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Feed the Future: Driving Africa's Next Agricultural Revolution With Climate-Resilient Innovation

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Executive Summary

The 20th century saw the development of groundbreaking agricultural innovations that helped feed much of the world's growing population. Fertilisers and pesticides, modern irrigation systems and genetically improved seeds led to major yield gains. Between 1900 and 2000, crop harvests grew six-fold while the global population increased less than four-fold.

These advances helped avert a global food crisis but their benefits were unevenly distributed. Many parts of Africa did not experience the productivity gains that transformed other regions.

Today the pressure on agriculture is intensifying and the impact is particularly acute in Africa. Across the continent, climate change is already undermining food systems: Kenya suffered its worst drought in four decades in 2023; the following year, southern Africa faced its most extreme drought in at least a century, slashing maize harvests by half in Zambia and Zimbabwe. At current warming rates, Africa's crop yields could fall by 18 per cent by 2050, with the continent's population projected to more than double by 2070.

While the scale and pace of climate-change repercussions differ across regions, the deeply interconnected nature of the global food system means that no country is shielded from their effects. Disruption in one region or country can ripple rapidly through supply chains elsewhere, driving up prices and worsening food insecurity. And there are far-reaching knock-on effects, including rising conflict and forced migration.

It is therefore in the interests of all countries, in all circumstances, to find and scale solutions that will increase the resilience of food production domestically, as well as around the world.

Science and innovation have staved off many of the food crises of the past 100 years, but many agricultural technologies that defined the 20th century didn't reach Africa's least-developed countries. They have also come at an

enormous cost: one-third of the Earth's soil is degraded because of industrial agricultural practices, while industrial farming remains the main cause of biodiversity loss, driving down agricultural yields. These impacts are now stifling the productivity gains that were made possible by these technologies in the first place, reducing agriculture's resilience to the effects of a changing climate.

For African leaders this is an opportunity to drive innovation, build resilience to climate impact and shape a more secure and sustainable future. Today's technology revolution offers the tools to do so: satellite data, gene-edited crops and precision agricultural tools, for example, all enhanced by artificial intelligence. These kinds of options enable governments to future-proof food systems without repeating the unintended consequences of the 20th-century agricultural model.

To turn this potential into impact, governments will need to create the right conditions to deploy and scale these tools in country-specific contexts – not only to strengthen national food security, but to contribute to global resilience.

Food-producing countries in Africa can:

- **Innovate government, so it is better equipped to plan and respond to climate impacts on agriculture.** An increasingly complex food landscape warrants a more sophisticated government response. Governments should optimise their approach to collecting and analysing data through satellites and remote sensing, as well as implement technologies such as digital ID and AI-enabled extension services to improve how they engage with other actors across the food system, such as farmers and the private sector. Such digital infrastructure is no longer optional: AI breakthroughs provide an array of new capabilities, dramatically improving the ability of governments to understand, predict and respond to climate impact on food systems.
- **Help deploy the tools and technologies that can help address the urgent food crises that many countries are facing now.** Multiple innovations already exist that can improve agricultural productivity in the face of climate change, but often the right technologies aren't reaching

the places that need them most. Different countries and contexts will require hyper-local solutions, with the deployment of new technology requiring innovative funding mechanisms and a more sophisticated approach to delivering information to farmers and food producers.

Food-importing countries around the world should:

- **Invest in innovation to find and scale the technologies that can help the world adapt to climate impact into the future.** In the context of increasing populations and competing demands on land use, today's technological solutions are unlikely to be sufficient to provide food security into the future. Governments globally need to increase public agricultural R&D, which has slowed over the past decade, as well as adapt regulatory frameworks so that they can be more responsive to new innovations. The countries that grasp this opportunity will also be able to capture economic benefits as global demand and markets for new solutions grow.

The impact of climate change means that food-system transformation is inevitable. If governments take bold but practical steps now, they can steer this transformation to create a more diverse food system that works for both people and the planet.

Put simply, the countries that invest in new solutions today will reap the economic rewards tomorrow.

01

Climate, Agricultural Productivity and Food Insecurity in Africa

Norman Borlaug – a botanist who grew up on a small farm in Iowa during the Great Depression – spearheaded a scientific revolution in agriculture during the 1940s, 50s and 60s. He developed new varieties of wheat, and his methods became a model for crops in other countries around the world. On a global scale, his work meant that the amount of food produced massively outstripped the agricultural land being farmed, at a time when population growth threatened to result in widespread food insecurity. It is estimated that Borlaug saved more than 1 billion lives through his work. He went on to win the 1970 Nobel Peace Prize – rather than a science or agriculture award – due to his role in preventing widespread famine.

However, these productivity gains didn't make it to some of the world's least developed countries. While in higher-income countries cereal yields almost tripled between 1961 and 2018, low-income countries saw a much smaller increase of 50 per cent.[1] Most of Africa's crop-production growth (74 per cent) has come from increasing land for agricultural production, while only 26 per cent has come from improvements in crop yield. This is because the new crop varieties developed by Borlaug required inputs of fertilisers and pesticides that were not available in sufficient quantities. Today, agricultural productivity in sub-Saharan Africa remains lower than the rest of the world.

Food security on the continent is now declining due to a complex set of factors, affecting both food production and access. High input costs, conflict and political instability, together with soil degradation and extreme weather, are threatening agricultural production, while supply-chain vulnerabilities, poverty and poor policy choices further decrease the ability of families and individuals to afford food.

Amid a backdrop of already-fragile food security and a rapidly growing population, Africa's agriculture is now grappling with the effects of climate change.

Agriculture is one of the most vulnerable sectors to the impact of climate change. Extreme weather affects the entire agricultural supply chain: more extreme and frequent droughts can cause soil fertility to decrease, crops to fail, and harvesting and planting times to be disrupted. It is – and will continue to be – the most critical factor affecting the security of global food production.

The whole world will be affected by the impact of climate change on agriculture – one study[2] suggests that even in the most optimistic scenario, assuming average temperature increase remains below 2 degrees Celsius above pre-industrial levels, global maize yields will decline by about 6 per cent. But in Africa, where crop yields are already the lowest in the world, climate impacts are having a disproportionate effect.[3]

There are a few reasons for this. One is simply that the primary impacts of climate change are expected to be more severe across Africa than in many other parts of the world. For example, warming in South Sudan is happening at two-and-a-half times the global average.[4] Africa also relies heavily on rain-fed agriculture, which is becoming less reliable as rainfall becomes more erratic. Finally, many countries on the continent have limited capacity to adapt because of their limited economic resources and existing, outdated infrastructure.

These impacts have a direct effect on production. It is estimated that climate change has already reduced agricultural productivity growth by as much as 34 per cent in Africa since 1961.[5] If temperatures continue to rise at the current rate, without action crop production in Africa could decrease by 18 per cent by 2050,[6] while the continent's population is set to grow by 63 per cent between 2024 and 2050.[7]

FIGURE 1

Climate change has multiple impacts across the agricultural value chain

Primary climate impacts | Secondary climate impacts across stages of the value chain

	Inputs (e.g. land, water, seeds, fertiliser, pest control)	Production and harvest	Post-production
Higher temperatures	Inputs that worked previously are no longer effective, e.g. seeds and fertilisers Higher temperatures can lead to reduced soil fertility	Can lead directly to failed crops and livestock death through heat stress Some crops grown previously are no longer viable Heat stress can reduce the fertility of livestock	Can lead to crop spoilage if there isn't adequate cold storage
More extreme weather events (e.g. droughts, floods, and storms)	Land previously suitable for production is no longer cultivatable due to droughts or flooding	Can lead directly to failed crops and livestock death Can drive disease, killing plants and animals	Can damage storage facilities Can wipe out travel routes, leading to food loss
Shifting precipitation patterns	Rainwater to irrigate crops is lacking or unpredictable	Can change when crops can be harvested and lead to changing growing systems Can lead to water stress, reducing yields and growth Lack of rain can dry out soil, leading to loss of organic matter	Increased rainfall can raise moisture levels and therefore the risk of spoilage

Source: TBI. Note: this list is illustrative and not comprehensive.

