments into desalination plants to support water resources, with global installed capacity growing at an average rate of 7% per year since 2010, according to the EU.[44]

Multilateral development banks (MDBs) are also investing into water infrastructure, with MDBs approving

US$19.6 BILLION IN 2024 FOR WATER-RELATED FINANCING.[45]

This increased investment in water infrastructure and technologies by governments and MDBs drives greater confidence for investors, signalling commitment to improving water infrastructure and management. Public investment also helps to build the foundation for more emerging and advanced technologies to be leveraged.

Policymakers are also increasingly implementing regulations on water. This presents an opportunity for potential investments in water technologies to support companies in remaining compliant with emerging regulations. For example, there have been increasing regulations around the presence of 'forever chemicals' in water, such as increased restrictions on per- and polyfluoroalkyl substances (PFAS) in water. The US and EU have implemented stricter contaminant limits through the National Primary Drinking Water Regulation in the US in 2024 and the EU reaching a provisional agreement in 2025 on an update to the list of pollutants affecting surface waters and groundwater.

Other forms of policies, such as water pricing and water markets, are increasingly leveraged by policymakers to control excessive water use in industrial and agricultural contexts. The implementation of potential water pricing policies adds more financial incentive and benefit to pursue solutions to reduce water consumption from public water resources, such as surface or groundwater.

From a water savings perspective, there are financial benefits to investment in water technology, through cost savings from the reduction in water use. Based on the World Wide Fund for Nature (WWF)'s estimated median global value of irrigation water in 2021,[46] water savings of 100 billion cubic metres can save up to US$13 billion.

Additional financial benefits for investments in water can come in the form of investments in the companies providing the solutions, generating revenue and profits for investors. With the growing demand for water and the potential financial benefit from water technologies, this presents a unique opportunity for investment while also supporting sustainable development.

3.2 TECHNOLOGIES AND INITIATIVES IN WATER MANAGEMENT

While a wide range of technologies and initiatives contribute to water resiliency, not all deliver impact at scale. We believe that a handful of priority areas, if backed by sufficient investment, have the potential to significantly move the needle. These include the areas of irrigation, alternative food sources, water distribution infrastructures, soil management, and precision agriculture.

Deploying water-saving technologies and practices across each of these areas effectively can provide water savings in agriculture in Asia, with a potential of about

10% SAVINGS IN WATER CONSUMPTION

arising from adopting more efficient technologies and practices.

This translates to more than 214 billion cubic metres of water saved, equivalent to almost 300 times the water use of Singapore. These efficiency gains can offset part of the expected increases in water demand from 2025 to 2035, while also helping to slow down the increase in water stress in the next ten years to less than a 1% increase, as compared to the projected more than 3% increase. Referring to WWF's estimated value of irrigation water, this represents cost savings of US$28 billion.

Greater adoption of these technologies can also provide even greater water savings and a positive impact to the water crisis in Asia. For example, by matching the adoption levels of drip and sprinkler irrigation of Europe or the US, an additional water savings of about 5% to 10% can be achieved, with water stress in Asia potentially decreasing by about 1% in the next ten years as a result.

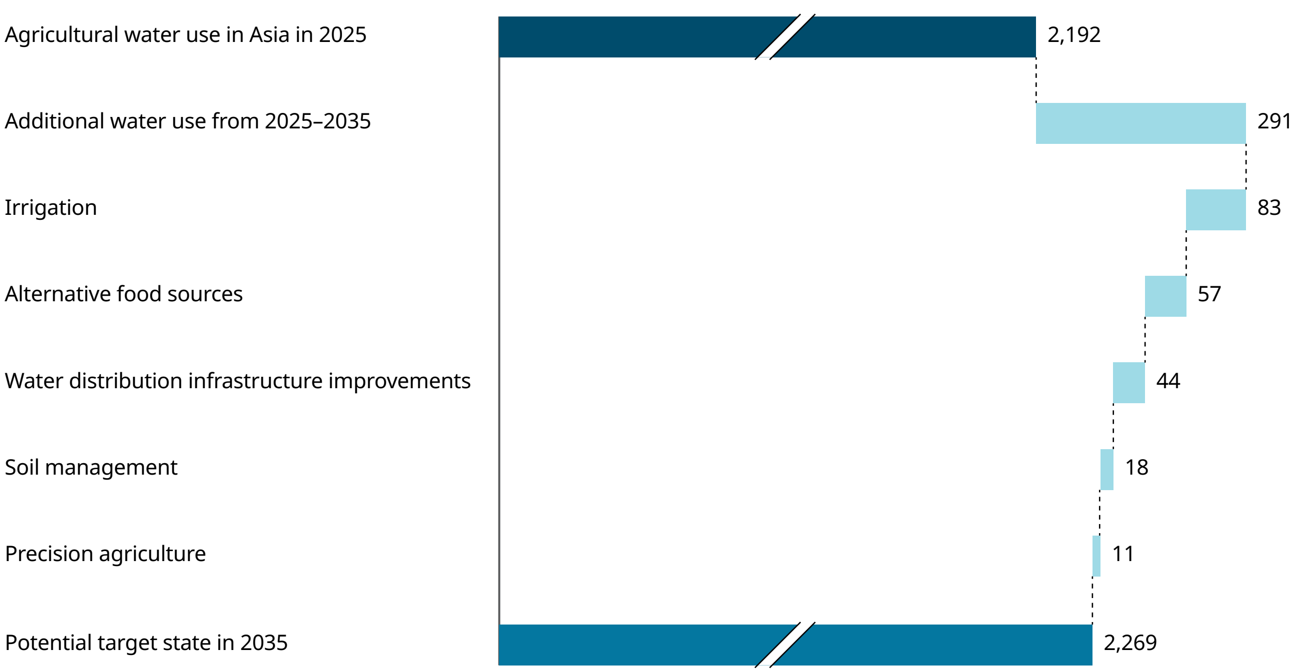
However, significant costs and investments will be required to implement these solutions, with an estimated cost of US$136 billion. A significant portion of this cost arises from one-off capital expenditures on infrastructure for irrigation, precision technology and water distribution networks. Other investments, such as soil management technologies require continued investment to provide these technologies and solutions to farmers. Additional costs would also come in the form of maintenance and replacement costs as these technologies degrade in the fields.

These water savings will be especially important during times of scarcity, which are expected to become more frequent with climate change. A study by Gu et al. (2025) looked at a "90% drought scenario," a situation so dry that such conditions would statistically occur only once in ten years. In Yuanmou County, China, the study found that irrigation accounted for 62% of rice yields under these conditions.

If in such a drought only 20% of the normal irrigation water were available, then using water-saving technology that reduces water needs by 13% could add about 155 kilogrammes of rice per hectare. Scaled across the county, this would mean nearly four million kilogrammes of additional rice, or about 10% of Yuanmou County's total rice harvest in 2021.

Exhibit 20: Potential impact of selected technologies and practices on water consumption in Asia

Billion m^3



Sources: FAO, Oliver Wyman analysis

Irrigation efficiency

Irrigation consumes a significant portion of the water used in agriculture, with water-efficient methods still seeing limited uptake globally, at about 21%, and Asia lagging further behind, at about 9%. Traditionally, Asia uses crop flooding heavily, while global peers leverage more efficient methods such as sprinkler or drip irrigation.

With more than

50% OF AGRICULTURAL LAND FOUND IN ASIA

a small increase in the use of water-efficient methods can provide large savings.

Increasing the use of drip and sprinkler irrigation from about 5% to 12%, thus closing the gap between Asia and the rest of the world, can result in approximately 83 billion cubic metres of water savings, with more water use reduction possible through the greater adoption of drip irrigation.

Examples:

- In Karnataka, India, with the help of 2030 Water Resources Group, a partnership hosted by the World Bank, 24,000 hectares of farmland was equipped with fully automated drip irrigation systems,[47] which can reduce the extraction of freshwater by about 24 million cubic metres.
- China has seen increasing use of water-saving irrigation technology. From 2004 to 2024, the average water use per hectare of irrigated farmland dropped from 6,750 cubic metres to 5,130 cubic metres. Total irrigation farmland using water-saving technology also increased 20% between 2020 and 2024, reaching about 28 million hectares.

Potential considerations:

- While increasing the adoption rates of sprinkler and drip irrigation provides water savings and yield benefits, there are additional considerations on choosing the right areas and crops to implement these solutions. Considerations include cost, environmental impacts, suitability to crops, and regional climate.
- For example, sprinkler irrigation is not suitable for soils that form a crust easily and can result in soil salinisation, which subsequently impacts crop productivity.

Precision agriculture

Precision agriculture can provide significant water savings by incorporating technologies together with irrigation to provide the right amount of water and nutrients to crops at the right time. As water consumption is based on the crops' needs and the growth environment, excess irrigation can be reduced, even for water-efficient methods.

These technologies further enable the use of greenhouses or controlled environment agriculture, where the environment for cultivation of crops is controlled and monitored within a controlled space. This limits the impact of environmental factors, while also better leveraging the data provided by precision agriculture technologies.

While costs may limit large-scale adoption of these technologies, continued implementation of precision agriculture technologies and greenhouses to just 0.8% of irrigated land in Asia by 2035 can result in water savings of up to 11 billion cubic metres.

Examples:

- China houses the largest agricultural greenhouse area in the world, accounting for about 60% of global greenhouse area at about 1.9 million acres of land, with much of the crops focused on fruits and vegetables.[48]
- Major players such as Beidahuang Group, one of China's leading agricultural brands, has been implementing smart technologies on their farms.[49] These include IoT sensors to monitor weather and soil conditions, as well as to allow farmers to adjust temperature, water, and acidity levels. Other players such as Olam have set 2030 water targets for almond orchards in the US and Australia, the goal being to implement soil and plant moisture monitoring in 100% of orchards to optimise water efficiency.

Potential considerations:

- Precision agriculture relies on advanced technologies to provide additional insights and automation to agriculture. However, the implementation costs of these technologies are relatively high, making them difficult for smallholder farmers to access without financial support from downstream partners or government subsidies.

Soil management

Growth conditions of crops can have an impact on yield and water use, with degradation and erosion of cultivated land impacting factors such as water holding capacity, resulting in more water being required to produce crops in certain areas. About a third of the world's arable land is moderately to highly degraded today.

Technologies such as soil nutrient mapping, nano fertilisers, and soil conditioners, enhance the soil through improving their nutrient and water holding capabilities, providing crops with a better environment to grow.

At the same time, farming practices and conservation agriculture efforts, such as minimum mechanical soil disturbance, crop cover, and crop diversification, can help to regenerate degraded lands and improve soil biodiversity.

By leveraging conservation agriculture efforts on 22% of degraded land in Asia, approximately 18 billion cubic metres of water can be saved through improving soil health and its capacity to hold water, thereby requiring less water in crop cultivation efforts.

