AI + Climate Futures in Asia

Smart Farms 2035
The Future of AI and Agriculture in Asia

How Might the Use of AI Transform Agricultural Practices in Asia by 2035?

What are the Likely Impacts on Climate Action in the Region?

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Foresight brief #1

Smart Farms 2035: The Future of AI and Agriculture in Asia

This foresight brief is part of a project on AI + Climate Futures in Asia, supported by The Rockefeller Foundation.

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Any errors or omissions are our own.

Countries across Asia have identified agriculture as a priority area for the use of artificial intelligence (AI).

The application of AI technologies is expected to increase farm productivity and support adaptation and resilience to changing climate conditions.

However, the adoption and effectiveness of AI are limited by several factors, including limited access to localized data sets and financing for farmers to change farming practices. Concerns around the commercialization of farm data, food sovereignty, and unequal distribution of value also need to be negotiated.

As agriculture is one of the largest emitters of greenhouse gases, AI tools are also being developed to support regenerative agricultural practices. Soil and forests can help absorb carbon from the atmosphere, but investments in this area have also been criticized for "greenwashing"[1]. However, a more holistic and locally rooted approach to regenerative agriculture could boost climate action while enhancing livelihoods and biodiversity.

This foresight brief presents two hypothetical scenarios – Fractured Futures and Hopeful Tomorrows – for how the use of AI technologies and the processes accompanying its development and deployment are likely to impact agricultural practices in the region.

The final section of this brief presents a set of shared concerns and levers for change.

These scenarios were developed over a 2.5-day workshop that brought together leading thinkers and practitioners from civil society, academia, and industry. A list of participants is provided in the Annexe.

These scenarios are not predictions but provocations to consider the implications of current trajectories and envisage alternative possibilities.

We hope this brief can serve as a tool to explore new pathways for promoting responsible innovation and the adoption of AI technologies for agriculture and climate action.

1 The act of making false or misleading claims about the environmental sustainability of a product or process.

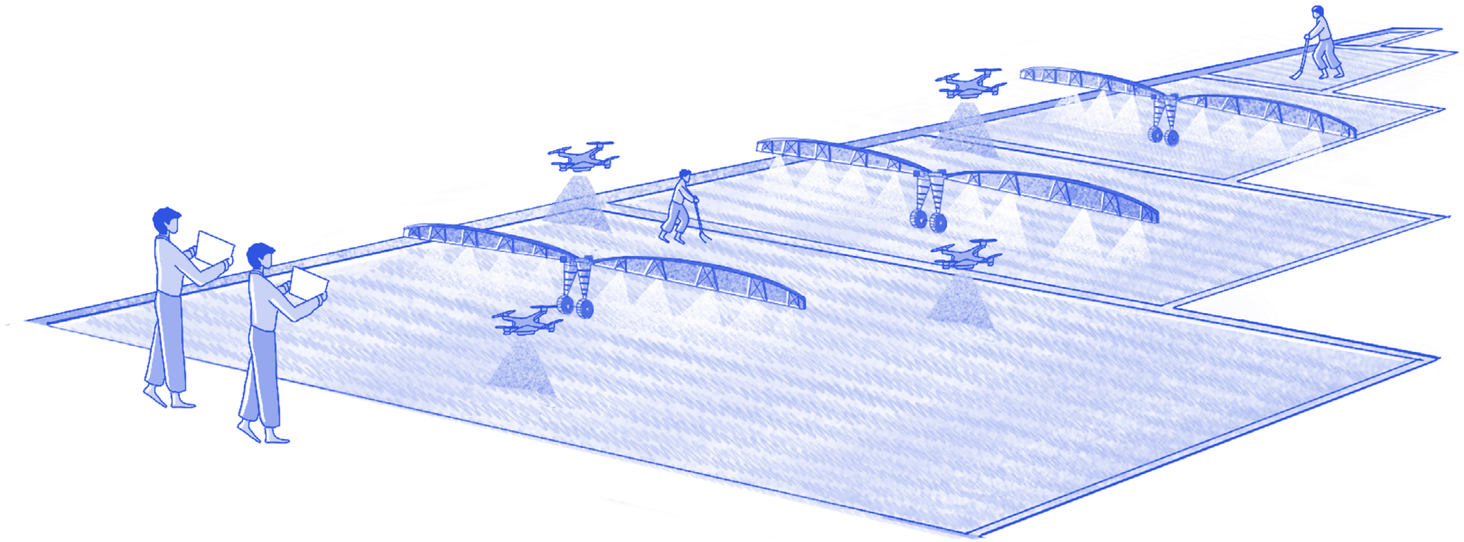
Scenario #1

Fractured Futures

Policy Shifts

After years of failed land reforms, governments in the region have been able to use new mapping and digital identity technologies to push through land reform policies.