As well as directly affecting hunger, climate impacts will have knock-on effects on livelihoods and economies on the continent; more than 40 per cent of the population works in agriculture[8] and currently over one-fifth of sub-Saharan Africa's economic output depends on it.

Ultimately climate change will make agricultural development and food security more challenging.

02

Local Impacts With Global Implications

The knock-on effect of climate change on food production will be felt across the globe. This will unfold in two principal ways.

The first effect is on food prices. Over the 25 years to 2020, world agricultural trade increased three-fold.[9] Reliance on global trade means localised climate shocks in one region can ripple through food prices and availability globally.

The impact of this is already being seen. Dry weather that affected crops in West Africa led global cocoa prices to hit a record high in February 2024,[10] leading to chocolate-ingredient prices doubling compared to the previous year.

If the world fails to build up its resilience to the impact of the changing climate, price rises will become more commonplace. Studies show global food inflation could increase by between 0.9 and 3.2 per cent a year by 2035 as crop yields suffer from extreme heat. This will add between 0.3 and 1.2 per cent to overall inflation.[11] By 2060, climate change could cause an increase in annual food inflation by as much as 4 per cent[12] in some parts of the world.

The impact of climate change on farmers' livelihoods – and on hunger more generally – can also exacerbate resource-based conflicts and trigger migration, both within and across borders. This is already playing out in some parts of the world. In the Sahel, recurring droughts and resource scarcity have fuelled conflict between farmers and herders, driving migration and violence (see *From Crisis to Conflict: Climate Change and Violent Extremism in the Sahel*). In Latin America, crop failures and climate variability have contributed to migration from Central America to the United States, creating political and social challenges in receiving areas.[13] This pattern will likely continue to be repeated elsewhere in the world.

The United Nations High Commissioner for Refugees (UNHCR) estimated that in 2022 31.8 million people were forcibly displaced by weather-related sudden onset hazards.[14] While there is no agreed way to reliably forecast future flows of migration as a result of climate change, its impact on resources and food security are likely to substantially increase migration flows over the coming decades.

Politicians around the world should pay close attention to this. Both food inflation and migration can impact political stability. In low-income countries, increases in international food prices often lead to a deterioration of democratic institutions. And it is well established that support for progressive politicians falls when food prices rise. An October 2024 poll, ahead of that year's presidential election in the US, showed that inflation and prices were the most important issues for voters.[15] Of people who voted for Donald Trump, 75 per cent reported that they had faced hardship as a result of price rises, compared to 25 per cent of those who voted for the Democratic candidate, Vice President Kamala Harris.

03 Food-System Resilience Through Technology and Innovation

There is no doubt that there is an urgent need to build resilience into food systems across Africa, but there isn't universal agreement on the way forward.

One approach is to prioritise demand-side rather than supply-side interventions, for example by pivoting diets away from meat, which would allow for a more efficient use of land. Although the production of meat takes a disproportionate amount of land compared to the number of people it feeds (it is estimated that about 80 per cent of agricultural land globally is used to rear animals or grow feed for livestock,[16] with a similar ratio in Africa), policy interventions to reduce meat consumption in Africa would be both socially and politically difficult. Other approaches include reducing post-production waste and localising food production to reduce supply-chain shocks. Many of these measures can help increase resilience, and in some contexts may not only be feasible but also necessary. Ultimately, every country will have its own vision for its food system and may lean on some of these approaches to help boost food resilience, while also meeting other domestic objectives.

However, against a backdrop of limited land and increasing populations, boosting the resilience and increasing the productivity of agriculture on Africa's currently farmed land is essential. Land degradation, partly driven by the impact of climate change, is likely to make more than half of Africa's cultivated land unusable by 2050.[17] Agriculture is also the main driver of deforestation in Africa – accounting for about 75 per cent of forest loss. Deforestation, while providing more land for farming, decreases biodiversity and increases soil erosion, leaving agriculture less resilient to climate impacts.

Increasing productivity in the face of climate impacts requires practical, implementable solutions and clear plans to scale them. Whatever broad objectives governments have for their food systems, adopting new technologies will be essential to boost the resilience of production.

The Previous Agricultural Revolution

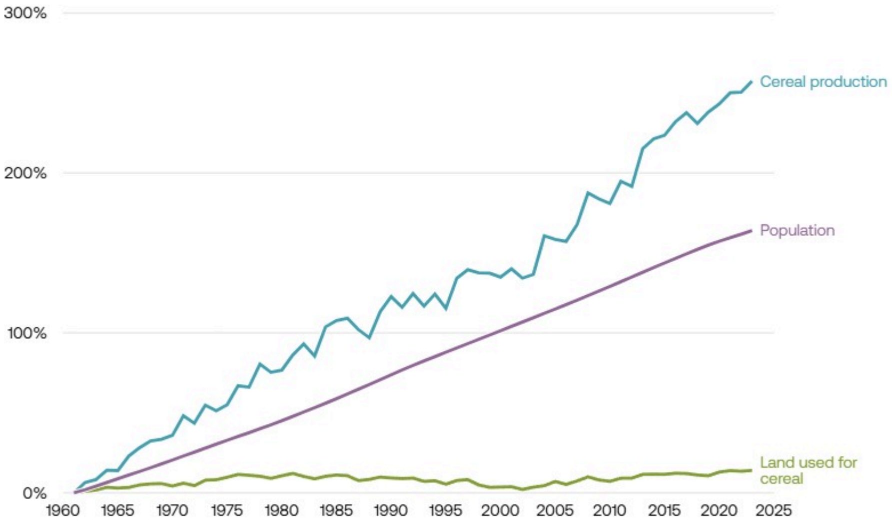
Technology and innovation have always been key drivers of progress. The food system is no exception.

In the early 20th century, the invention of the Haber-Bosch process allowed for the mass production of nitrogen fertilisers, which led to a significant increase in crop yields. Advances in seed genetics during the so-called "green revolution" in agriculture of the 20th century helped humanity escape the Malthusian trap – the theoretical scenario where population growth outpaces increases in food production – addressing fears that population growth would surpass food supply.

These innovations have had major implications for food security, population growth and economic development.

FIGURE 2

Innovation has enabled the world to feed growing populations without significantly increasing the amount of farmland



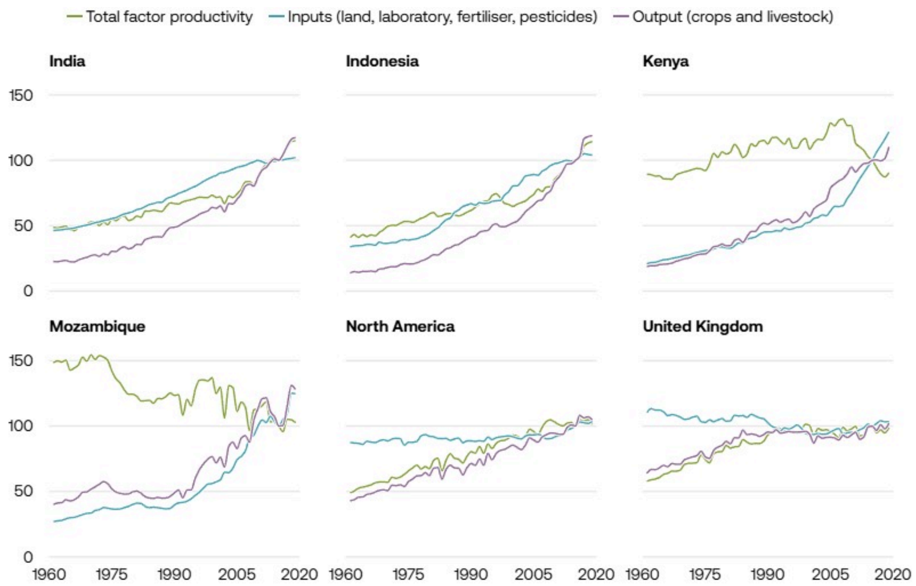
Source: Food and Agriculture Organization of the United Nations (2025) – with major processing by Our World in Data

However, there are two key challenges arising from the agricultural technologies that defined the 20th century.