Examples:

- The adoption of conservation agriculture farming practices has seen increasing adoption globally, with the largest adoption rates found in South and North America. In the US, the share of wheat croplands that adopt the no-till or reduced till practice grew from 21% in 1998 to 69% in 2022, with over a million acres in no-till production.[50]
- In Japan, Tottori Resource Recycling Incorporated has developed Porous Alpha, a foamed glass soil amendment made from recycled materials. By improving soil water retention and nutrient availability, it has demonstrated up to 50% water savings and yield gains of about 20% in conducted trials, offering a durable and eco-friendly solution for water-scarce agriculture.[51]

Potential considerations:

- Some types of conservation agriculture practices require specialised equipment, which may limit the uptake of such practices. At the same time, a key hurdle for conservation agriculture practices is the lack of knowledge and training, especially in several emerging markets.
- Soil amendment technologies, such as hydrogels or advanced microbial treatments, can help to improve the properties of soil. However, they may have limited reach to emerging markets in several parts of Asia, limiting the uptake of these solutions.

Alternative food sources and seed innovation

Some crops, such as rice and wheat, require 60% to 80% more water to produce compared to others. As a result, a shift in consumption behaviour to more water efficient alternatives can reduce the indirect water consumption through food. Water efficient food alternatives include switching to more water efficient crops, such as millets, or alternative foods, such as cultivated meats and plant-based meats.

On top of a push to adapt consumer demands, there are also increasing efforts to develop climate-resistant seed alternatives for staple crops, which require less water than their conventional counterparts.

By replacing just 2% of rice, wheat, and maize production with water-efficient crops or climate-resistant hybrids, and swapping out another 2% of meat consumed with cultivated meats, water savings of about 57 billion cubic metres can be achieved. With rice being a key source of food in Asia, rice alternatives would see the greatest savings in water.

Examples:

- In 2023, India produced around 38% of the world's millets, marking nearly 60% growth over the past three decades. This expansion has been strongly supported by government efforts to promote millet consumption, including designating it as the country's "special agricultural product" under the FAO's One Country One Product programme.[52]
- HB4 wheat, a drought tolerant wheat variety, was planted on 55,000 hectares in Argentina in 2022, following its commercialisation. HB4 wheat is also approved for food and feed use across several countries, including Australia, New Zealand, South Africa, and Thailand.[53]
- Thai Wah, a major agriculture and food player, has also been developing and researching "Thai Win Animal Feed" for buffaloes, beef cattle, and dairy cows. This animal feed is produced from cassava pulp, a byproduct of cassava starch production, which helps provide an alternative feed source and reduce the water footprint of livestock.

Potential considerations:

- While swapping to alternative crops or alternative proteins can provide substantial water savings, it requires significant change and acceptance by consumers in terms of their consumption behaviours. Such changes may be difficult, especially in Asia, where cultural practices drive food choices and would require extended time to set in motion.
- At the same time, for alternative seeds such as genetically modified seeds that are more drought resistant compared to their conventional counterparts, the uptake may be limited by hesitance from farmers who may fear loss of yields and profits as a result of the switch.

Water distribution infrastructure improvements

Poor or degraded water distribution infrastructure results in conveyance losses, which can account for about 30% of water losses in agriculture, with losses coming through runoff into drains, evaporation from water surfaces, seepage, or leaks.

Leak detection technologies, such as infrared thermography or acoustic sensors, can be used to monitor, locate, and pinpoint potential leaks, supporting farmers to address them.

However, a significant contributor to conveyance losses is the lack of lining for large portions of the distribution network. Conveyance losses in lined canals can reduce water loss by at least 20%, with greater savings in certain areas.

By lining just 16% of unlined conveyance canals in Asia, approximately 44 billion cubic metres of water can be saved, reducing seepage and percolation losses, allowing for greater water efficiency in the distribution of water across agricultural fields.

Examples:

- In 2024, Uzbekistan's head of state declared a "peak year of canal lining," with plans to line 1,500 kilometres of canals with concrete, in order to support the water saving agenda of the state. The state's efforts have been further supported by the World Bank through a US$200 million concessional credit to modernise irrigation and drainage infrastructure, including 259 kilometres of eight primary canals.[54]
- Xylem, a leading water technology provider, leverages data analytics and advanced algorithms through their Xylem Vue platform to support irrigation management, providing insights such as leak detection, excessive pressure, or overconsumption of water.[55]

Potential considerations:

- Improvements to water distribution infrastructure often require some level of capital outlay, which may hinder the further adoption of such improvements. These include investments from both governments and farmers.

Other factors to consider in the potential water savings from adopting these technologies and practices include the regional water use efficiency of Asia compared to the rest of the world. When looking at the average amount of water used for irrigation per acre, Asia lags Europe and the US in water use efficiency. The two main crop producers in Asia, India and China, use about 3,100 and 2,050 cubic metres of water for irrigation per acre, respectively, while the US and Europe use about 1,850 and 1,100 cubic metres, respectively.

When looking at specific crops, European countries and the US generally have greater crop water productivity (CWP), measured as the average number of kilogrammes of crop per cubic metre of water, compared to Asian countries, with the exception of China.

Exhibit 21: Mean crop water productivity of rice and wheat across various countries[56]

Crop	Countries	Mean CWP (kg/m^3)
Wheat	India	0.84
	Bangladesh	0.93
	Pakistan	0.99
	Australia	1.05
	China	1.22
	United States	1.26
	Netherlands	1.39
Rice	Malaysia	0.55
	Pakistan	0.57
	Australia	0.73
	India	0.75
	United States	1.26
	China	1.40

Source: Taylor & Francis Online

Across both rice and wheat, the US generally produces more crops per cubic metre of water, highlighting the gap between water use efficiency between Asia and the rest of the world. Even within Asia, there is disparity, with China matching or exceeding the water use efficiency of global counterparts for these water-intensive crops. This suggests that there is indeed potential for increasing CWP within the region.

Taking further action to align Asia's agricultural water use practices in line with those of Europe and North America can boost potential water savings, helping to ease some of the region's water issues.

3.3 ADDITIONAL BENEFITS OF WATER TECHNOLOGIES IN AGRICULTURE

While the implementation of these solutions can provide water savings to ease the water crisis in Asia, these solutions also help to address the other implications of Asia's water crisis, such as food security, economic stability and environmental impacts.

The proposed implementation of these solutions can help to slow down the projected increase in water stress levels in Asia over the next 10 years, with a potential decrease in water stress levels with greater adoption of these solutions. By using less water for agriculture, farmers reduce their dependence on groundwater, providing opportunities for groundwater sources to recharge. For example, in Uttar Pradesh, the government has been encouraging the uptake of drip and sprinkler irrigation, with the area equipped with these irrigation technologies growing from 1,730 hectares in 2020 to 18,189 hectares in 2024. This resulted in improvements to groundwater levels, with some districts seeing levels rise by as much as 164 centimetres.[57]

Technologies such as water-efficient irrigation, precision agriculture and soil management techniques can also provide increased yields of crops and in turn greater profits for farmers. As farmers are able to be more targeted with their water use and resource application to crops, crop yields can be improved by up to 40%, while also helping to reduce fertiliser use by 30%.

Bansal et al. found that drip irrigation applied to rice can result in an

11.65% INCREASE IN GRAIN YIELD OVER FLOOD IRRIGATION.

This allows farmers to produce greater output with less input, in terms of water and fertiliser. When looking at Asia's crop production of US$3 trillion in 2023, the increase in crop yields and reduction in resource use from adopting more water efficient technologies can translate to added value of approximately US$98 billion annually, with greater benefits as farmers continue to produce more crops.

At the same time, implementing adequate irrigation measures can support crops during times of drought and help to reduce crop loss. Irrigation can make farmers more resilient, helping them manage scarce water resources, respond to irregular water supply and provide a buffer against sudden drought shocks. Farmers are better equipped to adapt to changing climate conditions, through tools such as rainwater harvesting, soil moisture data and weather forecasts.

By being prepared, farmers can mitigate instances of a total lack of water for crops, reducing yield losses by 6% to 50% during extreme dry years or periods of drought.[58, 59] This can translate into savings from crop losses of approximately US$15 billion. This also provides greater stability to crop yields and income for smallholder farmers, as their crops receive the right amount of water and nutrients, while also being more resilient to climate impacts.

The increased crop yields and the reduction in crop losses in disaster events also help to mitigate the food security issues in Asia. While these impacts may not directly address the food security issue, they help to improve or maintain the status quo, instead of exacerbating the issues. With Asia's growing population, more efficient water use can also ensure greater sustainability in food production, ensuring that growth in crop production continues to grow with the population.

Water technologies can also provide added benefits to the environment, such as reducing greenhouse gas emissions or reducing agricultural pollution. Rice is a significant source of methane emissions, with the World Bank estimating that rice production accounts for 8% of all human-driven methane emissions.[60] A major contributor to methane emissions in rice production is the flooding of paddy fields, which creates an environment ideal for certain bacteria to decompose organic matter, releasing methane in the process. The use of alternative irrigation technologies replaces this practice of paddy field flooding with more direct water application, reducing these emissions.

With water more directly applied to crops, agricultural runoff is also reduced, with less excess water running off the surface of fields. This reduces the contaminants, such as fertilisers or other agrochemicals, that may flow and pollute water sources.

Collectively, when considering the financial impact of these solutions, they can provide approximately US$141 billion of cost savings and additional profit for agriculture. In the context of the estimated costs in implementing the solutions, this can help to offset the costs. With a significant portion of the financial benefits from the implementation of these solutions expected to be recurring, farmers can continue to reap the benefits of the increased crop yields from water-efficient technologies, compared to one-off infrastructure costs for the setup of these technologies.

Given the financial benefits from implementing these solutions, it further highlights the importance of investment to support smallholder farmers, who often lack the necessary capital to implement these technologies, in adopting these solutions, enabling them to be more water-efficient in their production.

IRRIGATION DEEP-DIVE SUB-SECTION

A key part of agriculture is irrigation, which supports the delivery of water to plants and crops for growth, while in some instances also providing additional nutrients carried in the water. Irrigation accounts for about 40% of global food production and covers about 20% of global cultivated land.[61] Of the world's irrigated area, Asia accounts for about 70%, covering more than 240 million hectares, with the majority of this irrigated land found in South and East Asia.

There are various types of irrigation that are used today, with varying levels of water efficiency. The four main types of irrigation are detailed below:

Exhibit 22: Key types of irrigation methods

Type of irrigation	Description	Water efficiency
Surface	Also known as flood or furrow irrigation, type of irrigation that applies water to crops with the help of gravity. Water is applied directly to the surface of the soil	Low
Sprinkler	Applies water through a system of pipes using high pressure, spraying the water into the air and in a circular pattern across the crop land	Medium
Drip	Uses a network of pipes and emitters to directly apply water to the soil, providing more targeted watering of crops	High
Subsurface	A type of drip irrigation that uses drip tubes or drop tap that is buried to provide water directly to the root zone of the crop	High

Source: Rivulis, Oliver Wyman analysis

The suitability of irrigation methods depends on various factors, including geographical climate conditions, types of crops, and water quality.