Smaller agricultural landholdings have been consolidated into larger farm parcels, a number of which have been classified as special agricultural production zones to facilitate increased investment and technological experimentation. This has also paved the way for higher use of automation and robotics in farming across the region, and most farms are now managed by large agro-technology companies.

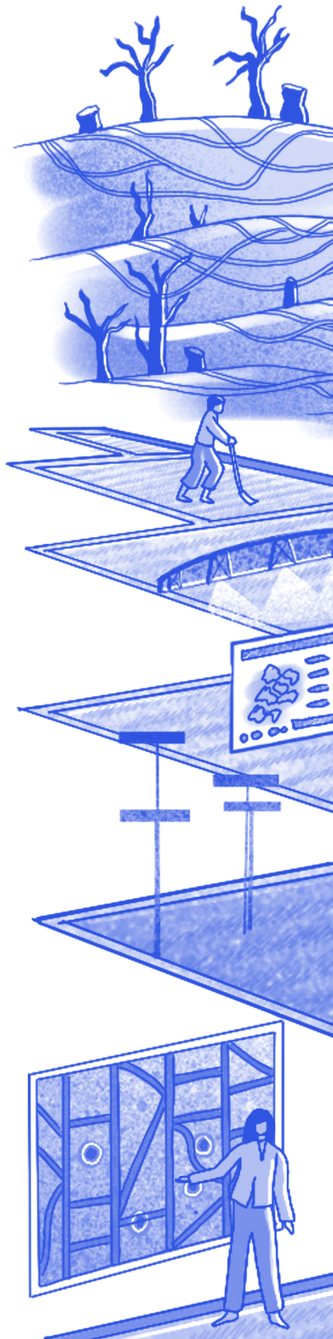


Impact on Farmers

Most farmers have lost access to their lands and now work as contract labour on larger farms. Many farming jobs are now performed by migrant labour.

The nature of farmwork has also changed; while some farmers, particularly women farmers, continue to work on specialized tasks involving high dexterity, many others are now employed as data collectors and annotators. Many farmers are worried that advances in technology will soon eliminate these jobs as well. The agri-data industry is already unable to absorb most farming communities, particularly those that are less digitally fluent.

However, returning to farming is also not a viable option; aside from a loss of land rights, rising temperatures in the region have made it nearly impossible to work long hours outside.

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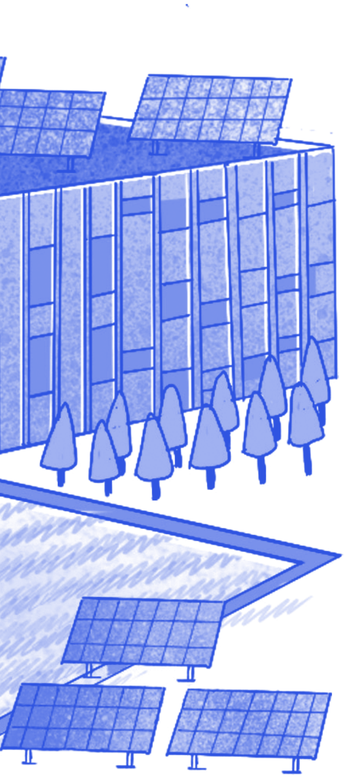


Increased Dependence on Agro-Technology Companies

A few independent farms remain, but they are struggling to remain afloat. The majority are reliant on sharing economy models for renting out farm equipment. While this seemed like an effective way to reduce costs a few years ago, the quality of equipment has deteriorated and prices have shot up.

Farmers' inability to repair their farm equipment has led to increased costs of equipment and a higher reliance on agro-technology companies. Unlike the past when farmers shared seeds, this practice is no longer viable as they now depend on agro-technology companies, and this has become progressively unaffordable. Some farmers have also highlighted that the seeds provided by these companies are not suited for their agro-climatic zones, and their continued use is displacing the local biodiversity ecosystem.

Improved but unequal agricultural productivity

Conversely, improved data collection tools and the use of AI and automation have helped boost crop yields despite rising climate variability.