The first is that their deployment and resulting impact have been uneven. Green-revolution technologies have had limited reach in Africa compared to other regions like South Asia and Latin America, limiting agricultural-productivity growth in many African countries.

FIGURE 3

The effects of innovation on agricultural productivity have been uneven across the world



Source: United States Department for Agriculture (USDA) Economic Research Service – processed by Our World in Data

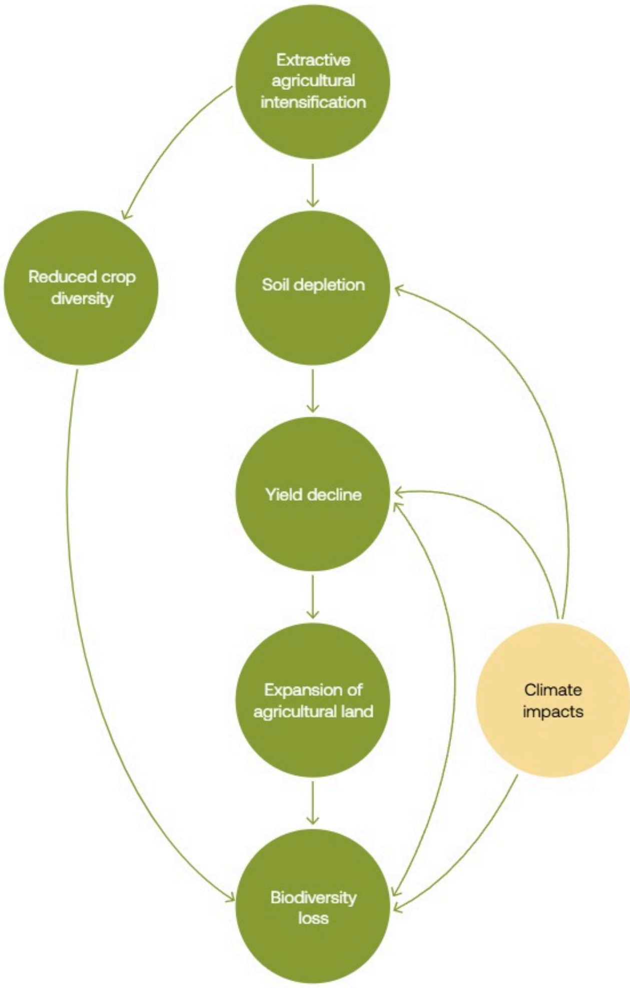
The second challenge is that the deployment of some of these technologies – mostly driven by government policy – has come with a raft of unintended consequences.

Industrial agriculture is the leading cause of land and soil degradation and, moreover, it fuels biodiversity loss. These impacts are now further weakening the resilience of food systems, meaning they are less prepared to deal with climate change. It's a vicious cycle. Degraded soil, partly due to excessive use of chemical fertilisers, cannot support healthy plant growth, while reduced biodiversity results in weakened natural pest control, lower soil fertility because of lower levels of soil organisms, and reduced pollination.

These modern agricultural practices have also driven the development of monocultures. The resulting lack of genetic diversity can leave crops more susceptible to pests and diseases, further threatening resilience to climate impacts.

FIGURE 4

The vicious cycle of unsustainable agricultural intensification and resilience



Source: TBI

These negative impacts are also playing out in Africa. Historically, Africa had about 30,000 edible plant species, with 7,000 traditionally cultivated for food, whereas now 60 per cent of Africa's food is based on wheat, maize and rice.[18] Relying so heavily on so few crops leaves the continent more vulnerable to climate impact – as does the fact that about 65 per cent of Africa's farmland has already degraded due to monocropping and overgrazing.[19]

Industrial agricultural practices that have improved productivity in other countries in the short term will not promote long-term resilience in today's climate and is therefore not a model that Africa should follow.

A 21st-Century Toolkit for Building Climate-Resilient Agriculture

Today, a new set of tools and technologies is emerging that can help future-proof the global food system. These technologies enable actors to address problems caused by climate impacts across the whole agricultural supply chain (set out in Figure 1).

The toolkit is made up of both on-the-ground solutions, supporting farmers to increase resilience, and enablers, helping governments to manage, plan and execute agricultural strategy, policy and delivery. The armoury of tools at the disposal of governments, food producers and farmers is rapidly expanding.

Some of these tools have economic and environmental co-benefits. For example, for governments, lower-cost and higher-resolution remote-sensing technologies can help policymakers access better data to understand their climate risk. AI-enabled data systems can help them make sense of these data to optimise policy choices. Real-time dashboards available across government departments can help address capacity constraints, while enabling more joined-up policymaking. And by enabling farmers to adopt technologies that can boost resilience as well as reducing emissions from agriculture – such as microbial fertilisers – governments are also more likely to be able to achieve their emissions objectives.

For farmers, adopting these technologies not only presents an opportunity to bolster resilience to climate impacts, but also to boost productivity and reduce costs. For example, by adopting precision-agriculture technologies, farmers can use fertilisers and pesticides in a more targeted manner, which reduces ongoing costs. And by adopting climate-resilient seeds, farmers can increase their productivity and, therefore, their income.

FIGURE 5

Technologies for agricultural resilience in the face of climate change

Key Established tech | Emerging tech | Government/enabling tech

INPUTS (LAND, WATER, SEEDS, FERTILISERS)

Technology	Climate impact the technology helps overcome
Gene-edited and microbially improved crops	These climate-resilient crops are more likely to survive even with higher temperatures and in more extreme weather events.
Smart precision irrigation and sustainable water-management tech	These can help prevent under- or over-watering, and mean crops can survive even during prolonged droughts or increased rainfall.
Microbial fertilisers and pesticides	Microbial fertilisers can help maintain a healthy soil structure that increases plants' stress tolerance to extreme weather and resistance to pests and diseases.
Alternative-protein animal feed	Producing this feed uses significantly less land, which will become scarcer as climate impacts intensify.

PRODUCTION AND HARVEST

Production and harvest	Climate impact the technology helps overcome
Precision-agriculture techniques	Variable-rate technology can help to reduce soil degradation by only applying inputs where they're needed. Soil-moisture monitoring can track soil water levels to optimise irrigation in drought-prone areas. Sensors can also help detect and manage pests and diseases, which are becoming more widespread due to climate impacts.
Agroforestry	Agroforestry can boost soil health, prevent soil erosion and increase soil water retention, reducing crops' risk of drought stress.
Agrivoltaics	Agrivoltaics can reduce heat stress on plants and reduce evaporation. Panels can also be designed to capture and direct rainfall into storage systems for later use.
Precision greenhouses and controlled-environment agriculture	Precision greenhouses maintain stable temperatures and protect plants from extreme weather and temperature fluctuations.
Smart farm-management software	Using real-time data and predictive analytics, this can help farmers anticipate extreme weather events and optimise planting times.
Regenerative and agroecological practices	Practices such as cover cropping, composting and reduced tillage can increase soil health and reduce erosion, making soils more resilient to extreme weather events.
21st-century public digital-extension services	By providing farmers with real-time information and training, digital-extension services can help them learn methods to build resilience.
Digital IDs	Digital IDs can help farmers access crop insurance, obtain loans more easily and receive subsidies, which will be important for building their adaptive capacity. They can also help farmers access carbon-credit markets.

POST-PRODUCTION

Technology	Climate impact the technology helps overcome
Cold storage and solar-powered refrigeration	Cold storage can prevent food from spoiling due to higher temperatures.

CROSS-CUTTING

Technology	Climate impact the technology helps overcome
Satellite tech, remote sensing and early-warning systems	These technologies can better predict risk, enabling governments and farmers to plan.
Agricultural-data systems	These can help governments better design resilience strategies based on the best available data.

Source: TBI. Note: This is not a comprehensive list of technologies.

Crucially, using these technologies rather than relying solely on 20th-century tools will allow countries in Africa to foster an agriculture sector that is resilient, regenerative and more diverse.

The capabilities of these technologies are expanding rapidly with advances in AI. For example, machine learning can significantly improve climate models by improving their accuracy and resolution, which in turn can enable governments to make better-targeted policy decisions. Advances in AI and machine learning could also revolutionise how the world identifies and breeds resilient crop varieties, enabling faster and more accurate predictions of how plants might perform under different environmental conditions.