Of the irrigated land in Asia, about 90% is currently surface irrigated, with drip irrigation accounting for less than 4% of irrigated land.

Besides reducing water consumption, drip irrigation provides additional benefits, such as improved crop yields and productivity, greater efficiency in fertiliser use, reduced evaporation, and improved crop quality.

Alternative irrigation techniques, such as Alternate Wetting and Drying (AWD), have shown promise in rice cultivation. AWD involves periodically draining fields so that they alternate between flooded and non-flooded conditions. In countries such as Bangladesh, Vietnam, and the Philippines, this method has delivered 17% to 38% reductions in water use while maintaining yields in many cases.

There has also been a growing push for the use of AWD. For example, in Vietnam, the government launched the "One Million Hectares of High-Quality Rice" programme in 2023, aimed at promoting the application of AWD and other practices. While a key focus remains the reduction of greenhouse gas emissions, the programme brings about added benefits such as water savings. Preliminary findings from the Ministry of Agriculture and Environment found cost reductions of up to 24.2%, yield increases of up to 7%, and increased income of 12% to 50% from the initial pilot models.[62]

Despite this push, the adoption of AWD remains limited because farmers perceive a risk of yield loss if the technique is not implemented correctly, highlighting the need for stronger training and support systems to build confidence.

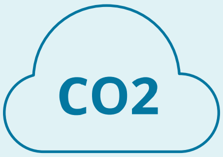
CASE STUDY
DFI RETAIL GROUP (DFI)

DFI launched a pioneering low-carbon rice cultivation pilot programme in Thailand in 2024, aiming to reduce greenhouse gas emissions and to promote the adoption of sustainable agriculture practices across its supply chains.

Rice is a staple crop in Asia, with the region producing and consuming over 90% of the world's supply.

For DFI, rice is one of their top Scope 3 emissions product categories, contributing approximately

6% TO TOTAL SCOPE 3 EMISSIONS.



A significant portion of these greenhouse gas emissions arises from traditional flooding practices in rice cultivation. Recognising this, DFI saw an opportunity not only to reduce emissions within its supply chain, but also to raise awareness of the environmental impacts of rice production at a broader scale.

DFI sought to address emissions through cost-effective methods by collaborating with agricultural experts, the Thai government, and researchers to develop the programme. Partnering with 30 local farmers, the programme introduced sustainable farming techniques, including alternate wetting and drying (AWD), straw burning prohibition, and soil and fertiliser management. By adopting AWD, the programme reduced the flooding in rice fields from the traditional 120 days to approximately 10 days, significantly cutting water use and methane emissions. This approach also ensured that the price of sustainable rice remained affordable for customers.

In 2024, the programme successfully produced 110 metric tons of certified low-carbon rice in 2024, reducing greenhouse gas emissions on the rice fields by at least 30% as compared to conventional farming methods.

Building on this success, DFI plans to launch 200 metric tons of low-carbon rice under the Yu Pin King brand for the Hong Kong market in 2025. Furthermore, DFI formed a five-year partnership with Toumi Foods, one of Thailand's leading rice exporters, for the continued production of the low-carbon rice. This partnership sets an ambitious goal of increasing production of the low-carbon rice to 1,000 metric tons in 2026, further driving the transition toward sustainable rice cultivation.

"Our low-carbon rice programme reflects our commitment to find solutions that achieve multiple objectives — to provide customers with affordable, eco-friendly choices, protect our planet, and empower farmers."

— DFI

Globally, there are several large players in the irrigation space that provide irrigation solutions for farmers.

Exhibit 23: Examples of irrigation companies globally

Netafim	Netafim is a company specialising in precision irrigation solutions, providing drip irrigation, sprinklers, filters, and valves, among others. They aim to increase the adoption of precision irrigation and agriculture solutions that maximise yield, supporting global food security.
Rivulis	Rivulis offers full turnkey micro irrigation solutions to promote a sustainable agri-food supply chain, with solutions across the industries of agriculture, horticulture, greenhouses, and mining. They cater their solutions to both smallholder individual farmers and large corporate producers.
Dayu Irrigation	Dayu Irrigation Group provides water-saving irrigation materials, such as drip tape, sprinklers, pipes, and fittings. Most of their operations are within China, with the Northern regions of China contributing to more than 80% of their revenues.

Source: Netafim, Rivulis, Dayu Irrigation, Oliver Wyman analysis

Many of the players in the irrigation space provide solutioning projects outside of irrigation materials and tools, supporting farmers through larger scale projects to implement the various tools and technologies across their farms.

For example, Dayu Irrigation supports projects to implement their technologies on farms, both within China and globally. One example within China is the implementation of a smart water-fertiliser irrigation project in Henan. Dayu leveraged their technologies, including foliar spraying, video monitoring, field automation, and smart irrigation to implement UAV foliar spraying and smart irrigation across 1,950 mu, equivalent to about 130 hectares. This helped to reduce water, fertiliser, time, and labour use across the project area, and led to yield improvements of 24% per mu.[63]

CASE STUDY
RIVULIS

Rivulis is a global leader in precision irrigation solutions, having successfully executed precision irrigation projects globally. An example of a successfully executed project is one in Kalimantan, Indonesia, where they supported the implementation of precision irrigation for palm oil tree plantations.

With over a billion palm oil trees in Indonesia, palm oil trees are a crucial part of the economy, where their output plays an important role in the development of the local economy. With the importance of palm oil trees to Indonesia, precision irrigation is a method that can provide added efficiency to the industry.

Palm oil trees require 8 years to reach their peak yielding period, which lasts for another decade, before a gradual decline of output. To keep plantations at high productivity, constant replanting and replacement is required, creating high demand for nurseries to supply the mature plantations with young trees.

Conventional manual watering systems, which is a standard practice in the nurseries, have several weaknesses. These include inefficient use of fertiliser and irrigation water due to an inability to access real-time monitoring and controlling, high manual labour demand for fertiliser application on each seedling polybag, and exposure to fungi and weeds resulting from over-irrigation around the plant.

Precision irrigation provides an optimal solution to these problems. They incorporate automatic monitoring and control systems, along with advanced algorithms that optimise water and fertiliser use, significantly reducing the need for labour and the exposure to plant disease. At the same time, despite the required investment cost for precision irrigation systems, such systems return their investment rapidly through providing efficient and predictable outputs.

In the project executed in Kalimantan by Rivulis, the higher efficiency from the precision irrigation system resulted in a reduction of between 3 and 4 months of growth within the nursery, saving the client yearly operating expenses of US$150,000, while providing consistent quality of product and available data for better decision making.

PRECISION AGRICULTURE DEEP-DIVE SUB-SECTION

Precision agriculture leverages advanced technology to collect and analyse data for data-driven insights, in order to optimise farming practices. This allows for the optimisation of agricultural inputs, such as water or fertiliser, to be able to produce similar or improved crop yields, and reduce environmental impacts.

Precision agriculture can be the use of a singular piece of technology or incorporate a group of technologies to achieve the desired results. The technologies involved include Global Positioning System (GPS), Geographical Information System (GIS), remote sensing, and sensors.

Exhibit 24: Examples of precision technologies used in agriculture

Type of technology	Description
Global Positioning System (GPS)	GPS satellite-based navigation system that can be leveraged to provide mapping and navigation information. This includes the creation of accurate maps of fields, and guidance for farming machinery.
Geographical Information System (GIS)	GIS is a tool that collects, manages, analyses, and integrates spatial and geographical data into simple and understandable maps for farmers. The GIS-based maps provide information of specific locations in fields, such as soil types, topography and moisture levels.
Remote sensing	Remote sensing involves the use of satellite imagery or unmanned aerial vehicles to collect data on fields, allowing farmers to monitor and manage crops without physical contact. This can also support variable rate applications within fields.
Sensors	Range of sensors that provide data for farmers to optimize resource allocation and improve crop productivity. Sensors used in precision agriculture ranges from soil moisture sensors and temperature to humidity and pH.

Source: Oliver Wyman analysis

Collectively, the use of these technologies can allow farmers to optimise their resources through a better understanding of the needs of their crops, applying the right amount of water and nutrients at adequate timings. Precision agriculture brings about both economic and environmental benefits, as noted below:

Exhibit 25: Examples of precision technologies used in agriculture

Type of benefit	Benefits
Economic	• Increased yield of crops • Reduced inputs and input costs, such as less water and fertiliser consumption
Environmental	• Water savings • Reduction in greenhouse gas emissions • Reduction of runoff into waterways

Sources: Oliver Wyman analysis

Precision agriculture has seen increasing innovation in recent years, with Asia being home to several key players. Japan has seen increasing use of digital farming, emerging as a leader in digital farming innovations. For example, Kubota Corporation, a Japanese agricultural machinery manufacturer, has been developing their Agri Robo series of unmanned automated agricultural machinery, including tractors, combine harvesters, and rice transplanters. Some of Kubota's machinery leverages its Model Predictive Control, which uses algorithms to make precise steering, supporting the accuracy of farming. While currently having people monitoring the automated and unmanned machines, Kubota aims to develop its technologies to achieve completely unmanned operations.[64]

Also within Asia, XAG, a Chinese smart agriculture company, focuses on robotics and AI to support agriculture. It provides a range of products, including agricultural drones, smart IoT products for automation and monitoring, and unmanned ground vehicles. XAG's agricultural drones have capabilities to spray, spread, and map crop fields, allowing farmers to remotely apply pesticides and fertilisers to their crops.[65]

Precision agriculture is not limited to crop fields, as a key type of precision farming enabled by precision agriculture technologies is controlled environment agriculture (CEA). CEA involves technologies used within facilities such as greenhouses or vertical farming to produce crops outside their natural or preferred environments. Crop growth and development can be optimised within CEA facilities compared to conventional farming, as environmental factors, such as excessive rainfall, can be controlled and adjusted. At the same time, water use can be further reduced compared to water-efficient irrigation. For example, Simply Fresh, an operator of high-tech hydroponic farms in India, uses a closed-loop water recycling system in their climate-controlled greenhouses, allowing them to reduce freshwater use by up to 95% as compared to traditional farming.

While CEA provides several benefits in terms of yield improvements, protection from adverse weather, and water savings, there are also challenges. For example, the initial capital investments in setting up CEA facilities are significant, limiting their potential for several emerging markets. Another key challenge is the initial time and investment required for the implementation of such tools, especially on larger-scale farms.