The use of AI has also rendered agricultural supply chains more efficient, largely eliminating food shortages. Corporations have patented new seed and crop varieties, consolidating control over food supply chains.

However, this is not the case everywhere. As evidence of crop-specific shortages grows, several countries are forced to ration food. In response, leading economies have established their own networks of artificial biomes to facilitate the uninterrupted production of high-value agricultural products.

Increasing health crises

Health crises are on the rise. Leading scientists attribute this to the decreasing nutritional quality of diets due to the growing focus on improving crop yield by increasing the use of fertilisers and new seed varieties.

Reduced crop diversity and increased monoculture have also led to a decline in the nutritional quality of food. While in the past, humans derived nutrition from 80 of 7,000 edible plant species, this has dwindled to just 20 over the last decade.

Boom in carbon off-setting industry

Advancements in AI for processing hyperspectral imaging have enhanced the ability to calculate soil and forest carbon sequestration.

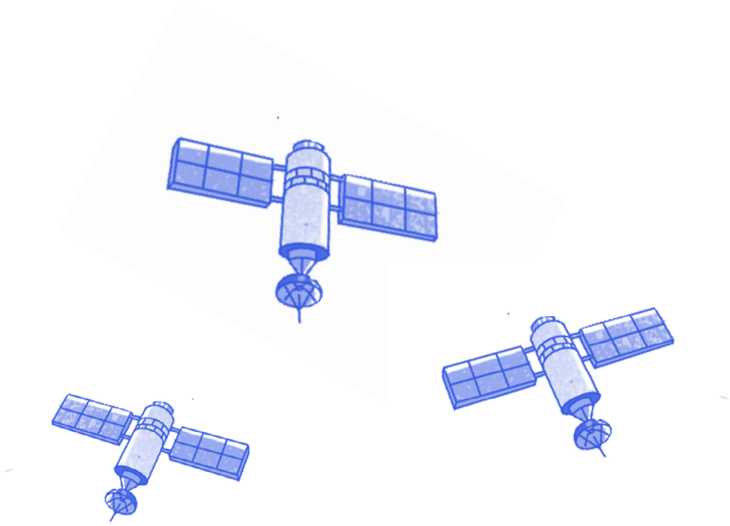
Several companies that offer a suite of carbon offsetting services have sprung up. They offer real-time advice to corporations running farms on how to adapt agricultural practices to augment carbon sequestration, and through this, provide them with carbon credits that can be traded in carbon markets. A lot of these companies have been able to register themselves as public interest companies under the pretence of amplifying regenerative agricultural practices.

This industry has boomed despite continued warnings from civil society organizations about viewing agricultural lands and forests through the prism of financial carbon sinks.

As they had predicted, this has contributed to growing monoculture and a loss of biodiversity. These vast monocultures have heightened the vulnerability of the ecological ecosystem, adversely affecting conditions such as soil moisture and erosion, streamflow, evaporation, and groundwater quality – ultimately bringing down ecological resilience.

A few civil society organizations across the region have come together to advocate for alternative agricultural practices and farmer rights. At present, many of their worst fears have come true. They had cautioned that the unfettered collection of agricultural data under the guise of driving AI for social good did not aid farmers.

The most pressing issue facing farmers was never a lack of information about cropping practices but rather the depletion of natural resources (particularly groundwater) and the dwindling returns on their produce due to unfair market practices.



Loss of food sovereignity and biodiversity

Both these problems have only worsened with the rising involvement of technology companies in agriculture. Crop advisories pushed farmers to optimize practices to enhance market profitability, oblivious to the negative impacts (overuse) on the natural resource base and disregarding biodiversity.

The patenting of seed varieties by large corporations has also led to species extinction and a loss of food sovereignty for most farmers. Farm advisories had also compelled farmers to buy farm inputs produced by the companies issuing the advisory, but this conflict of interest was ignored for several years.

The collection of agricultural data and the creation of complex data intelligence dashboards bring about more sophisticated forms of speculative trading in agricultural data markets, leading to higher food prices and declining incomes for farmers.

However, with limited data collected on farmers' well-being and livelihoods, the evidence to help these organizations build their case is also restricted. The proprietary nature of the algorithmic models underlying advisory applications has also made it harder to challenge the outputs.