It is important to note that agriculture is highly context-specific and, therefore, different solutions will be appropriate in different countries' contexts. In countries with more financial constraints, it may make sense to begin by implementing lower-cost solutions, like agroecological farming methods, while also building the capacity to enable farmers to implement more advanced solutions in the future.

04

A Three-Part Government Strategy to Build Resilience to Climate Impacts

Agricultural systems are complex, and harnessing the technology toolkit requires action from a range of stakeholders – including farmers and food producers, other private-sector actors, and government.

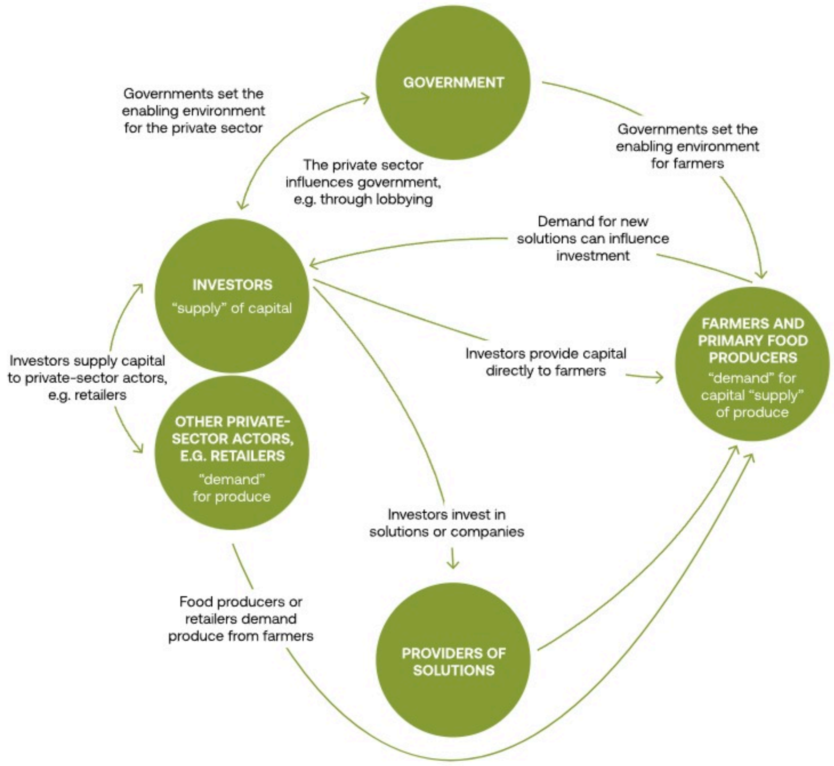
The development of new technologies is, and will continue to be, largely driven by the private sector, while their uptake will depend on the actions of farmers. Yet progress isn't happening quickly enough.

The role of governments is to set the enabling conditions to incentivise and facilitate the appropriate deployment and creation of tools and technologies.

In practice, this means measuring and managing their country's risk, supporting the deployment and uptake of current solutions by farmers – through information dissemination and de-risking finance – and promoting the development of new solutions through innovation support. It does not necessarily mean deciding exactly which technologies should be deployed, and where.

FIGURE 6

The connections between different actors in the system



Source: TBI

Without action from governments, there is a risk that African countries could lose out on the benefits of this revolution, as they have with previous waves of technology. For countries to benefit, they need a bold new strategy.

Governments need to move from a reactive to a proactive approach – meaning that, instead of responding to shocks to the food system after they happen, they need to take steps now to make their food systems more resilient in advance of climate shocks.

There are three high-level actions governments should take to harness the potential of these technologies and increase resilience to climate impacts. The first is to take steps to innovate government by adopting technologies like satellites, data systems and dashboards, and by rolling out digital ID for farmers. This will set up governments to make better immediate and long-term policy choices.

Another set of technologies (see "Established tech" in Figure 5) can directly help farmers increase their climate resilience – but there is a role for government in deploying them. As such, the next step for governments is to implement policies that can help farmers understand, adopt and scale these climate-resilient technologies.

Finally, given the scale of the future challenge, it is unlikely that today's technologies will be sufficient to secure food production for the rest of this century. Climate shocks are worsening while populations are increasing, and land use faces competing demands. Beyond the African continent, governments need to channel their best scientific efforts into finding new agriculture solutions. Innovation is the main tool through which new technologies can be created, so that costs for farmers – and ultimately consumers – remain predictable. This has played out in the renewable-energy revolution, where the cost of solar panels has decreased by 90 per cent in the past decade, partly due to government support. The same can happen for agricultural technologies. Governments – both in Africa and elsewhere – should invest in innovation to create and scale the frontier innovations that will be necessary to provide food security into the future.

Make Governments Better Equipped to Plan for and Respond to Climate Impact on Food Systems

Building resilience in agriculture needs to be an ongoing process, as the impacts of climate change evolve and new risks to the sector emerge. Governments need a solid understanding of these risks, as well as data on which to base policy decisions to boost agricultural resilience. But many governments in Africa aren't set up well to handle this rapidly changing context and too often rely on outdated approaches. As a result, some governments are spending more money responding to food crises than preventing them in the first place. Dealing with extreme weather is costing close to 6 per cent of GDP in Ethiopia alone.[20]

There are some key reasons for this failure: a paucity of good-quality and accessible data, and a lack of government capacity – both of which can make delivery more challenging.

KEY CHALLENGES FOR GOVERNMENTS

First, African leaders often lack of granular, accessible, up-to-date and high-quality data to enable them to make decisions about the risks their countries face. For example, they may lack early-warning systems or data about which crops and areas of land will be most affected by climate impacts.

The absence of agricultural-information systems that are able to provide accurate and timely information on agricultural markets can lead to blunt policy choices in response to climate shocks. These include trade restrictions, which can drive up global food prices and worsen the problem of food insecurity.

Where governments do have access to these data, sometimes the information exists in silos across different agencies and organisations, making it hard to integrate and interpret.

Second, many governments in Africa are constrained by a lack of capacity. Governments often face multiple challenges at once, yet departments are often under-equipped and under-resourced. Responsibility for food systems often spans multiple departments, meaning agriculture policies and climate policies are developed in isolation.

This can also make it hard to deliver services or information to farmers. Farmers need ongoing training, financial support and resources to implement resilient practices. Even when governments are well-equipped with the knowledge and data on which to make decisions, it can be challenging getting information (such as weather forecasts), new insights or inputs (such as seeds) to farmers on the ground. Although many yield-improving technologies have been generated in the agricultural sector, they often do not reach smallholder farmers, partly due to poor extension services.

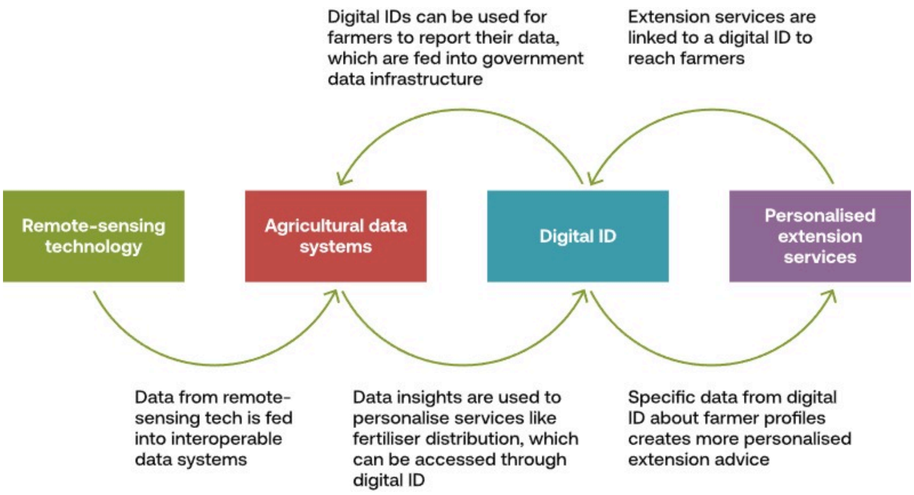
Technologies exist that can help overcome these challenges. The combination of remote-sensing technologies, agricultural-data systems and dashboards, and early-warning systems can help governments prepare and plan more effectively for climate impacts. Digital IDs and 21st-century extension services can help governments deliver end-to-end services to farmers in a timely manner.

