Critical Transition 2. Scaling Productive and Regenerative Agriculture

Productive & Regenerative Agriculture	Better Futures Additional Investment Requirements 2030 *(USD billions)*	Better Futures Business Opportunity *(USD billions)*	Economic Prize from Hidden Cost Reductions *(USD billions)*	
	2030	2030	2030	2050
	$35 - 40	$530	$1,170	$3,035

Much of world food production takes place in industrial farms that make heavy use of synthetic chemical inputs. This form of agriculture has significant benefits: generally high productivity per hectare, reliable output, and delivery of affordable food in large quantities at a time of rapid population growth. There are areas of the world that do not have access to this technology, and there are many opportunities to improve its productivity, through forms of precision agriculture for instance. However, as Chapter 2 demonstrated, high-input agriculture carries hidden costs.

Alongside improvements in mainstream high-input agriculture, a regenerative farming movement is emerging. There are a number of definitions of regenerative agriculture. For the purposes of this report, a broad definition is used that includes a set of practices that regenerate soil, that reduce but do not necessarily eliminate synthetic fertilisers and pesticides, and that go beyond the reduction of negative impacts to ensure that agriculture has a positive environmental effect.[23] It seeks to maintain high levels of productivity while reducing inputs, to restore soil health, to increase agrobiodiversity and to reduce negative effects on freshwater and the ocean. It is supported by related techniques such as sustainable land management and integrated water resource management.

An increasing proportion of farmers are adopting regenerative farming practices, often employing digital tools (to monitor soil health, for example), new forms of biological inputs and in some cases practices such as regenerative grazing. It is crucial both to scale such approaches and gradually integrate them into mainstream agriculture to make it more sustainable.

BOX 13

Agriculture is affecting the quality and quantity of freshwater

As discussed in Chapter 2, freshwater is increasingly scarce. By 2050, half of the world's population will live in water-stressed areas.[24] Agriculture is responsible for over 70 percent of global freshwater withdrawal and is thus a leading contributor to the freshwater stress affecting two billion people today.[25] India has four percent of global freshwater resources to support 19 percent of the world's population. Some 80 percent of water in India goes to agriculture, primarily from groundwater sources.[26] This is unsustainable.

Irrigated agricultural land represents 20 percent of total global cultivated land (about 300 million hectares) yet produces 40 percent of all food worldwide.[27] Increased irrigation thus has the potential to improve global yields dramatically, particularly in sub-Saharan Africa, where 95 percent of cropland is rain-fed.[28]

However, conventional irrigation cannot be the whole solution. It too has an environmental impact, because of associated water logging and salinisation. The Food and Agriculture Organization of the United Nations (FAO) estimates that around 30 percent of irrigated land is now severely or moderately impaired by these side effects, with salinisation effectively reducing the world's irrigated area by one to two percent a year.[29] Technologies such as precision agriculture and genetic breeding could address some of these challenges.[30]

Agriculture also affects the quality of freshwater as large quantities of agrochemicals, organic matter, drug residues and sediments contaminate water bodies. In China, agriculture is responsible for a large proportion of surface-water pollution and is the leading cause of groundwater pollution by nitrogen. This has severe impacts on aquatic ecosystems and human health.

Agricultural impact on waterways can be alleviated via policy and regenerative agricultural practices. Supporting farmers to develop water impact plans, manage manure away from areas with high groundwater levels, invest in riparian planting and fence off waterways from cattle will all have an impact on water quality in agricultural environments. Similarly, smart irrigation technologies such as drip-fed precision irrigation can reduce water waste and excess fertiliser run-off.

Goals and benefits

Scaling productive, regenerative agriculture could deliver four main potential benefits.

- **Environment.** Improvements from rebuilding soil health and carbon content (so that soil acts as a carbon sink), lowering greenhouse gas emissions from synthetic fertilisers, protecting biodiversity through reduced use of pesticides, herbicides and fungicides, and reduced negative impacts on freshwater and the ocean.
- **Health.** Improvements from better air quality (by reducing nitrous oxide releases from chemical fertilisers and inadequate manure management and reducing particulate matter by cutting down on tillage) and reduced exposure to chemical toxins.
- **Inclusion.** Gains from developing more diversified, profitable markets for agricultural produce, creating more skilled roles in farming, and lowering dependency on chemical inputs. This last dependency creates a significant cost for most farmers and a major risk for smaller farmers. Production risk would decrease due to improved resilience against disease and drought associated with healthier soils and more regenerative forms of agriculture.[31]
- **Food security.** Healthy soils can store more water and, according to some studies, deliver more nutrients to food crops. Greater agrobiodiversity increases resilience to pests and weather instability and diversifies nutrition.

The annual economic gain from this transition is an estimated $1.170 trillion by 2030, and $3.035 trillion by 2050. A reduction in public health costs of $850 billion a year by 2030 would be the biggest driver of the gain.