CASE STUDY
PERFECTION FRESH

An example of controlled-environment agriculture (CEA) in practice is Perfection Fresh (PF), one of Australia's leading suppliers of fresh fruit and vegetables. PF sources produce through a combination of its own farms and a network of 400-500 third-party growers. Notably, 100% of PF's own farms operate under CEA, using a mix of high-tech glasshouses and medium-tech plastic tunnels. Its flagship Two Wells Glasshouse facility in South Australia, the largest glasshouse in the Southern Hemisphere, spans 43 hectares and combines advanced production systems with rainwater harvesting, on-farm storage, and precision irrigation to optimize water use.

The facility integrates multiple layers of technology to minimize water demand and maximize efficiency:

Rainwater harvesting and storage:
Roof-runoff channels capture rainfall into on-site tanks and ponds, enabling irrigation entirely from self-sourced water.

Hydroponics with targeted drippers:
Water and nutrients are delivered directly to root zones, eliminating conveyance losses and significantly reducing per-plant application.

Sensor technology:
Soil and substrate moisture sensors provide real-time data to guide optimal watering schedules, balancing grower expertise with digital decision support.

Water reuse technology:
Run-off from hydroponic systems is fully captured, treated via UV disinfection, and recycled for irrigation, reducing wastage and closing the loop.

Together, these measures create a highly water-efficient production system that has helped Two Wells and PF:

- Two Wells aims to use 100% harvested rainwater to meet its irrigation demand, to eliminate its dependence on costly and variable irrigation scheme water.
- ~30% of applied water across all PF's farms are reused through capture and treatment of run-off.
- Secondary benefits including healthier plants, reduced pesticide use and lower nutrient runoffs.

SOIL MANAGEMENT DEEP-DIVE SUB-SECTION

Effective soil management is a critical driver of water efficiency in agriculture. Approaches range from simpler conservation agriculture practices, such as reduced tillage and cover cropping, to more advanced solutions, such as biotechnology and soil microbiology.

Exhibit 26: Selected examples of soil management techniques

Approach	Description and techniques	Sophistication
Conservation agriculture	• Reduced or zero tillage to limit erosion and preserve soil structure • Cover cropping and mulching to retain soil moisture, suppress weeds, and build organic matter • Contour farming and terracing in hilly areas to slow runoff and prevent erosion	Low
Soil health and nutrient management	• Soil testing and nutrient mapping to guide precise application of nitrogen, phosphorus, and potassium, avoiding both underuse and harmful overuse • Composting, green manures, and biofertilizers to rebuild organic content and microbial activity • Agroforestry systems, which integrate trees into cropping systems to improve soil fertility and structure	Medium
Biotech and soil microbiology	• Bioengineered microbes that improve nutrient uptake (e.g., phosphorus solubilizing bacteria, nitrogen-fixing inoculants) • Nano-fertilizers that provide controlled-release of nutrients to the soil, thus reducing leaching and improving efficiency • Polymer-based soil conditioners such as hydrogels or superabsorbents that improve water-holding capacity in drought-prone areas	High

Source: SARE, USDA, Garg et al. (2023), Ali et al. (2024), Oliver Wyman analysis

Improving soil structure and organic matter enhances water-holding capacity, reducing irrigation needs and helping crops withstand periods of drought or irregular rainfall. At the same time, healthier soils make nutrients more available, supporting stronger root systems and greater crop resilience. This translates into higher and more stable yields, in effect, producing more food with every drop of water used.

There are several players in the soil management space, with increasing research and development into solutions to improve soil health through external additions, such as soil conditioners or nano-fertilisers.

One example is SOCO Polymer, a Chinese company specialising in sustainable superabsorbent polymers. SOCO's superabsorbent polymers can improve the water-holding capacity of soils by storing rainwater and irrigation water.[66] Other innovations include nano-fertilisers, such as the Indian Farmers Fertiliser Cooperative (IFFCO)'s nano urea product, which provides a sustainable fertiliser option for farmers. Due to the product's particle size, it increases the nutrient availability to crops, providing greater nutrient use efficiency, while also minimising the loss of nutrients from fields through leaching.[67]

ALTERNATIVE FOOD SOURCES DEEP DIVE SUB-SECTION

Our diets and preferences play a significant role in the agricultural crops cultivated. For example, in Asia, consumer preferences for rice have driven rice cultivation in the region. Some of these staple crops, such as rice and wheat, are water-intensive, requiring large volumes of water to produce compared to other alternatives. However, encouraging changes to consumer behaviours and diets can provide an opportunity for greater water savings in agriculture and irrigation.

Changes to our diets can come in the form of replacing staple crops with more water-efficient alternatives or replacing our meat consumption with alternatives such as plant-based meats or protein from other sources.

Potential water efficient alternatives include millets and sorghum. These crops require on average 60% to 70% less water to produce as compared to rice and wheat. Replacing staple crops can provide a key source of water savings, since rice accounts for about 30% of the world's freshwater withdrawals.

Countries in Asia are also increasingly pushing the cultivation of alternative crops as a way to support their future food security. India has introduced several initiatives to promote millets, including incorporating millets into their National Food Security Mission in 2018, and sending a proposal to the UN to declare 2023 the International Year of Millets, a proposal that was eventually approved.[68]

Exhibit 27: Water required to produce each kilogramme of selected food products, in litres[69, 70, 71]

Food product	Water required
Beef	~15,000
Pork	~6,000
Poultry	~4,500
Rice	~2,500
Wheat	~1,800
Lentils	~1,250
Pearl millets	~750

Sources: World Economic Forum, WaterAid, NIH National Library of Medicine

At the same time, water can be saved through replacing traditional protein sources of meats with high protein plant-based alternatives. For example, pulses, which contain 20% to 25% protein, can also be used to supplement protein in diets.[72] In comparison, meats such as beef, pork, and poultry contain 23% to 27% protein.[73] Pulses such as lentils and chickpeas also require about 70% to 90% less water per kilogramme to produce, supporting greater water savings potential.

In addition to changing existing diets, another effort would be to increase adoption of modified seeds which are more climate resistant, allowing crops to continue to grow in harsher conditions, and requiring less water compared to their conventional counterparts. Research and development in the space has been growing, with commercially available seeds, such as HB4 wheat from Bioceres, in the market today. This provides a growing opportunity that can support changing the diets of consumers while also providing water savings.

CHAPTER 4

THE NEED FOR MULTI-STAKEHOLDER ALIGNMENT TO DRIVE SYSTEMIC CHANGE

Addressing Asia's agri-food water challenge requires more than isolated fixes in irrigation, technology, or policy. It demands a holistic approach that brings governments, industries, and smallholders into alignment.

We propose a five-principle framework designed to cut across the value chain, shaping what we grow, how we govern, how we adapt, and where capital flows. This effectively recognises that water stress is not simply a technical problem, but a systemic one, driven by incentives, governance, and investment priorities as much as by infrastructure or tools.

THE FIVE PRINCIPLES

1. GETTING WATER ON THE AGENDA

Water should have an equal consideration in decision-making and not take a back seat.

Water plays a significant role in agriculture in Asia and is an important component in the agri-food value chain. However, despite the importance of water, water remains an under-prioritised sustainability issue for organisations, with many placing greater focus on decarbonisation and climate change. Without adequately considering the impacts of decisions on water, the water crisis will only continue to worsen, with food insecurity deepening.

Putting water at the centre of agricultural decisions can ensure decisions do not worsen the water crisis at the expense of achieving other goals, but instead collectively advancing each goal. For example, policy intervention was taken to support the recovery of aquifers in the North China Plain, a region that supports about 10% of China's grain production and has had its groundwater resources heavily exploited due to increasing demands of the population. The intervention, through water diversions from the humid Yangtze River basin and stringent groundwater pumping regulations, has resulted in groundwater levels rising by about 0.7 metres per year from 2020 to 2024.[74]

Giving water an equal consideration in decisions also encourages more organisations to think about water and place greater emphasis in water in their operations. A growing number of organisations are adopting water stewardship frameworks and certifications, such as the Alliance for Water Stewardship (AWS) Standard, with over 350 AWS certified sites in 2025, compared to the 140 sites in 2021. Such standards help organisations to engage with key stakeholders within the supply chain, supporting better water management.

By focusing on water in decisions, benefits such as water savings, water resource recovery, increased crop yields, and greater resilience to climate conditions can be reaped. This can act as the first step in tackling the agri-food-water challenge in Asia.

2. POLICIES AND INCENTIVES TO GUIDE WATER IN AGRI-FOOD

Agriculture's water problem should be tackled with what, where and how we grow it.

Water, not yield, should guide crop choices. Governments should encourage the cultivation if "the right crops in the right places" rather than water-hungry staples in arid zones, through using soil, rainfall, and hydrology data to steer production. For example, China has piloted crop zoning policies that shift maize and rice production to wetter regions, reducing groundwater pressure in the North China Plain.

At the same time, farmers over-irrigate not because they are careless, but because water is often free or underpriced. Correcting this means tackling the incentives head-on. Water pricing reforms can provide the economic nudge for farmers to adopt water saving technologies and practices, such as drip irrigation, or shift to less water-intensive crops. If water cost were a greater factor of consideration for farmers, they would look to means to reduce the use of these resources, through more precise application of water, or reducing the overall consumption of water within their operations.

More ambitious still are formal water markets, where rights can be bought and sold. In California, water rights can be traded through short-term or long-term leases, as well as through permanent sales. Traded water accounts for about 1.5 million acre-feet of water annually, accounting for about 4% of water used within the state.[75]

In Asia, within some areas in China, such as Ningxia, a water use rights trading scheme was launched in 2021, leading to a

10% INCREASE IN FARMLAND IRRIGATION EFFICIENCY.[76]

Rules also work through regulation. Enforcing efficiency and discharge benchmarks can push companies and cooperatives to modernise systems, much as emission standards have transformed the energy sector. Once the signals flip, wasteful practices quickly become irrational, and efficiency is rewarded.

At the consumer-end, demand is a potent lever. Eco-labels and certification schemes can shift purchasing towards water-efficient products, signalling to investors that sustainability sells. Similar forces are visible in coffee and cotton, where global buyers increasingly insist on water-responsible sourcing. As investors and non-governmental organisations (NGOs) add their pressure, agri-food companies pass requirements upstream, forcing farmers and processors to adopt more efficient practices. The ecosystem begins to rewire itself when policy, consumer demand, and investor scrutiny all converge on water.

3. LEVERAGE TECHNOLOGY TO BUILD ADAPTIVE, WATER-EFFICIENT SYSTEMS

Technology enables more effective use of water and provides insights for adaptive decision-making.

Technology is the key to unlocking water savings and providing more effective use of resources in agriculture. Technology enables more targeted application of water, while also reducing the overall need for the resource. Governments in Asia are understanding the water saving value of such technologies and are encouraging the adoption of water-efficient micro irrigation technologies.