The capabilities of these technologies are quickly expanding with the rapid development of AI. For example, DeepMind has recently unveiled an AI model for weather prediction (GenCast), which can outperform the world's top operational forecasting system.[21]

Implementing this kind of digital infrastructure is no longer a choice, but a necessity for governments operating in the 21st century.

FIGURE 7

Key technologies should be used together to gain maximum value for governments and farmers



Source: TBI analysis

RECOMMENDATIONS TO INNOVATE GOVERNMENT

Here we outline the actions that African leaders can take to innovate government, in order to improve policymaking and delivery in agriculture.

Recommendation 1: Harness the latest satellite and remote-sensing technologies to collect high-quality data sets related to agriculture and land use

In the past only a few governments could afford to launch and use satellite-based Earth observations. Now, with the massive growth in satellite systems and the cheaper cost of space-based imagery, the technology has been democratised and is more widely used by organisations and governments.

This remote-sensing technology has a range of use cases across agriculture, and its data can help governments with their resilience strategies.

In 2024, the Indian government launched a satellite-based agricultural decision-support system[22] to provide farmers with real-time information on crop conditions, weather patterns, water resources and soil health.

The capabilities of these technologies are improving rapidly. Satellite technology can increasingly collect data at regular frequency, over large areas, and with fast turnaround. However, studies have shown that weather monitoring across Africa is often missing or outdated.[23] Given the potentially high returns, governments should ensure they have access to the latest data sets from satellite and remote-sensing technology and, where countries don't own satellites, they should explore leasing data from private companies, as well as building partnerships with other nations.

Recommendation 2: Put in place a comprehensive agricultural-data strategy by undertaking a comprehensive review of existing data sources, filling gaps and setting out a data-governance framework
Data and the insights that can be derived from them are crucial for agriculture and food systems, with the potential to improve policymaking and deliver agricultural services far more effectively.

Agricultural and farm data can include raw data obtained from remote-sensing technology, administrative data from government departments and agencies (like farmer registries), surveys of farms, citizen-reported data, as well as data collected by the private sector.

However, many challenges exist around data collection, storage and analysis, meaning governments cannot currently make the best use of the data they have. All governments should implement comprehensive agricultural-data systems – the underlying infrastructure that facilitates the management, sharing, linkage and protection of data.

Governments should undertake a comprehensive assessment of existing data sources. They should address early concerns regarding privacy by putting in place a data-governance framework. Governments will also need to bring data experts into government to help build and maintain these systems.

Where possible, data should be made publicly available so the private sector can use them to develop new agricultural solutions and services.

The Tony Blair Institute for Global Change (TBI) has worked with governments to implement agricultural-data strategies. For example, in Malawi (see *Transforming Agriculture Through Data: Insights From Malawi*), TBI helped to integrate data from disparate sources into a single system to optimise the impact of subsidies to achieve the highest possible output in food production. TBI has also supported the government of Kenya (see *Unlocking the Power of Data: How TBI Is Supporting Kenya's Agricultural Transformation*) on the development of an agricultural-data platform, which brings different information streams together within a single hub to serve as a one-stop shop to inform government.

Recommendation 3: Develop a food-security dashboard to receive regular updates on the food-security situation and drive evidence-informed and real-time policy decisions

Once governments have collected and organised data, they need to be able to access and interpret them in real time to help make informed decisions. There is huge untapped potential from applying AI to interoperable data sets.

Food-security dashboards can integrate and analyse a range of data, for example on crop health and yields, planting, harvesting and weather conditions, and potential pests, to provide insights to enhance decision-making and improve resource allocation. These insights can help governments to act more quickly to reduce the impact of climate shocks – for example by advising farmers to change their planting or harvesting times – or to respond to pest outbreaks, as well as to make more well-informed long-term policy decisions. For example, data insights may enable policymakers to see what impact deforestation has had on agricultural productivity, offering insights for policy planning to support resilient agricultural production.

Trade also plays an important role in resilient food systems.[24] Food security dashboards should integrate data on agricultural-market information, including supply, demand, stock levels and prices. This will help governments work effectively with other supply-chain actors to strengthen and diversify supply chains, further boosting resilience.

These food-security dashboards should be available across government, including to agriculture, climate and trade departments. Providing visibility to the same data can help ensure more joined-up policymaking between departments.

TBI's Agriculture Intelligence Tool with Oracle

TBI's experts and Oracle's product team have co-created a new Agriculture Intelligence Tool that equips governments with real-time data to strengthen food security, drive smarter policies and budget allocation, and attract investment.

Ag Intelligence creates a digital twin of a country's available agricultural land using satellite, weather and ground data, powered by AI and machine learning. The current version helps governments forecast production, predict weather impacts and plan mitigation. Future updates will support smarter subsidies, soil-health tracking, pest control and market stability.

Recommendation 4: Introduce digital IDs for farmers and connect them to digital extension services and early-warning systems

Digital IDs can help improve outcomes for both farmers and governments. They can help farmers build resilience to climate impacts by improving their timely access to resources like credit, insurance and subsidies, as well as new knowledge. Digital IDs can also help governments identify and prioritise support to farmers who are most vulnerable to climate impacts. In addition, they enable the design of region- or crop-specific policies tailored to the needs of certain farmers. Digital IDs also provide a reliable mechanism to track the implementation and impact of agricultural programmes.

Farmer digital IDs should be linked to personalised extension services, as well as early-warning systems, so farmers can receive timely information to help them prepare for climate events, as well as on best-practice farming techniques.

India's digital farmer ID[25] which is linked to the Aadhaar biometric system, is a unique digital identify for farmers and will be used to monitor farmers to provide various types of information about them (such as the land and livestock they own, and the type of crops they have cultivated), as well as help deliver services such as crop insurance and loans. It will also have personalised agricultural extension services tailored to the farmer's needs.

Recommendation 5: Develop a comprehensive food and land-use strategy, with clear plans for implementation based on insights from the latest agricultural and land-use data

Implementing the enabling digital infrastructure is necessary, but not enough. Once governments have put these building blocks in place, they need to set out a comprehensive long-term plan for their food systems.

Every country should publish a food strategy which establishes a vision for the country's food system, with clear goals. It should integrate steps for building resilience in the food system – setting out clear plans for implementation and eventually being followed up with sector-specific investment plans that integrate both public and private financing.

These should be aligned with the country's national adaptation plans. To date, although almost every country has engaged in some form of climate-change adaptation-planning for agriculture, national adaptation plans don't yet have a sufficiently in-depth implementation strategy.[26]

A comprehensive food strategy will set clear policy direction to help attract private investment into the country's agricultural sector.

Governments should also publish land-use strategies. These are increasingly necessary as the world faces growing demands for land – for food, renewables, reforestation, housing and infrastructure. In the absence of land-use frameworks, countries' policies will be disjointed.

A land-use strategy that provides a structured framework to manage land resources – built on the best available data – will ensure that agriculture can continue to thrive alongside other competing demands, and that agricultural activities are located in the most suitable areas for climate-impact resilience.

Both these strategies should ensure buy-in from departments across government, including those responsible for agriculture, climate, trade and health, to ensure more joined-up policymaking.

Deploy the Tools and Technologies Available Now, to Address the Immediate Challenges Faced by Farmers

It is essential that governments set themselves up in the best possible way to enable successful interventions in the food system. But this alone won't be enough; given that many countries are already facing the consequences of climate change, farmers urgently need to be able to deploy technologies that can help build resilience today.

Multiple tools and technologies already exist that can help farmers and food producers adapt to climate impacts. These include low-tech or nature-based solutions – such as agroforestry and water harvesting – all the way through to climate-resilient crops and precision agriculture. And if the right technologies and techniques are deployed in the right contexts, they can work effectively to address challenges across the supply chain. For example, in Malawi, the rollout of agroforestry alongside coffee production has resulted in increased yields.