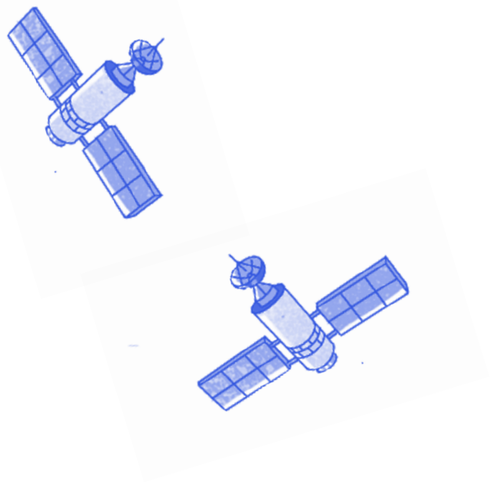
Civil society mobilisation

To address these issues, these civil society organizations are trying to recover traditional farming practices, but much of this knowledge has been displaced through years of AI-driven farming. Moreover, the commercialization of satellites has meant that it is considerably harder for these organisations to access data and build an evidence base.

Despite the development in satellite technology, the data is still not of a sufficiently high quality, and tremendous resources are required to process this data – something that is out of reach for most civil society organizations.

Scenario #2

Hopeful Tomorrows



Consultative and Judicious Technology Development

Improvements in the quality of satellite imagery and coverage and remote-sensing data have drastically enhanced the quality of agricultural data in the region. New decentralized innovation hubs have been set up to support farming communities with the tools and support they require to utilize this data.

However, the growing recognition of the fallibility of digital technologies along with their rising environmental footprint has instigated more judicious and problem-driven data collection and technology-development processes.

At present, it is well understood that big data is less important than smaller, localized data sets.

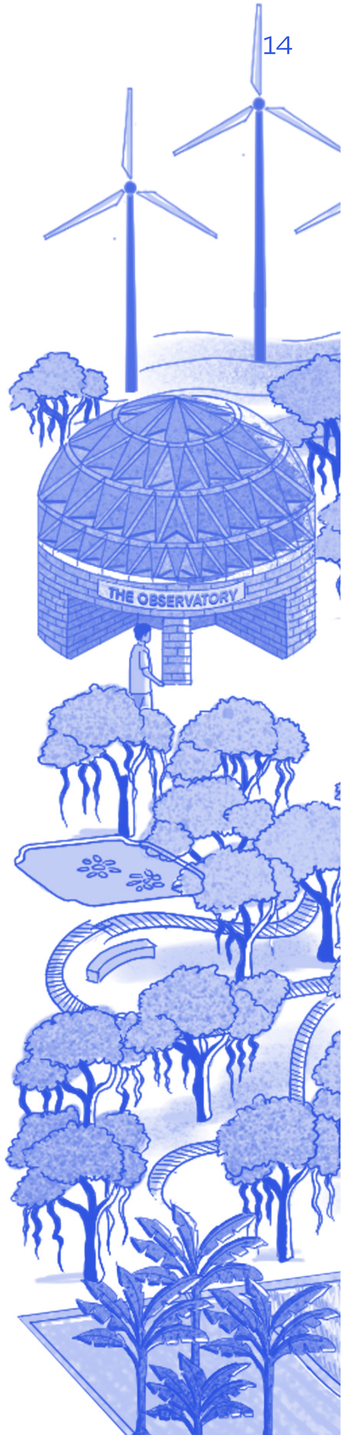
Additionally, extreme and rising heat combined with ongoing droughts have rendered maintaining large data centres in the region unsustainable.