Programmes such as India's Per Drop More Crop, which subsidises 45% to 55% of micro-irrigation costs, have already brought over eight million hectares under more resilient systems.[77] China also introduced their agricultural water conservation policy in 2012, which included the promotion of the adoption of water-saving irrigation technologies, ultimately leading to an 11% increase in water use efficiency by 2020.[78]

Hyperlocal weather forecasts, soil moisture sensors, and satellite imagery can provide the data for farmers and stakeholders to make adaptive investments, supporting their ability to maintain agricultural output.

Technology's impact on water also goes beyond the fields. For policymakers, leveraging hyperlocal intelligence and embedding these insights into subsidy design or compliance regimes ensures that decisions reflect real conditions, not averages. For investors and consumers, standardised disclosures and certification schemes amplify credible information into market signals.

4. EDUCATE TO GET BUY IN FOR WATER EFFICIENCY

Understanding benefits of technologies and practices encourages uptake by farmers.

Technology and data only matter if they change behaviour, and that requires education and trust as much as technology. Many smallholders still lack reliable knowledge and advice on water saving techniques, soil health, and crop suitability. Many of their practices are tied to tradition and existing practices that have been passed down through families. Without the relevant knowledge, farmers have been overapplying water and excessively damaging their fields, requiring more water for the same amount of crop.

However, without structured education through extension services, farmer cooperatives, and demonstration plots, subsidies are underused and technologies mistrusted. Governments can provide additional support to farmers on top of subsidies through these services, leveraging existing trust within these communities to spread awareness. In Andhra Pradesh, India, for example, farmer field schools have been used to demonstrate micro-irrigation techniques, creating peer-to-peer proof that efficiency safeguards rather than sacrifices yield.

5. INVESTMENTS TO DRIVE THE FUTURE OF WATER IN AGRICULTURE

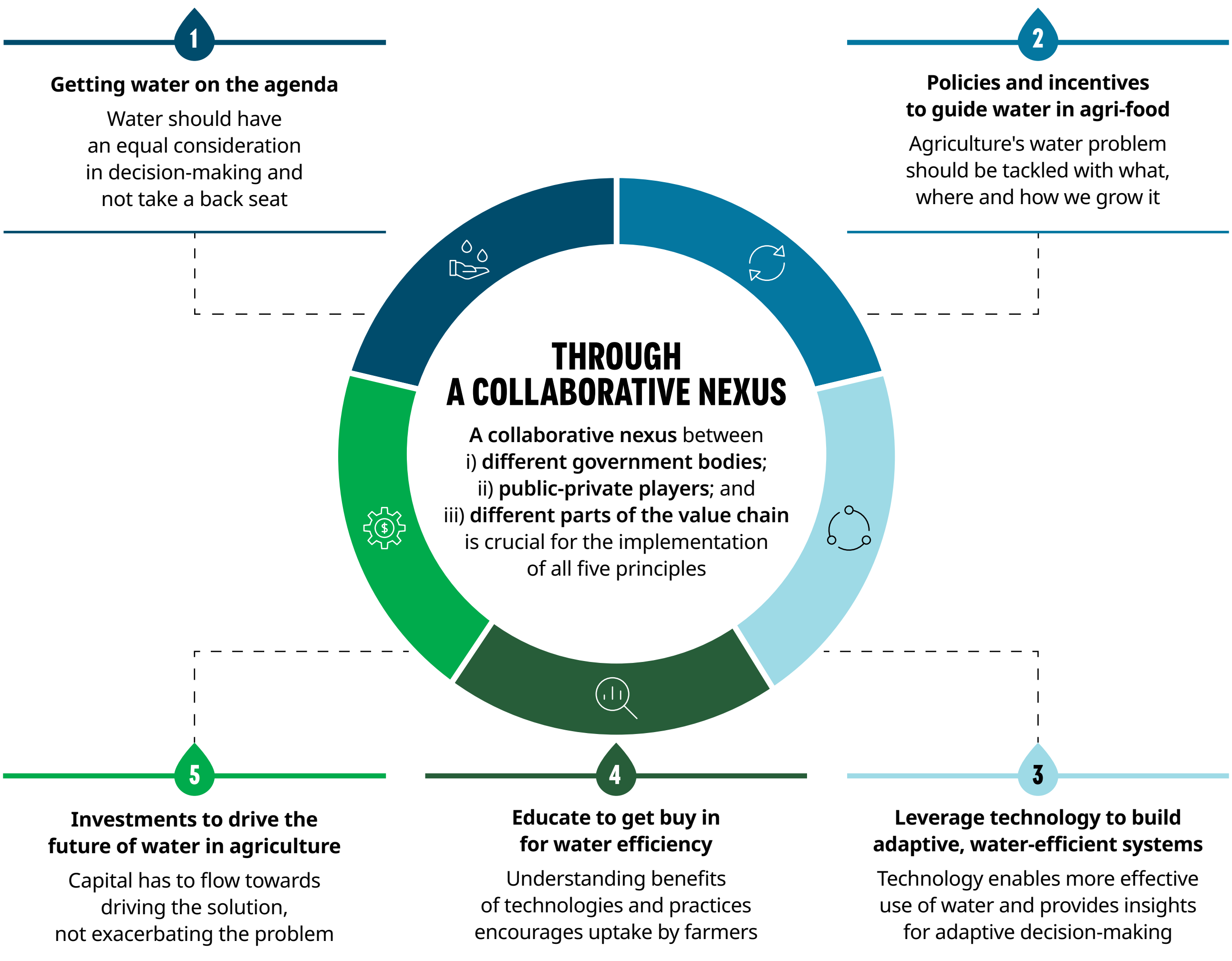
Capital has to flow towards driving the solution, not exacerbating the problem.

Agriculture runs on tight margins, which means efficiency investments are often shelved in favour of immediate survival. Tax credits and rebates can tilt the balance for farmers and processors considering investments in water-saving technologies. In Israel, long-standing tax breaks for wastewater reuse and drip irrigation equipment helped the country achieve one of the world's highest reuse rates of treated water in agriculture. In Australia, farmers can immediately deduct the cost of water-saving infrastructure, such as dams and irrigation channels, from taxable income, accelerating adoption by lowering upfront costs. However, capital must also be smarter, outcome-based financing ensures funds are released only when water savings are verified.

Public-private partnerships (PPPs) also offer another route for financing: governments provide de-risking while private players bring capital and execution. The Asian Development Bank's US$500 million results-based programme in Indonesia tied disbursements to tangible improvements in irrigation delivery across 2.9 million hectares, proving that finance can demand performance, not just construction.

Global finance is also catching up. Disclosure frameworks, such as CDP Water, TNFD, and Science-Based Targets for Water, allow investors to benchmark companies and channel capital to leaders. Multilateral development banks, by structuring PPPs and results-linked lending, can unlock scale. As scrutiny from NGOs and consumers rises, financiers will increasingly treat water waste as a liability, not a neutral factor. When capital rewards efficiency and penalises water wastage, the sector's future will begin to fund itself.

Exhibit 28: A systematic view of the Five-principle Framework



Source: Oliver Wyman analysis

ILLUSTRATIVE EXAMPLE OF RICE FARM

To visualise how this can be applied, we can apply it in the context of a typical two-hectare rice farm in Asia.

For meaningful change to occur, the local government has to put water at the forefront of decision making, ensuring that agricultural decisions are made with the consideration of water use and the impact on water resources. In this hypothetical case of a rice farmer in Asia, the local government enacts policy reforms on the water use in agriculture, with the goal of making water use more sustainable and providing opportunities for aquifers to recharge.

The government implements stringent groundwater pumping regulations, while also instituting pricing reforms for water. This encourages more efficient use of water in agriculture, while also limiting the total amount of water available for use. Due to the impact of the rising costs of water, the rice farmer has to look for alternatives to reduce water use in his fields.

This can be enabled by micro-irrigation, such as drip irrigation, which can provide more targeted water application, reducing the farmer's water use across his farm. The investment required for the adoption of micro-irrigation on a typical two-hectare farm would be approximately US$1,000 to US$2,000 for a low-cost system.

However, without prior exposure to the use of micro-irrigation technologies, the farmer is hesitant to utilise these tools, concerned that they may damage his crops and yields. Through community programmes to increase awareness and understanding of the impacts of these technologies. In several parts of Asia, farming communities work around farmer leaders who have influence over the practices of other farmers. By working with these farmer leaders, the rice farmer is able to better understand the benefits of these technologies.

However, even with greater trust in the effectiveness of irrigation systems, the farmer has to finance the implementation of this solution on his farm. The significant capital expenditure require is too much for the farmer to be able to afford. This is where financing and investments comes in. Through financing schemes and investment into smallholder farmers, farmers are able to receive the required funding to implement technologies on their farms, to supercharge the water savings and yield benefits they can receive.

With the capital expenditure of US$1,500 to implement micro-irrigation on the two-hectare rice farm, the farmer can see an estimated 30% reduction in operating expenses from the reduction in water and fertiliser use. At the same time, with increased yields, the farmer is able to generate about 15% to 20% more revenue.

Through this example, it highlights the importance of the water agenda starting from the top with governments and organisations putting water first to make the necessary changes to get the ball rolling. At the same time, it also requires efforts from all stakeholders for the adoption of water technologies on farms, from buy in from the farmer to investment from investors to provide the necessary capital.

EXAMPLES OF THE FIVE-PRINCIPLE FRAMEWORK IN ACTION IN ASIA

Today, we observe promising efforts and solutions emerging across Asia that are fully or partially embracing the five-principle framework. This indicates hope but more still needs to be done.

CASE STUDY
REWIRING THE MURRAY-DARLING BASIN IN AUSTRALIA[79, 80, 81, 82]

The Murray-Darling Basin problem highlights that systemic problems need systemic solutions. The early Murray-Darling response shows that no single solution — no matter how well-funded — can solve a systemic crisis in isolation.

The big picture: A coordinated national reset

By the late 2000s, Australia recognised that fragmented, single-issue responses were failing to stabilise the Murray-Darling Basin. In 2007, the federal government took decisive action through the Water Act, leading to the creation of the Murray-Darling Basin Authority (MDBA) and a series of ambitious reforms under the Basin Plan (2012).

The pivot was clear: Australia moved from local tinkering to a system-wide redesign, prioritising water sustainability and cross-state coordination. This was not just a policy response. It was a coordinated governance transformation, driven by a recognition that water needed to shape agriculture, and not the other way around.

At the heart of this pivot were two core principles: one, redesigning the agri-food system around water, and two, rewriting the rules of the game to align incentives, markets, and ecological limits.