Many of these technologies also have co-benefits. The use of climate-resilient crops can reduce the need for chemical inputs like pesticides and fertilisers, which can lower costs for farmers and reduce the emissions associated with heavy chemical use.

However, many of these solutions already exist but have not yet been scaled, and the right tools and technologies are not necessarily reaching the places that need them most. Governments should introduce policies that incentivise farmers to adopt these resilience technologies.

There are two key challenges preventing the deployment of current tools and technologies: insufficient information and a lack of finance.

KEY CHALLENGES PREVENTING THE DEPLOYMENT OF RESILIENCE TOOLS AND TECHNOLOGIES

The first challenge is a lack of information – either about the type of risk farmers face, or the actions that can help reduce this risk and boost resilience. For example, farmers do not often receive information[27] on drought forecasts or pest outbreaks. Uncertainty about the type, scale and timing of climate impacts can make decisive action difficult. Farmers can also be put off by insufficient information on the effectiveness of new tools. This means they may have to take risks without a clear understanding of the payoffs. And even when farmers do have the means to adopt new practices that can increase resilience to climate impacts, such as new equipment, they can lack the skillset to use them effectively. Studies show that farmers – and in particular smallholder farmers – have lower digital literacy than urban residents.[28]

The second key challenge is insufficient finance. Many tools required to increase resilience have high upfront costs, but farming is typically a low-margin industry, making it hard for farmers to invest in new solutions and access loans. Many farmers in sub-Saharan Africa have insecure land tenure, meaning they struggle to access loans or subsidies for adaptation measures.

In sub-Saharan Africa, the amount of finance that goes to agriculture adaptation is significantly less that what is required: in 2019 and 2020, the agriculture sector received about $3 billion per year in climate finance, which was less than half the reported need.[29]

RECOMMENDATIONS TO ENABLE THE DEPLOYMENT OF RESILIENCE TOOLS AND TECHNOLOGIES

Governments can help overcome both these challenges. They can help provide farmers with information about new practices and techniques, through training schemes or extension services. They can also provide finance directly to farmers to help them adopt new technologies, for example through subsidies, as well as helping to promote and de-risk private-sector funding.

Recommendation 6: Repurpose agricultural subsidies to tie them more closely to boosting the resilience of production

Many agricultural-subsidy schemes are not fit for purpose. Between 2020 and 2022, a global total of $851 billion was directed to agricultural subsidies annually, about 60 per cent of which was expected to have a negative effect on climate and nature. The World Bank has stated that direct subsidies of more than $635 billion a year are driving the excessive use of fertilisers that degrade soil and water, and subsidies for products like soybeans, palm oil and beef result in actions that are responsible for 14 per cent of forest loss every year.[30]

In many countries in sub-Saharan Africa, continued blanket subsidies for seeds and fertilisers are not necessarily promoting resilience or resulting in improved outcomes. In some cases, nitrogen-based fertilisers are being applied to soils that are already acidic;[31] this means plants are not able to absorb nutrients in the soil, leading to lower yields.

Ultimately, public money is being spent in ways that undermine resilience and therefore food security. Many countries have realised this and are now shifting away from blanket subsidies to payments tied to specific outcomes. For example, the UK's post-Brexit subsidy system, the Environmental Land Management (ELM) scheme, pays farmers and land managers to take up or maintain sustainable farming and land-management practices that protect and benefit the environment, support food production and improve productivity – all of which should enrich resilience to climate impacts. It also incentivises the uptake of resilience-enhancing technologies through its sustainable-farming incentive.

In theory, redesigning subsidy schemes in this way can encourage farmers to boost diversity. This is the right sort of framework in principle but, in practice, it is not working effectively in the UK. The main criticisms are that the ELM scheme is significantly underfunded, too complex, and that farmers haven't been given the policy certainty they need to plan ahead. There are also reports of landowners forcing tenants off their land so they can rewild it or grow trees for carbon offsets.[32]

Countries should redesign their subsidy schemes, so they are more closely tied to boosting production resilience by incentivising the uptake of resilience-enhancing tools and technologies.

Recommendation 7: Explore innovative public-financing mechanisms to crowd in and de-risk private investment for adaptation technologies and solutions

Farmers need capital to fund the adoption of new tools. Given the fiscal constraints of governments, much of this capital will need to come from the private sector. However, many investors are currently unwilling to provide capital to drive the deployment of solutions.

One key reason is that farmers are often viewed as high-risk borrowers. Most farmers in Africa operate on small profit margins and have limited financial reserves. They can also have irregular and unpredictable income patterns due to harvesting cycles and weather conditions, which are increasingly affected by climate change. Some farmers lack credit histories or formal documentation to demonstrate financial reliability, making it difficult for private-sector institutions to assess and manage lending risks.

Another key challenge is the long-term nature of many climate-adaptation measures, which creates uncertainty around whether farmers can pay back loans. For example, agroforestry can help boost resilience and enhance productivity, but it takes time until trees mature and provide the functions and benefits expected. It therefore may take several years for agroforestry to become profitable. In other instances, the main function of resilience-boosting technology solutions is avoiding losses, which might not generate a natural return on investment (ROI). Weak ROI fundamentally erodes farmers' willingness and ability to implement adaptation solutions. According to a global farmer survey conducted by McKinsey, 30 per cent of farmers cite unclear returns as the biggest barrier to the adoption of solutions.[33]

The uncertain ROI faced by farmers also threatens the financing ecosystem upstream as, without robust demand for solutions, investment into technology firms that produce these solutions is also hindered. For early-stage investors looking to commercialise R&D into agriculture-tech solutions, unclear or delayed returns significantly weaken incentives to invest – especially as this stage is often already speculative. When agtech firms seek capital to scale operations and expand their businesses, the ROI challenge persists. Without clear and reliable revenue streams, investors are unlikely to provide capital, as there is little incentive to scale.

Governments need to address challenges that block capital flow by crowding in and de-risking private finance. Various innovative public-finance instruments can be used by governments to mobilise private capital. For example, pooled funds can help de-risk investment and compensate for uncertain return on investment during early stage and scale up investment in agtech solutions. They work by aggregating capital from both public and private sources into funds that mobilise capital while sharing risk. Concessional financing models can help to derisk implementation debt at the farmer level. For example, through government-enabled leasing – whereby the government pays the initial upfront cost and the farmer then leases the solution (repaying the government), or deferred payments, where farmers pay for agtech solutions in structured instalments that align with the harvest season. By supporting carbon markets, governments could help to deliver further funding streams for farmers. More detailed examples are set out in Figure 2 in the annex.

Recommendation 8: Build AI-enabled public-extension services to encourage the adoption of new techniques and technologies

Farmers need to know both which practices and technologies to adopt and how to use them effectively.

Agricultural extension services were originally created by governments to disseminate knowledge on agricultural-management practices among farming communities. In most developing countries, agricultural extension services are the dominant method of public-sector support towards knowledge diffusion.

Agricultural extension services have traditionally relied on human expertise and field-based interactions to provide farmers with information, training and guidance. Extension agents have either tried to educate farmers directly about best practices or have worked with selected model farmers who are then expected to act as information multipliers. The World Bank estimates that upwards of $10 billion has been spent on extension programmes in the past five decades.[34]

Extension services often face challenges in terms of scalability, reach and timeliness. In particular, smallholder farmers struggle to access information. Moreover, there is either too little funding and therefore low outreach, or information isn't tailored to farmers' needs. There has also been a huge decline in investments by governments in several countries, which has affected the quality and availability of services. In many developing countries, the ratio of government extension agents to farmers, which was a healthy 1:300 on average, has widened to 1:1,500 to 1:3,000 today.

AI is capable of revolutionising agricultural extension services. These systems can provide real-time recommendations and assist in decision-making processes for farmers. They can also offer personalised insights on crop management and anticipate pest outbreaks, as well as better tailor information to farmers' needs and conditions. Generative AI and large language models (LLMs) can combine relevant information quickly and cost-effectively.

In partnership with Digital Green and other stakeholders, the Ethiopian government has implemented Farmer.Chat, a multilingual, GPT-4-based AI platform.[35] This service facilitates real-time communication between government extension agents and farmers, offering data-driven insights to optimise crop management and increase yields.