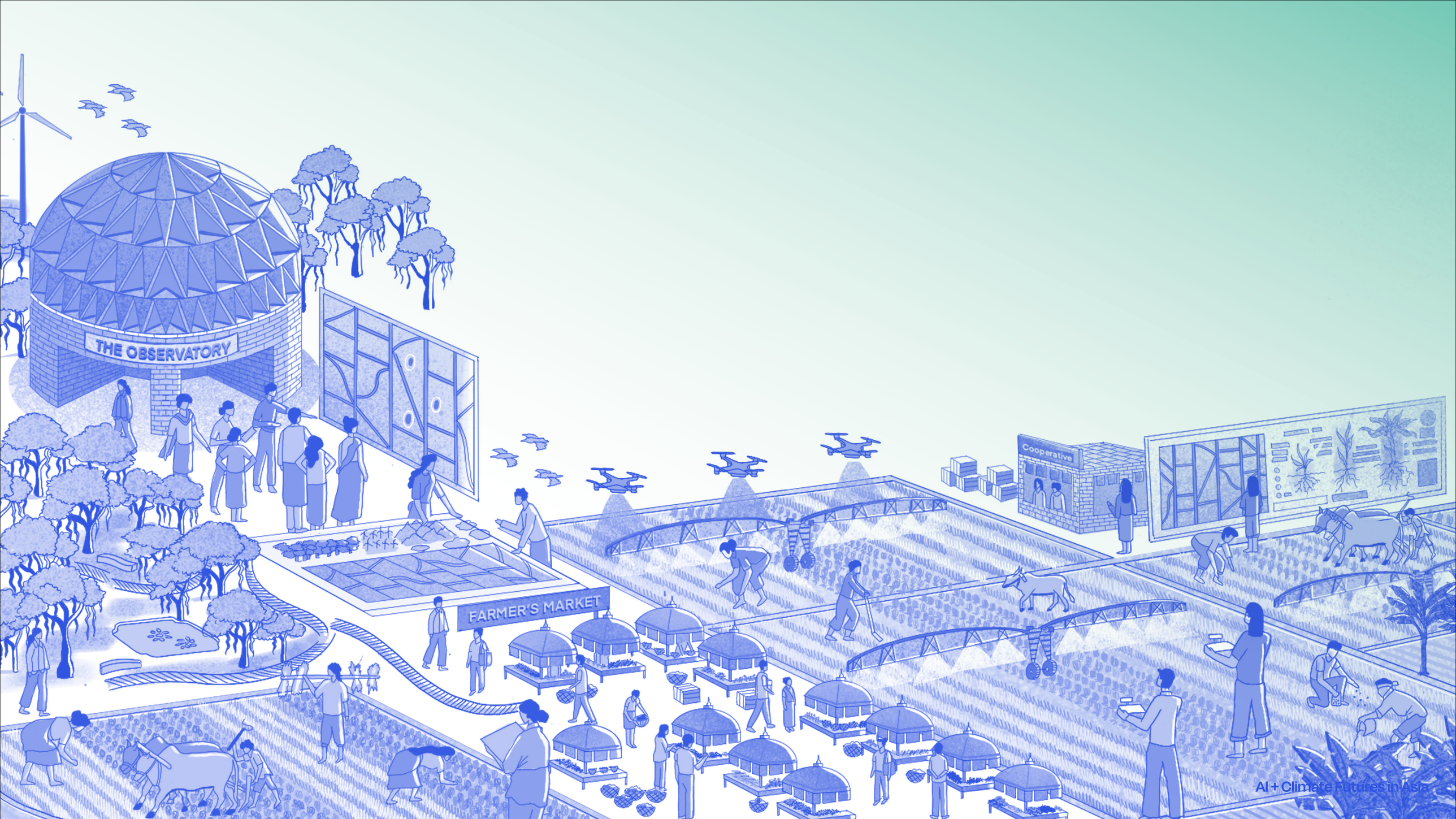
Data requests are crafted through a consultative process, engaging the local farming communities, local agricultural experts, and data scientists. Together, they identify the problem at hand, determine how AI can be helpful, and specify the data that is needed to build the identified AI model.

Unlike earlier one-time consultation processes, the current processes extend over several months – sometimes even years – and involve regular feedback and learning mechanisms. Farming communities are no longer passive participants in these processes but are active shapers of the governance structures driving technological development. The farmer-led, sustained nature of these processes has also facilitated a gradual revival of traditional knowledge systems, a lot of which form the basis of new AI models and applications. This has further meant that greater attention is paid to the specific technology requirements of smallholder farmers and the ways in which AI can amplify or back their existing farming practices.

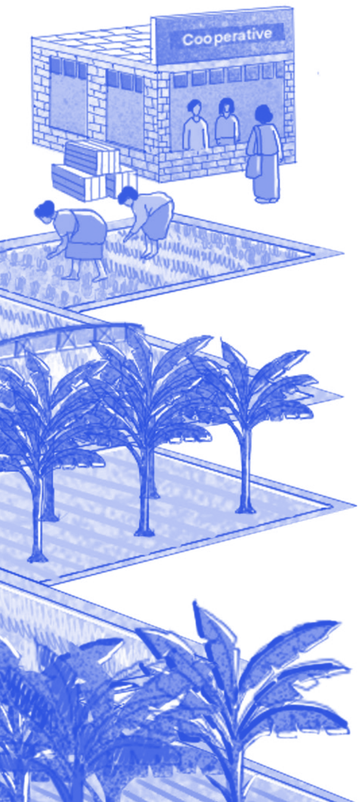
After years of issuing faulty crop advisories by agri-tech companies, one of which caused a large-scale production breakdown, technology companies have lost trust and all agricultural data is held by local academic institutions and civil society organizations.