These were backed by supporting pillars of adaptation systems, hyperlocal intelligence, and strategic finance, introduced through a web of nexus-driven actors, including national agencies, state governments, farmers, indigenous communities, and civil society groups

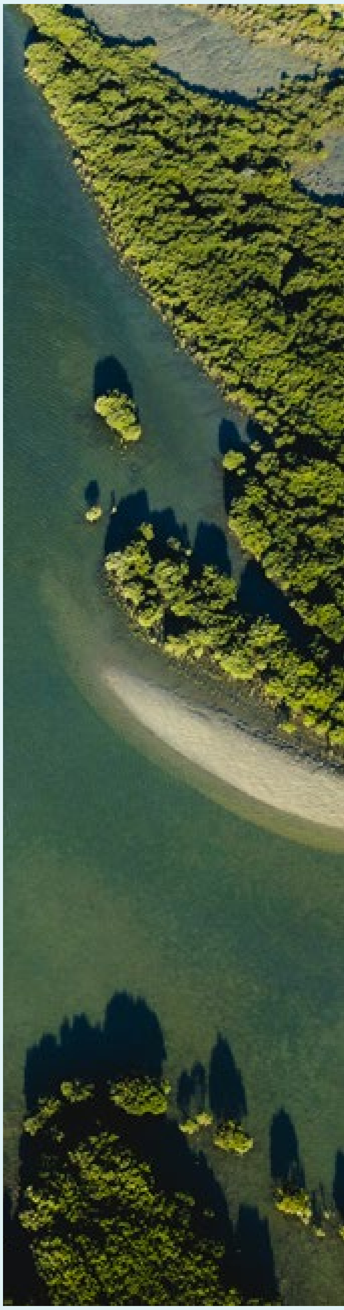


Exhibit 29: Rewiring the Murray-Darling basin

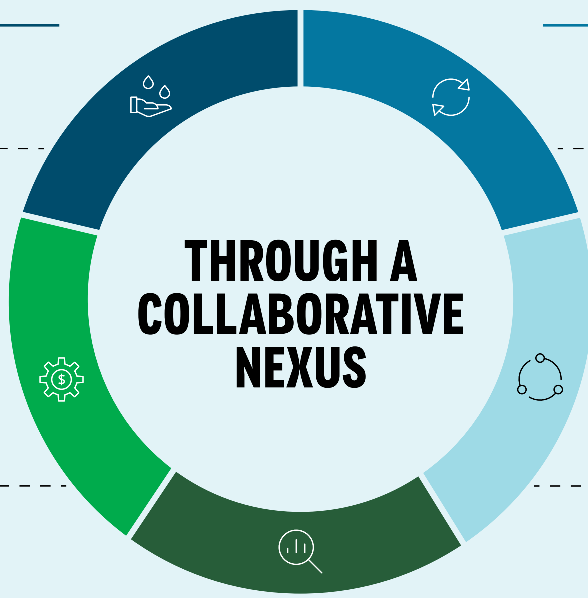
1 Getting water on the agenda

The government changed their approach to agri-food — putting water and water rights at the center of the conversation

2 Policies and incentives to guide water in agri-food

Water was redefined as a finite resource with environmental needs

National trading system incentivized farmers to profit by selling saved water



5 Investments to drive the future of water in agriculture

National water trading system introduced, unlocking private capital

Government allocated over AUD $13 billion for buybacks, infrastructure upgrades — with explicit water recovery targets

4 Educate to get buy in for water efficiency

Creation of programmes to educate and provide specialist advice on the effective use of irrigation

3 Leverage technology to build adaptive, water-efficient systems

Technology used to make the system adaptive via drought triggers, monitoring and seasonal planning

Source: Department of Climate Change, Energy, the Environment and Water (DCCEEW), Australia, Murray-Darling Basin Authority (MDBA), Oliver Wyman analysis

Exhibit 30: Aligning the response with the five principles

1. Getting water on the agenda

The Australian government established the Water Act in 2007 to manage water resources more sustainably in the Murray-Darling Basin. This led to the Basin Plan in 2012, which introduced sustainable diversion limits (SDLs) for every sub-catchment, capping the volume of water that could be extracted each year. The introduction of the SDLs also required equal consideration of environmental, social and economic outcomes in water planning. Water recovery targets ensured that a minimum share of water was reserved for the environment, maintaining ecological flows that set the boundaries for when and where irrigation could occur. While there is still more to be done, the Basin Plan has allowed more than 2,100 gigalitres of water per year to be recovered and put to use in supporting environmental outcomes.

Water was put as the main focus in the Basin, to ensure continued sustainability.

2. Policies and incentives to guide water in agri-food

Water was decoupled from land rights and established as a tradable commodity. This allowed more flexible redistribution and a more efficient allocation of a scarce resource. A national water market was set up, enabling entitlements and allocations to be bought and sold across both regions and years. Buyback programmes were launched, with the federal government purchasing entitlements from willing sellers to restore environmental flows. Incentives shifted: farmers who conserved water could sell their surplus and earn additional income, creating a profit motive for efficiency. Transparency tools and public registers improved market visibility, reducing information asymmetry.

Together, these reforms rewired the entire incentive structure to reward efficiency, adaptability, and ecological stewardship, rather than extraction for extraction's sake.

3. Leverage technology to build adaptive, water-efficient systems

Environmental Water Holder institutions were established to safeguard water for rivers and wetlands, releasing it based on seasonal conditions. Scenario planning models were embedded in MDBA tools, simulating outcomes under different rainfall and climate conditions. Communities were given early warnings on allocation changes, supporting cropping and investment decisions. Infrastructure upgrades went beyond improving efficiency to strengthen adaptability, with smarter controls, gates, and storage that operated according to water variability.

This utilized technology to ensure the system could bend, not break, when exposed to future droughts or climate shocks.

4. Educate to get buy in for water efficiency

Programmes, such as the Sustainable Irrigation Program, were put in place to support on farm water use. These programmes included the provision of specialist advice on more effective use of irrigation, allowing farmers to adopt improved irrigation infrastructure and decision making on farm plans.

This helped farmers better understand their irrigation needs and improve on water use practices.

5. Investments to drive the future of water in agriculture

The government committed billions in transitional assistance, not only for buybacks but also for modernising irrigation, training, and re-skilling. PPPs helped scale smart irrigation systems and drought-resilient crop varieties. New financial instruments were developed to help farmers hedge water risk, including water banking, insurance pilots, and forward contracts. Funding also supported ecosystem restoration, generating jobs and diversifying rural economies in regions where irrigated farming contracted.

Capital was not just used to fix problems, it was used to build the future economy of water-smart agriculture.

Sources: Department of Climate Change, Energy, the Environment and Water (DCCEEW), Australia, Murray-Darling Basin Authority (MDBA), Oliver Wyman analysis

The collaborative nexus that made it possible

This transformation was not the work of one agency or moment. It was enabled by the following:

National leadership:
The federal government legislated a basin-wide approach that set the foundation for reform

Institutional coordination:
The MDBA was created to oversee implementation across states and monitor compliance

Farmer participation:
Buy-in was secured through well-compensated, voluntary transitions that gave irrigators agency in the shift

Scientific consensus:
Evidence and modelling provided by CSIRO, universities, and hydrology experts underpinned decisions with credibility

Legal backing:
High Court recognition of federal primacy over water strengthened the legitimacy of national reforms

Public pressure:
Civil society and media amplified the crisis, from fish kills to wetland decline, creating urgency that governments could not ignore

CASE STUDY
INCREASING PRODUCTION OF PULSES IN MAHARASHTRA, INDIA[83, 84, 85]

The problem: Historical dependence on water-intensive crops

In Maharashtra, sugarcane occupies less than 4% of the cropped area but consumes approximately 70% of the state's irrigation water. The average water requirement for sugarcane in the state ranges from about 2,000 millimetres for pre-seasonal crops to about 2,400 millimetres for adsali crops, which have an 18-month or longer cultivation period. This over-reliance on water-intensive crops has strained water resources, leading to declining groundwater levels and increased vulnerability to droughts. The situation has been particularly dire in regions like Marathwada and Vidarbha, where externalities like recurrent droughts have compounded the challenges faced by farmers.

The consequences: Water stress and socioeconomic impacts

Maharashtra's dependence on water-intensive crops has driven severe groundwater depletion.

By 2024, over half of the state's talukas, or subdistricts, were classified as

"OVER-EXPLOITED" OR "CRITICAL" IN TERMS OF GROUNDWATER USE

by the Central Ground Water Board.

In Marathwada, average groundwater levels fell more than three metres over the past decade, leaving wells in districts like Beed and Jalna dry by mid-Rabi season, the middle of the spring harvesting season. Excessive pumping and poor drainage have also degraded the resource base, with soil salinity now affecting more than 0.6 million hectares of farmland, steadily eroding productivity and locking farmers into a cycle of higher input use and declining returns.

The human toll has been just as stark. Rising irrigation costs, crop failures from erratic monsoons, and mounting debts have intensified farmer distress. In 2023, Maharashtra recorded 2,851 farmer suicides, nearly 70% in Vidarbha and Marathwada alone. Beyond agriculture, water scarcity has strained rural drinking water schemes, increased reliance on tankers during summer, and fuelled tensions over allocation between agricultural, urban, and industrial users.

Initial siloed responses: Ineffective incentive mechanisms

Initial government responses included subsidies for irrigation infrastructure and minimum support prices for water-intensive crops. However, these measures often encouraged continued cultivation of such crops, perpetuating water scarcity issues. Lack of integrated water management policies and coordination among stakeholders limited the effectiveness of these interventions.

Moreover, the absence of comprehensive support systems for alternative crops such as pulses meant that farmers had little incentive to diversify their cropping patterns. This highlighted the need for a more holistic and integrated approach to agricultural reform.