Recommendation 9: Update procurement rules to give preferential treatment to suppliers who invest in resilient supply chains
Governments are often large-scale purchasers of food, for schools, hospitals, the armed forces, prisons and government offices.

Governments should first set standards for what counts as resilient and sustainable food production. Procurement rules should then be updated so that they incentivise the purchasing of resilient and sustainable food. This will encourage suppliers and retailers to invest in more resilient supply chains, which will have a knock-on impact on the behaviour of farmers, and their willingness and ability to take up new solutions.

Targets for the purchase of "resilient" food should be set and then increased over time, to give suppliers time to adjust.

Recommendation 10: Roll out demonstration farms focused specifically on adaptation solutions to demonstrate their benefits and increase farmers' trust
Adopting or investing in new solutions can be a big risk for farmers if they don't know if they will be effective.

Farmers are more likely to adopt solutions when they see tangible benefits, like improved yields, reduced costs or improved resilience to climate impacts. Demonstration farms allow farmers to see adaptation solutions and assess the outcomes for themselves. These farms can also provide hands-on experience to farmers with new technologies, practices and tools in a controlled environment, making it easier for them to replicate the model on their own farms. They can also serve as hubs for the exchange of knowledge between farmers.

TBI's Agri-Innovation Centres

TBI is piloting agri-innovation centres (AICs) across the Global South. They are TBI's reimagined approach for the smallholder farmer model, with the aim of strengthening food security and economic viability. They introduce new agroecological models and sustainable practices, monitoring the macro environment and enabling a continuous process of innovation, as well as adaptation to new climate challenges.

The centres will develop new agro-models based on demand and local climate, equip agricultural-research groups, extension services and local farming communities with a climate-adaptive toolkit, and leverage technology and innovative solutions to monitor environmental changes.

Working with governments at a national scale, TBI also focuses on enhancing capacity within extension services, aligning their advice with our approach. We also assess the impact of the AICs as a feedback loop to inform policy.

Following the successful completion of the pilot in Angola, the government has requested the expansion of the AIC model to four additional provinces. Concurrently, we are engaging with the governments of seven other countries across Africa and the Caribbean to support the establishment of new AICs.

Picture: TBI's pilot AIC in Angola, based at Mazozo Agricultural Research Station. Credit: TBI Angola

Create and Scale the Frontier Innovations Necessary for Future Food Security

Innovation is crucial to create new technologies and solutions, to bring down the cost of emerging solutions and ultimately to boost productivity growth in agriculture. It was the agricultural R&D conducted in the 1950s and 60s that resulted in the green revolution in the 1970s and 80s, lifting millions of people out of poverty and famine. R&D improvements are a key driver of farm productivity around the world, helping to drive down food costs and global poverty rates.[36] To date, studies suggest an average cost-benefit ratio of 1:10 for R&D spending on agriculture.[37]

The current challenges across the food system necessitate a wave of new innovations to make farming more resilient to climate impacts. However, R&D investment is falling. Between 2018 and 2020, just 6 per cent of all budgetary transfers to the agricultural sector was spent on agricultural innovation systems, despite their high social returns.[38]

There is significant underspending on agricultural R&D in poorer countries.[39] In 2015, 80 per cent of global agricultural R&D funding went to rich and upper-middle-income countries.

The countries that invest in innovation now can be the world leaders in the next generation of agricultural technologies. As there will likely be a huge global market for affordable agricultural-resilience tech as climate impacts increase, there is a notable opportunity for future growth. For example, alternative proteins – which can help boost food security because they use significantly less land and water, and are less sensitive to weather extremes compared with traditional livestock or crops – could be a growth opportunity for the UK. Estimates show that, with regulatory reforms and public investment, the industry could add £6.8 billion annually to the economy and create 25,000 jobs by 2035.[40]

KEY CHALLENGES PREVENTING AGRICULTURAL INNOVATION

Agricultural innovation is slowing down. Total factor productivity – the measure of how much output can be produced from a certain number of inputs – grew at an average annual rate of 0.68 per cent between 2003 and 2022,[41] with a rate of 1.68 per cent from 2003 to 2012.

One key reason is simply that governments are investing less money in innovation than they used to. After reaching a peak in 2002, spending on US public agricultural R&D has fallen by approximately one-third over the past two decades.[42] Governments often also spend relatively more on incumbent solutions, which can make it hard for new innovations to compete. Even when innovations are developed, they can struggle to commercialise – meaning it can take a long time before the benefits of new innovations are realised. Often this is because regulatory processes are burdensome and slow, or because the technology is not actually appropriate for real-world conditions.

RECOMMENDATIONS TO BOOST AGRICULTURAL INNOVATION

Boosting innovation should be a key priority both for countries in Africa and for territories elsewhere, which face either primary or knock-on impacts such as food inflation.

Recommendation 11: Higher-capacity countries should significantly increase and streamline public agricultural R&D

The evidence for increasing investment in agricultural R&D is overwhelmingly strong. A recent analysis by the United States Department of Agriculture's Economic Research Service found that investment in agricultural R&D has a 20:1 ROI: for every $1 invested in research in the US, $20 worth of value is realised.

Research estimates that the world will need to increase its annual spend by only a modest amount (about $5.5 billion) to generate huge benefits.[43] This could result in a net benefit of more than $2 trillion over the next 35 years. The same research claims that by 2050, this funding will boost agricultural output by 10 per cent and reduce food prices by 16 per cent.

Investing in agricultural R&D could also have spillover effects that will help the world to address other problems. For example, biotech innovations in agriculture could unlock innovations in health care.

Exciting new areas for new agricultural R&D include new sustainable fertilisers,[44] next-generation climate-resilient crops and novel foods (the Good Food Institute publishes a set of innovation priorities for alternative proteins). It could also include how to reduce energy usage in controlled-environment agriculture and smart greenhouses.

As well as increasing funding for R&D, countries should strengthen their appetite for risk-tolerant R&D. One criticism of the UK R&D landscape, for example, is that its relatively limited appetite for risk makes it less likely to discover groundbreaking innovations. The Advanced Research and Invention Agency (ARIA) has been set up to plug this gap with its mission to "identify and fund transformational science and technology that could yield huge benefits for society". ARIA's Programmable Plants project aims to develop new sustainable and climate-resilient crops. However, as we have previously argued (see *A New National Purpose: Innovation Can Power the Future of Britain*), ARIA's budget is currently modest, and there is a strong case for it to be funded at a much higher level.

The US's 2018 Farm Bill authorised $50 million per year for AgARDA (the new Agricultural Advanced Research Development Agency),[45] but in the following three years, the United States Department for Agriculture did not fund the agency, and in 2022 it was given only $1 million. The US should fully establish AgARDA to support high-risk, high-reward projects that could have large returns. AgARDA should also help to overcome the "valley of death" (the phase between developing a new technology and commercialisng it) by funding prototyping of these technologies.

Recommendation 12: Deploy new approaches to increase the pace of regulatory approval for new technologies

Smart regulation is essential to boost innovation for new technologies. If it is difficult for companies to get their product to market safely and quickly, it can disincentivise them from investing in new solutions. It can also disincentivise private-sector investment in high-risk, long-term R&D.

One example is alternative sources of protein for animal feed, such as insects, which are less land intensive but are currently held back by a rigid regulatory environment.[46]

However, regulatory approval for new technologies, for example new crop types, new pesticides and biotechnology solutions like novel foods, often involves lengthy and costly testing and review periods.

Another key challenge is inconsistent and fragmented regulations across borders, which can make it hard for technology developers to commercialise innovations globally.

Recommendation 13: Create an advance market commitment in the World Bank for climate-resilient crops

A core example of a type of innovation that could be transformative for many developing countries is the development of new climate-resilient crops, such as sorghum and maize, that can be affordably rolled out across the world.

New climate-resilient versions of these staple crops could mitigate billions of dollars in agricultural production losses and enhance global food security. Researchers from the University of Chicago have estimated that every $1 spent on health-tolerant varieties of staple crops could generate $24 in benefits.[47]

There are more opportunities for driving this type of innovation than ever before. While it currently takes about ten years to introduce a new trait into a crop, new technologies such as RNA methylation and CRISPR could dramatically reduce development times.