While this has slowed down the pace of technological innovation, communities enjoy greater trust in these localized academic institutions, owing to their lack of commercial incentives. This allows for far more granular, curated, and sustained data collection and analysis, and eventually, better-localized interventions.




THE OBSERVATORY
FARMER'S MARKET
Cooperative

2 The digital counterpart of a physical object, system or process, used for purposes such as simulation, testing, monitoring, and maintenance.



Digital Twins for Regenerative Agriculture

As a result, most of these local academic institutions have started building digital twins[2] of the local agro-climatic zone, including the interaction between human activity and natural systems. This has greatly enhanced the quality of climate and agricultural advisories to farmers, assisting them to better manage natural resources as well as anticipate the impact of changing agricultural practices on their livelihoods and farm productivity. The recognition of the rights of non-human species and plant life signifies that they are now also factored into these models, fostering a growth in biodiversity and more sustainable practices. Moreover, plant and animal life is digitally tagged, in an effort to protect and promote agrobiodiversity.

By building on digital twin models that combine factors such as farmer profitability, biodiversity, and nutrition, several new AI-based products have received a "true-regen" agriculture certification.

The critical criteria for obtaining such a certificate are the presence of domain expertise and regular testing and evaluation, not big data alone.

In the current scenario, farmers are recognized as stewards of the land, not just growers of crops, and the health of the soil is widely understood to be a more important consideration than the type of crop.

Improved trust and accountability

However, as digital infrastructure, access, and skills remain unevenly distributed across the region, a lot of farming communities are unable to develop their own localized models. They continue to rely on off-the-shelf products available through a government-run marketplace.

The signing of a global agreement on climate action and national-level actions towards protecting farmers have inspired increased trust in this model marketplace. Products are accompanied by meticulous documentation around their features, processes, and limitations as well, provided to farming communities free of charge. A popular AI tool in the market supports farmers' practice of multi-cropping in a manner that reduces the need for tilling the soil and regenerates the landscape.

Shift in public attitudes

A global pandemic caused by the contamination of an industrial livestock farm and the resulting death of millions of people, including children around the world has brought about a shift in public attitudes and dietary habits.

The disruption of industrial-scale monoculture supply chains caused by frequent wildfire outbreaks and the drastic increase in food prices triggered a shift in public attitudes and perceptions.

In the face of these circumstances, purchasing locally grown and organic food becomes mandatory for all government offices and public institutions. Several companies have begun to develop AI-based services to facilitate this shift in agricultural production and supply, such as tools to help institutions verify the quality of agricultural produce and help farmers anticipate changing local demand through social media intelligence.

In this case, farming communities earn a fairer and more stable income, but opportunities for further market expansion remain limited. In addition, this brings down emissions from the global transport of agricultural produce.

Observatory for monitoring AI impacts

A new regional institution – the Observatory for AI in Agriculture – has been established to direct and monitor research and innovation on emerging technologies in the agricultural sector. For example, it has established a research centre for the use of large language models to advance R&D in food science and has seen early success in developing new climate-resilient, high-nutrition grain varieties.

The observatory's flagship initiative for evaluating the impact of climate-tech investments using AI-based simulation tools has helped reduce instances of greenwashing. It also supplies important evidence for holding companies accountable for promised emission reductions. The observatory also conducts evaluations of agri-tech tools in the market to certify products that promote ecological farming.

This is instrumental in weeding out frivolous AI applications and advancing trust in AI applications.

The institution is managed by a consortium of farming communities from the region and organized around the principle of bioregionalism – wherein human relationships are driven by the duty to protect natural resources and the accompanying ecosystem.

Financing has been made possible through ongoing reparations collected from private companies found to be manipulating (now discredited) carbon markets. The observatory has its head office adjacent to one of Asia's largest sacred groves and serves as a template for the conservation of other protected habitats in the region.