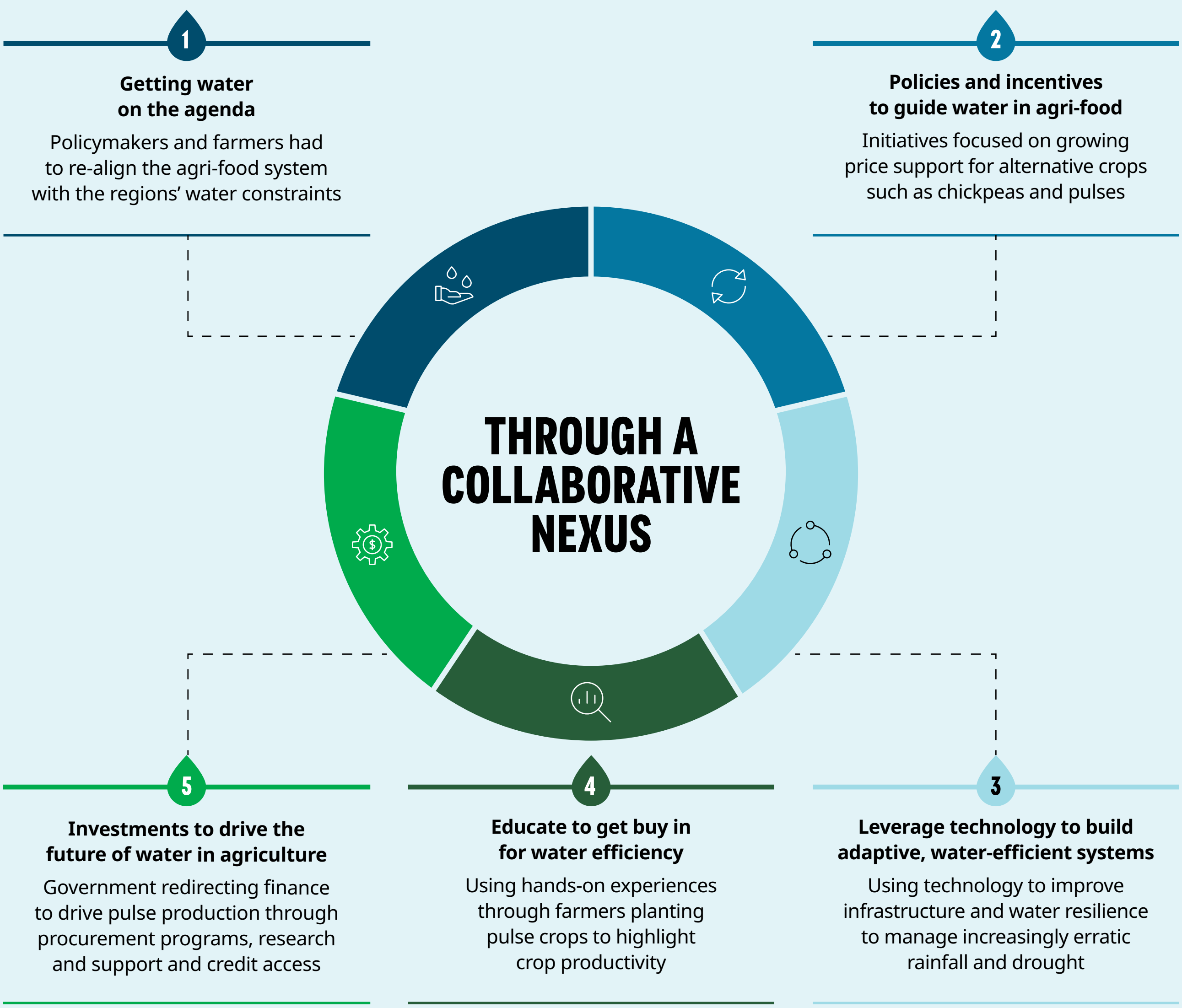
Spotlight on pulses: A water-efficient alternative

Pulses, such as chickpeas, lentils, and pigeon peas, have emerged as a sustainable alternative due to their low water requirements and soil-enriching properties. GPC President, Vijay Iyenger, highlighted that, "For India, pulses are a sensitive food of national importance"

Pulses require significantly less water compared to crops such as sugarcane and cotton. For instance, pulses need about 20 times less water than sugarcane. Specifically, the water requirement for blackgram is approximately 280 millimetres, and for soybean, it is around 320 millimetres, compared to 2,200 millimetres for sugarcane and 600 millimetres for cotton.

The adoption of pulses has not only contributed to water conservation but also improved soil health and provided farmers with a more resilient and sustainable cropping option. As pulses are legumes, they help to fix atmospheric nitrogen, enhancing soil fertility and reducing the need for chemical fertilisers. Pulses are well-suited to semi-arid conditions and can withstand periods of drought, making them ideal for regions facing water scarcity.

Exhibit 31: Increasing production of pulses in Maharashtra, India



Source: The Times of India, Oliver Wyman analysis

Exhibit 32: Aligning the response with the five principles

1. Getting water on the agenda

The Maharashtra government saw the importance of prioritising water over crop yields, taking a step to transition from water-hungry staples to water-smart pulses. The transition towards pulses represents a fundamental redesign of the cropping system around water realities of Maharashtra. Pulses require five to 10 times less water than traditional cash crops, while also enriching soil fertility through nitrogen fixation. By promoting pulses through access to quality seeds and technical support in semi-arid zones like Marathwada, where growing sugarcane had long distorted water use, policymakers and farmers are re-aligning the agri-food system with the region's water constraints.

By putting water first, the first step to reduce water exploitation is taken through a structural reset shifting cropping patterns.

2. Policies and incentives to guide water in agri-food

Minimum support prices (MSPs), input subsidies, and weak enforcement of groundwater regulation historically locked farmers into crops like sugarcane. Recent initiatives to expand pulses have begun to shift these rules. The initiatives include price support for chickpeas and pigeon peas, procurement programmes, and targeted extension services. These interventions signal to farmers that cultivating pulses is not only agronomically sustainable but also economically viable.

Incentives were re-tuned to make efficiency and resilience profitable.

3. Leverage technology to build adaptive, water-efficient systems

Beyond encouraging the growth of pulses, Maharashtra has adopted measures to help farmers cope with increasingly erratic rainfall and drought. For example, the state rolled out the Jalyukt Shivar Abhiyan in 2016 and Jalyukt Shivar Abhiyan 2.0 in 2022 to promote water resilience across villages through desilting water bodies, deepening of drainage lines, construction of check dams, and promoting rainwater harvesting. Jalyukt Shivar 3.0 further aims to repair water conservation structures and leverage the Geographic Information System (GIS) to map water structures at 44,000 villages.

Technology supports community efforts to improve infrastructure for water efficiency.

4. Educate to get buy in for water efficiency

The government launched their Seed Minikit Programme, which distributes high yielding variety seeds of pulse crops to farmers free of cost, to allow farmers to see the productivity and effectiveness of these seeds firsthand. Together with the minikits were pamphlets on guidelines to maximise productivity of the seeds.

Hands-on experiences to educate can provide greater confidence in new practices.

5. Investments to drive the future of water in agriculture

Capital has historically flowed into irrigation subsidies and crop support that entrench water-intensive production. Redirecting finance towards water-smart crops like pulses is critical. In Maharashtra, early efforts to finance pulse production through procurement programmes, research support, and credit access for smallholders have begun to shift investment patterns.

Finance is slowly being rewired, channelling capital from water-intensive subsidies to water-smart crops.

Source: The Times of India, Oliver Wyman analysis

In Ahmednagar's Hiware Bazar, villagers led by Popatrao Baguji Pawar overhauled their agricultural practices around water conservation. Once facing systemic drought and migration, the community built check dams, percolation tanks, and bunds, and embraced drip irrigation methods.

They intentionally shifted away from crops that demand large quantities of water, such as sugarcane and bananas, towards more drought-tolerant crops. With improved water availability from harvesting rain and capturing runoff, farmers report steadier yields, reduced input costs for water, and the return of families who had left. Their success has inspired neighbouring villages to replicate similar water-conserving crop shifts and infrastructure investments.

Case study conclusion

Maharashtra's farmers continue to face significant pressures from a legacy of water-intensive cropping, entrenched subsidies, and limited institutional safety nets. These vulnerabilities have been magnified by recurrent droughts and extreme weather events, leaving many communities exposed to both ecological and financial risks. The persistence of farmer suicides is a stark reminder of the social cost of water stress and inadequate resilience mechanisms.

At the same time, the gradual shift towards pulse cultivation offers a pathway to more sustainable agriculture. Pulses require far less water than traditional cash crops, while improving soil fertility and providing a measure of drought resilience. Scaling up their production and consumption will require a systemic approach that aligns incentives, strengthens market support, and improves efficiency in crop allocation. Done well, this transition could not only conserve scarce water resources but also enhance livelihoods and build greater long-term resilience for farmers across the state.

CONCLUSION AND KEY TAKEAWAYS

Asia stands at the frontline of the global water crisis. Agriculture, which consumes more than 80% of the region's freshwater, is both the largest driver of water stress and the sector most vulnerable to its impacts. Declining groundwater, soil salinisation, and increasingly erratic rainfall are already undermining yields and threatening farmer livelihoods. The solutions to address these pressures exist today. Proven technologies and initiatives, such as water-efficient irrigation, precision agriculture, soil management, improved water distribution infrastructure, and alternative food sources, could collectively reduce water demand by nearly 10% in Asia while boosting resilience across food systems. However, time is of the essence. Without rapid scale-up, water scarcity risks becoming an irreversible constraint on growth, food security, and stability.

Encouragingly, early action is already underway. Governments across the region are beginning to experiment with reforms, from water pricing in Australia to tighter groundwater extraction limits in Indonesia. Global and regional financiers are opening new channels for blended finance and PPPs that can de-risk investment in capital-intensive water technologies. Farmers are also responding, whether through millet adoption in India, precision farming pilots in China, or conservation practices in Southeast Asia. These have often been supported by targeted subsidies, technical extension, or corporate supply-chain programmes. These initiatives show that transformation is possible, but they remain fragmented and uneven, with adoption still far below the scale required.

The opportunity now lies in connecting these pieces into a coherent, system-wide push across all actors in the value chain. Governments must create enabling environments that reward efficiency and penalise waste, aligning incentives across food, water, and energy. Investors and development banks can channel capital into water-smart technologies, supported by standardised metrics and disclosure frameworks that make water risks visible and investable, to bring much needed capital to farmers. Companies across the agri-food value chain can embed water efficiency into sourcing, processing, and consumer-facing commitments, creating demand signals that ripple back to farmers. Finally, across society, consumers and the media can sustain pressure for reform by elevating the urgency of water resilience as a cornerstone of Asia's development.

The competition for water will only intensify. Industries such as data centres and semiconductor manufacturers are already major consumers of water, and their demands are set to rise. The International Energy Agency estimates data centres consume about 560 billion litres annually, a figure projected to more than double to 1,200 billion litres by 2030. Reducing agricultural water use is therefore not just about easing water stress, it is also essential for food security, by reducing the share of water for which agriculture must fight against fast-growing industrial demand.

Addressing the nexus of water, agri-food, and environmental sustainability in Asia is no longer just an agricultural challenge, it is a necessity for the well-being of millions who depend on these resources for their very existence. The time for action is now.