However, despite the potential, there are factors standing in the way of the market driving this innovation itself. New crop traits are not immediately valued by farmers – especially in the developing world – which makes it difficult for companies to charge a premium.[48] This means that there is not necessarily a natural business model for this innovation.

There is therefore a strong case for the global community to step in to correct this market failure. Currently, the World Bank is focused on country-specific interventions, mostly through loans. An opportunity, at a time when more countries "graduate" from International Development Association eligibility, could be to dedicate some of the money in the Bank towards R&D into transformative global products. Developing climate-resilient staple crops offers a prime example of an intervention where World Bank investment could drive substantial benefits in line with the stated aims of the bank.

The University of Chicago has developed a proposal for an advance market commitment for climate-resilient crops.[49] In such a model, money would be set aside to pay for a specific outcome (in this case, climate-resilient crops) to create the demand-pull that incentivises firms to invest in R&D. Under this model, funders could reward innovators based on a certain set of criteria and, for a model that targets sorghum and maize across East and West Africa, the investment could come with a cost-benefit ratio of 24:5. The World Bank has the capability to launch this advance market commitment.

Conclusion

This is a defining moment for Africa's food system. As climate events continue to unfold, food security is worsening.

The rapid development of technology presents new and exciting opportunities to build resilience into food systems. However, these technologies won't be scaled at pace without government intervention.

Political leaders can prevent large-scale disruption before it unfolds if they take the necessary steps now. That includes innovating governments, so they can make better decisions and deliver better services. Leaders should also take steps to help deploy technologies that are already available by unlocking finance and breaking down information barriers. And in addition, all governments should invest in innovation to help develop new cost-effective solutions that will help boost resilience into the future.

Taking these steps is not just about mitigating risk. It presents an opportunity for stable food systems that support the health of citizens and the livelihoods of millions of farmers, while also creating positive spillover effects from new innovations and fostering new growth opportunities.

There is no time to waste. To avoid today's crisis turning into tomorrow's catastrophe, African countries urgently need a food-production tech revolution.

Annex

FIGURE 8

Examples of instruments used to derisk and attract private investment

Government instrument	Application	How does it work?	Case study
Pooled funds (with first-loss guarantees)	Derisk investment and compensate uncertain returns on investment (ROI) during early-stage and scaleup investment in agtech solutions.	Pooled funds aggregate capital from both public and private sources into funds that mobilise capital while sharing risk. Funds can be structured into tranches (buckets) that further share risks to better align with the risk appetite of investors. A first-loss guarantee serves as the initial tranche of the fund, absorbing early losses. Public finance typically takes on this risk, improving the fund's risk profile and attracting private capital. This structure enables investors who recognise the potential of agtech to invest confidently by mitigating uncertainty around ROI.	Innovate UK has fostered growth in the agtech sector by partnering with private-equity investors to provide grant funding and equity investment to innovative agtech SMEs. By combining grant funding with equity investments from notable firms such as Yield Lab Europe and 24Haymarket, the programme accelerates the commercialisation of agtech solutions to enhance productivity and sustainability.
Results-based financing (including market commitments)	Derisk investment and compensate uncertain returns on investment (ROI) during early-stage and scaleup investment in agtech solutions.	Results-based financing models see the government committing to repaying investors if products meet specified criteria. This payment upon results (socially desirable outcomes or production of x quantity, for example) can take various forms, such as impact bonds, advance market commitments and offtake agreements. All forms enable the government to mobilise investment by creating a revenue stream where ROI is weak. To maximise their effectiveness, these mechanisms should be strategically structured to attract investors at the earliest, least commercially viable stages, such as during project piloting. By doing this, the government helps derisk further investment and creates a pipeline for continued funding as investors gain exposure and confidence in the project's potential for scalability. By aligning financing with additional results criteria, the government can also shape solutions to better serve adaptation requirements – namely, dealing with the unique contexts of farmers (via requirement that solutions are applicable for certain underserved contexts, for example).	**The Gavi Pneumococcal Advance Market Commitment** (AMC) is a prime example of results-based financing that successfully mobilised private investment to address global challenges. While not a specific climate example, it makes a robust case for AMCs. Gavi committed $1.5 billion to guarantee an attractive price for manufacturers once they delivered vaccines meeting specific performance criteria. Companies such as Pfizer and GSK responded, developing and scaling up pneumococcal vaccines. The programme helped deliver vaccines at a lower, sustainable price of about $3.50 per dose in eligible countries, compared to about $70 to $100 per dose in high-income countries. Between 2009 and 2023, it is estimated that Gavi's pneumococcal-vaccine programme averted a total of 1.2 million deaths, with a significant contribution by Gavi's flagship AMC.
Viability-gap funding (VGF)	Derisk and compensate uncertain ROI for agtech firms and farmers.	VGF allows the government to bridge the gap between a solution's expected financial returns and the returns needed to attract investment. It addresses uncertain ROI by compensating investors through capital grants, subsidies or guarantees. To ensure value for public money, governments must conduct thorough due diligence and only support projects with a robust impact. This backing not only reduces investor risk but also serves as a financial and informational signal of a credible and worthwhile investment.	ILX Fund 1 is a private credit fund focused on emerging markets, managed by ILX. The fund gives institutional investors access to investment opportunities in development-finance assets, by investing in private-sector loans arranged by multilateral development banks and development-finance institutions, targeting sustainable development and climate finance. VGF for private investors is provided by EU guarantees through the European Fund for Sustainable Development Plus (EFSD+) Guarantee Programme.
Concessional debt	Derisk implementation debt at the farmer level.	Concessional debt refers to loans provided on more favourable terms than those available on the market. The role of the government is to enable lower interest rates and longer repayment periods. Concessional loans can also combine grant elements with standard loan financing, reducing the effective cost of borrowing (for example, a loan with a 20 per cent grant component effectively reduces the repayment burden).	The **NABARD Refinance Programme** provides long-term concessional loans to eligible financial institutions to support investment in agriculture, allied sectors and rural development. NABARD (National Bank for Agriculture and Rural Development, India) provides funds to banks at concessional interest rates. This enables banks to lend to farmers at affordable rates, making credit more accessible for investment in agriculture, agtech and climate-resilient practices. Refinance from NABARD also allows banks to offer loans with longer repayment tenures. Climate-adaptation projects are explicitly set out as a key objective for long-term refinancing.
Concessional financing models	Derisk implementation debt at the farmer level.	The government can support farmers in deploying agtech solutions by restructuring repayment models to better suit farmers. This could take the form of government-enabled leasing, whereby the government pays the initial upfront cost (which the farmer is unwilling or unable to do, due to credit constraints or uncertain ROI) and the farmer then leases the solution (repaying the government). It could also take the form of deferred payments, whereby farmers pay for agtech solutions in structured instalments that align with the harvest season (or other times when income is generated). Governments provide partial guarantees to lenders in the process to derisk this arrangement.	Hello Tractor's **pay-as-you-go financing model** makes agricultural machinery more accessible for entrepreneurs and smallholder farmers by aligning loan repayments with their income cycles. The platform uses IOT technology for remote monitoring to track tractor usage and deducts repayments directly from income, making mechanised farming sustainable. If governments can back such innovative financing models, agtech investment becomes significantly more accessible.
Support for carbon credits	Adjusts uncertain ROI for implementation at farmer level.	Ecosystem credits provide an additional revenue stream for adaptation solutions that have an environmental benefit, improving the perceived ROI and thus increasing deployment. The scope of this paper does not cover the exact requirements for governments to boost ecosystem-based markets. However, if governments can create an enabling market environment with robust regulation, ecosystem credits provide a clear, additional revenue stream for the implementation of ecosystem-based agtech.	The **Kenya Agricultural Carbon Project**, led by Vi Agroforestry and supported by the World Bank, helps smallholder farmers adopt climate-smart agricultural practices such as reduced tillage and agroforestry. These practices sequester carbon in the soil, generating verified carbon credits sold in international markets, which fund the project. More than 60,000 farmers across 45,000 hectares have benefited, improving soil fertility, increasing crop yields and enhancing resilience to climate change.

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