Discussion

These two scenarios about the future of AI, agriculture, and climate action suggest a few shared concerns about the deployment of data-driven technologies for climate action. Potential levers of change can also be extracted from the scenarios.

Shared Concerns

If the current trajectories of the use of AI in agriculture and food systems continue, they are likely to have negative impacts on the rights and well-being of farmers and lead to the degradation and collapse of agri-food systems.

The natural resource base for agriculture risks being depleted even more and the early improvements in crop yield using AI may prove unsustainable in the long run. The concentration of big data and analytics in the hands of a few companies can also undermine food sovereignty for communities and make global food systems more vulnerable.

Loss of Agency, Rights, and Livelihood

The increased datafication of agriculture and the dominance of top-down AI interventions, primarily led by technology companies, pose a risk of diminishing farmer agency and autonomy. This trend may not necessarily improve farmers' income or well-being. Farming communities may find themselves in an unequal relationship of dependency on technology companies, with negative impacts on food sovereignty, rights, and livelihoods.

Inaccurate Problem Diagnosis

Many AI-based products and services are not aligned with the priorities of farmers. There is a common misconception that farmers lack information or knowledge, but this is often not the case – rather, traditional forms of knowledge are not recognized as being equally valid as data-driven intelligence. Farming communities tend not to be consulted, nor are their local contexts adequately understood.

Crowding Out of Knowledge Systems

Traditional knowledge systems risk being displaced by the introduction of AI systems, which poses a major threat to meaningful climate action and sustainable agriculture. The dominance of data scientists rather than domain experts in the development of AI systems is another concern.

Declining Health and Environmental Impacts

While technological innovations have the potential to make agricultural food production more efficient, when these technologies are optimized for commercial gain or yield efficiency alone, there is a risk of declining nutritional quality of food and, consequently, food security. The natural resource base for agriculture risks being further depleted - the early improvements in crop yield using AI may prove unsustainable in the long run.

The Commercialization of Farm Data

The market concentration of food and agricultural inputs and outputs is being amplified with the growing datafication of agricultural supply chains and the involvement of technology companies. Unregulated agricultural data markets can also directly harm farming communities. The dominance of global Big Tech companies also poses a challenge to the food security of countries in the Global South and increases the vulnerability of global food systems.

Levers of Change

Consultative Technology Development

Including farming communities in the process of identifying the problems they face and the interventions they require, as well as sustaining such a consultative process, is crucial.

This must not be limited to consultation alone—these communities must be equitably included in decision-making and governance for technology development. Additionally, technology development must be led by interdisciplinary domain expertise and those with knowledge of the local context.

Trustworthy Data Institutions

Institutional structures that are designed to create, use, and share agricultural data need to be delinked from commercial interests. This can augment social trust and allow better innovation for people and the planet.

Communities must be given a say in the creation of data sets – if data continues to be disconnected from people and systems, derivatives extracted from data will continue to be irrelevant to real-life settings and context.

Public Policy for Innovation

Letting market forces alone determine how and where AI will be used in the agricultural sector will not help achieve positive climate action. Governments must play a critical role in defining a political vision for climate change and developing appropriate policy levers to realise that vision. Market forces alone will also not be enough to develop localised data sets and disciplinary research and product development tools.

Market Policies

Competition policy frameworks that check the monopolization of agricultural markets, including data markets, will be required to secure fair and sustainable agricultural markets. While not a new concern, the urgency of this lever is increasing with the advent of AI.

Monitoring and Evaluation

Regular evidence gathering and evaluation are required to understand where and how AI systems can add value to and impact agricultural practices from a climate perspective. Common metrics will need to be established that account for broader planetary impacts, including outcomes for biodiversity and natural resource management.

Annexe
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About the Project

About DFL

Digital Futures Lab is an interdisciplinary research collective that interrogates the complex interaction between technology and society in the global South. Through evidence-based research, public engagement and participatory foresight, we seek to realise pathways toward equitable, safe and just digital futures.

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About the Project

Commissioned in early 2023 by The Rockefeller Foundation, this project explores the intersection of Artificial Intelligence and Climate Action in Asia. It examines opportunities, challenges and risks across three domains – agriculture and food systems, energy transitions, and disaster response in nine countries - Bangladesh, China, India, Indonesia, Malaysia, Singapore, Thailand, The Philippines and Vietnam.

We assembled a network of regional experts to help guide our investigation and provide context specific insights.

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For additional reports and outputs from this project visit – climateai.asia

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