REFERENCES

1. World Economic Forum, *Global freshwater demand will exceed supply 40% by 2030, experts warn*, retrieved on 9 October 2025.
2. Huili He, Rafiq Hamdi, Geping Luo, Peng Cai, Miao Zhang, Haiyang Shi, Chaofan Li, Piet Termonia, Philippe De Maeyer, Alishir Kurban, *Numerical study on the climatic effect of the Aral Sea*, Atmospheric Research, Volume 268, 2022, 105977, ISSN 0169-8095, retrieved on 9 October 2025.
3. SCMP, *Yangtze River, lakes at record low levels as heatwaves, drought hit southern China*, retrieved on 9 October 2025.
4. Ao Duan, Yulong Zhong, Guodong Xu, Kaijun Yang, Baoming Tian, Yunlong Wu, Hongbing Bai, E. Hu, *Quantifying the 2022 extreme drought in the Yangtze River Basin using GRACE-FO*, Journal of Hydrology, Volume 630, 2024, 130680, ISSN 0022-1694, retrieved on 9 October 2025.
5. SCMP, *China's Poyang Lake marks earliest dry season on record, sparking drought concerns*, retrieved on 9 October 2025.
6. Carnegie Politika, *Aral Sea Syndrome: Why Is the Caspian Sea Shrinking?* retrieved on 9 October 2025.
7. The Telegraph online, *Himalayan foothills 'drying up', study shows steady vanish of vibrant lifelines*, retrieved on 9 October 2025.
8. World Resources Institute, *Without Forests, Jakarta's Water Situation Worsens*, retrieved on 9 October 2025.
9. Eco-Business, *Jakarta is a thirsty metropolis without drinkable water*, retrieved on 9 October 2025.
10. NPR, Indonesia Plans To Move Its Capital Out Of Jakarta, A City That's Sinking, retrieved on 9 October 2025.
11. LEAP, *Presidential Regulation No. 37 of 2023 establishes the National Water Resources Policy until 2030.*, retrieved on 9 October 2025.
12. Nature, *Global impacts of heat and water stress on food production and severe food insecurity*, retrieved on 9 October 2025.
13. Springer Nature Link, *Estimating the potential effects of climate change on rice production in Thailand*, retrieved on 9 October 2025.
14. MDPI, *Effect of Drought on Agronomic Traits of Rice and Wheat: A Meta-Analysis*, retrieved on 9 October 2025.
15. Nature, *Closing water productivity gaps to achieve food and water security for a global maize supply*, retrieved on 9 October 2025.
16. Naresh Kumar, Soora & Aggarwal, P.K. & Rani, DN & Saxena, R & Chauhan, Nitin & Jain, S. (2014). Vulnerability of wheat production to climate change in India. Climate Research. 59. 173-187. 10.3354/cr01212.
17. Pequeno, D. N. L., Hernández-Ochoa, I. M., Reynolds, M., Sonder, K., MoleroMilan, A., Robertson, R. D., Lopes, M. S., Xiong, W., Kropff, M., & Asseng, S. (2021). Climate impact and adaptation to heat and drought stress of regional and global wheat production. *Environmental Research Letters*, 16(5), 054070.
18. MDPI, *Factors Affecting Crop Prices in the Context of Climate Change — A Review*, retrieved on 9 October 2025.
19. Reuters, *Flood-hit India, Pakistan face rising basmati prices amid crop losses*, retrieved on 9 October 2025.
20. UN.ESCAP. (2023) *Seizing the moment: targeting transformative disaster risk resilience.* Retrieved from: https://hdl.handle.net/20.500.12870/6258.
21. FAO. 2023. *The Impact of Disasters on Agriculture and Food Security 2023 — Avoiding and reducing losses through investment in resilience.*
22. ADB, *Ensuring Food Security for Asia and the Pacific*, retrieved on 9 October 2025.
23. UNESCO, *2024 UN World Water Development Report: Water for Prosperity and Peace*, retrieved on 9 October 2025.
24. Kazem Javan, Ali Altaee, Saeed BaniHashemi, Mariam Darestani, John Zhou, Gloria Pignatta, *A review of interconnected challenges in the water–energy–food nexus: Urban pollution perspective towards sustainable development*, Science of The Total Environment, Volume 912, 2024, 169319, ISSN 0048-9697.
25. Bikramaditya Ghosh, Mariya Gubareva, Anandita Ghosh, Dimitrios Paparas, Xuan Vinh Vo, Food, energy, and water nexus: *A study on interconnectedness and trade-offs*, Energy Economics, Volume 133, 2024, 107521, ISSN 0140-9883.
26. ScienceDirect, *Agricultural policies for mitigating groundwater depletion in central Punjab*, retrieved on 9 October 2025.
27. UN News, *First Person: Farmers running out of water in Punjab, India*, retrieved on 9 October 2025.
28. ResearchGate, *Water Resource Scenario in Punjab: Challenges and Technological Interventions for Sustainable use in Agriculture*, retrieved on 9 October 2025.
29. CGIAR, *Mobilizing and supporting a community of practice for scaling sustainable water use in rice production in Ghana*, retrieved on 9 October 2025.
30. FAO, *A Manual for the Design and Construction of Water Harvesting Schemes for Plant Production, 2. Water and soil requirements*, retrieved on 9 October 2025.
31. Nature, *The role of farm subsidies in changing India's water footprint*, retrieved on 9 October 2025.
32. ScienceDirect, *Spatio-temporal assessment of groundwater depletion in Punjab, India*, retrieved on 9 October 2025.
33. Nature, *Solving groundwater depletion in India while achieving food security*, retrieved on 9 October 2025.
34. J-PAL, *Pricing Schemes and Irrigation Techniques for Water Conservation and Farm Profits in Bangladesh*, retrieved on 9 October 2025.
35. MDBA, *The Basin*, retrieved on 9 October 2025.
36. The Guardian, *Murray-Darling: when the river runs dry*, retrieved on 9 October 2025.
37. Circle of Blue, *Australia's Food Bowl, Like The World's, Is Drying Up*, retrieved on 9 October 2025.
38. Dealroom.co, *The $58T water ecosystem & Water tech innovation*, retrieved on 9 October 2025.
39. Reuters, *EIB commits 15 billion euros to protect EU's water resources*, retrieved on 9 October 2025.

40. AIIB, *Water Sector Strategy*, retrieved on 9 October 2025.
41. Dealroom.co, *The State of Global VC*, retrieved on 9 October 2025.
42. S&P Global, *Private Equity*, retrieved on 9 October 2025.
43. Microsoft, *Water replenishment*, retrieved on 9 October 2025.
44. EU Blue Economy Observatory, *Desalination*, retrieved on 9 October 2025.
45. World Bank Group, *Water Security Financing Report 2024*, retrieved on 9 October 2025.
46. WWF, *High Cost of Cheap Water: The True Value of Water and Freshwater Ecosystems to People and Planet*, retrieved on 9 October 2025.
47. World Bank Group, *Connecting Bagalkote Farmers to Water Supply and Market Opportunities for Growth*, retrieved on 9 October 2025.
48. NASA Earth Observatory, *A Greenhouse Boom in China*, retrieved on 9 October 2025.
49. Xinhua Net, *Smart farming heralds new era of modern agriculture in northeast China*, retrieved on 9 October 2025.
50. USDA, *Percent of no-till plus reduced till acres planted to major U.S. commodities have increased*, 1998-2023, retrieved on 9 October 2025.
51. ITPO-Tokyo, *Water-Saving Porous Alpha Technology Increases Crops*, retrieved on 9 October 2025.
52. FAO, *OCOP Webinar Explores the Development of Millets in India*, retrieved on 9 October 2025.
53. Bioceres Crop Solutions, *Bioceres Crop Solutions Receives Green Light for Cultivation of Drought Tolerant HB4 Wheat in the United States*, retrieved on 9 October 2025.
54. World Bank Group, *Uzbekistan to Modernize Its Irrigation Infrastructure with World Bank Support*, retrieved on 9 October 2025.
55. Xylem, *Xylem Vue: A single platform for end-to-end management of agricultural irrigation infrastructure and networks*, retrieved on 9 October 2025.
56. Taylor & Francis Online, *A meta-analysis of global crop water productivity of three leading world crops (wheat, corn, and rice) in the irrigated areas over three decades*, retrieved on 9 October 2025.
57. *Drip & sprinkler to boost groundwater recharge in state*. (2025, June 12). The Times of India; Times of India.
58. Zhang, L., Bai, G., Evett, S.R. et al. *Increased irrigation could mitigate future warming-induced maize yield losses in the Ogallala Aquifer.* *Commun Earth Environ* 6, 483 (2025).
59. Zhang, Q., Yu, H., Li, J. et al. *Divergent effectiveness of irrigation in enhancing food security in droughts under future climates with various emission scenarios.* *npj Clim Atmos Sci* 6, 40 (2023).
60. *World Bank steps up efforts to address methane emissions*. (2023, December 4). World Bank.
61. World Bank Group, *Climate-Resiliant Irrigation*, retrieved on 9 October 2025.
62. IRRI, *Mekong River Delta's Low-Emission Rice Program Shows Promising Early Results, Expansion Planned*, retrieved on 9 October 2025.
63. Dayu Irrigation, *Henan high-standard farmland water-fertilizer integration project*, retrieved on 9 October 2025.
64. Kubota, *Unmanned Automated Agricultural Machinery*, retrieved on 9 October 2025.
65. XAG, *The Next-Level Efficiency: XAG P150 Agricultural Drone*, retrieved on 9 October 2025.
66. SOCO, *Powder Water Crystals for Plants in Crops Plant*, retrieved on 9 October 2025.
67. IFFCO, *Nano Urea (Liquid)*, retrieved on 9 October 2025.
68. NITI Aayog, *Promoting Millets in Diets*, retrieved on 9 October 2025.
69. World Economic Forum, *Which foods need the most water to produce?*, retrieved on 9 October 2025.
70. WaterAid, Beneath the Surface: *The State of the World's Water 2019*, retrieved on 9 October 2025.
71. NIH National Library of Medicine, Millets: the future crops for the tropics — Status, challenges and future prospects, retrieved on 9 October 2025.
72. ScienceDirect, Water productivity of major pulses — A review, retrieved on 9 October 2025.
73. NIH National Library of Medicine, *Perspective: The Place of Pork Meat in Sustainable Healthy Diets*, retrieved on 9 October 2025.
74. Long, D., Xu, Y., Cui, Y. et al. *Unprecedented large-scale aquifer recovery through human intervention*. Nat Commun 16, 7296 (2025).
75. PPIC, *California's Water Market*, retrieved on 9 October 2025.
76. MDPI, *Water Rights Trading and Agricultural Water Use Efficiency: Evidence from China*, retrieved on 9 October 2025.
77. PIB, Government of India, *Micro Irrigation*, retrieved on 9 October 2025.
78. ScienceDirect, *Role of China's agricultural water policy reforms and production technology heterogeneity on agriculture water usage efficiency and total factor productivity change*, retrieved on 9 October 2025.
79. DCCEEW, Australian Government, *Murray-Darling Basin Plan*, retrieved on 9 October 2025.
80. MDBA, *Water limits*, retrieved on 9 October 2025.
81. MDBA, *Water trade*, retrieved on 9 October 2025.
82. MDBA, *Deciding where water goes*, retrieved on 9 October 2025.
83. The Times of India, *Excess sugarcane water to be diverted for jowar, tur*, retrieved on 9 October 2025.
84. The Times of India, *Maharashtra: Water-guzzling sugarcane cultivated on largest area*, retrieved on 9 October 2025.
85. The Times of India, *Jalyukta Shivar scheme to cover 24,000 villages in state*, retrieved on 9 October 2025.

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