BOX 14

Agrobiodiversity[32]

The potential benefits of agricultural biodiversity in regenerative food and land use systems is often not realised because of poor conservation, lack of information and/or restrictive policies. Public policies, which often focus on a narrow variety of staple seeds and as a result, crowd out the informal seed sector, need to explicitly support and stimulate the production and distribution of a diversity of crops and varieties of high-quality seed through both formal and informal seed systems. Successful conservation in support of regenerative systems needs an integrated approach that safeguards genetic diversity and would be:

1. Backed up in ex situ facilities (gene banks) for posterity and in perpetuity and made readily available and accessible for use by researchers and farmers.
2. Conserved "on farm", managed by farmers and allowed to respond to natural and human selection.
3. Conserved in situ in the wild, in natural habitats responding to natural selection.
4. Underpinned by effective information systems at the international, regional and national levels on the availability, status, threats, characteristics/traits of genetic diversity for food and agriculture.
5. Coordinated across agricultural and environmental ministries responsible for genetic resources use and conservation.

The regenerative farming revolution now under way is comparable to the renewable energy movement of ten to 15 years ago. Some large companies are heavily engaged in forms of regenerative agriculture, in dairy as well as crop production. Many farmers in livestock, fruit and vegetables as well as staple crops are progressively reducing chemical inputs, using more crop rotation, building up soil health and making their production mix more biodiverse. This change in farming practice is taking root not only in food production, but also in other areas of the agriculture sector such as fibre production (see Box 15 on the Better Cotton Initiative).

BOX 15

Better Cotton Initiative

The Better Cotton Initiative (BCI) is the largest cotton sustainability programme in the world. It has over 1,600 member organisations spanning the global supply chain from civil society and farmers' organisations to retailers and brands.[33]

With its partners, it provides training in sustainable, regenerative farming practices to more than two million cotton farmers in 21 countries. In the 2017-2018 cotton season, licensed BCI farmers produced more than five million metric tonnes of "Better Cotton", making up around 19 percent of global cotton production.

The BCI Better Cotton Standard System is designed to ensure the exchange of good practices, and to encourage the scaling up of collective action to establish Better Cotton as a sustainable mainstream commodity.[34] It is made up of the following components:

- **Principles and criteria.** Key principles provide a definition of Better Cotton, including: minimisation of the harmful impact of crop protection practices, promotion of water stewardship, use of practices that care for soil health, enhancement of biodiversity, responsible land use, care and preservation of fibre quality, promotion of decent work, and operation of an effective management system
- **Capacity building.** Support and training for farmers in growing Better Cotton, through working with experienced partners at field level
- **Assurance programme.** Regular farm assessment and measurement of results through consistent results indicators, encouraging farmers to improve continuously
- **Chain of custody.** Linking of supply and demand in the Better Cotton supply chain
- **Claims framework.** Communication of data, information and stories from the field to spread the word about Better Cotton
- **Results and impact.** Monitoring and evaluation mechanisms measure progress to ensure that Better Cotton delivers the intended impact

Regenerative farming is likely to scale further as practices improve and consumers demand food that is more sustainable. The British Broadcasting Corporation's (BBC) Blue Planet documentary series, narrated by Sir David Attenborough, initiated a social movement against single-use plastics. A consumer-led revolution centred on food could be triggered by a similar exposure of the kind of evidence that fuels health and environmental concerns. The differences in environmental impact between various types of livestock production would make a striking example (see Box 16).

BOX 16

Cattle systems

In many parts of the world, animals – cattle, sheep, goats, chickens, pigs and fish – are important both as a store of wealth and in enabling rural communities to secure resilient livelihoods, in particular those of women. In rural areas of lower income countries with high levels of malnutrition, animal protein can provide important nutrients of which it may be the only available or accessible source. Well-managed animals can also play a vital role in enhancing the resilience and health of the soil. Furthermore, much of the land used for producing ruminants (cattle, sheep and goats) is grassland that is unsuitable for growing crops or trees. Animal protein therefore should and will remain a key part of diets and livelihoods.

It remains the case, however, that the amounts of animal protein consumed by some parts of the population, and the way it is produced, are highly problematic. This is particularly true in relation to ruminants, which were responsible for nearly half of the greenhouse gas emissions from agricultural production in 2010, or about 6 percent of total global greenhouse gas emissions that year, even before accounting for land use change.[35] On average, meat from ruminants is far more resource-intensive than other commonly consumed foods. Beef on average requires ten times more land and emits ten times more greenhouse gases per gram of edible protein than chicken, for example.[36] Compared to common plant proteins such as beans, beef is on average 20 times as land- and greenhouse gas-intensive. Beef production in a number of key producer countries is also a leading driver of tropical deforestation. And, since most suitable native grasslands are being used for pasture already, increasing demand for beef will put further pressure on tropical forests, the climate and biodiversity. One estimate projects growth in demand for ruminant meat of nearly 90 percent between 2010 and 2050.[37] This would be a major challenge for sustainability.

A number of studies have shown that high consumption of red meat (both ruminant meats and pork) is correlated with damage to health.[38] The exact connections remain debated, with some research focusing the concern more on processed meats such as bacon and sausages, but nutritionists generally agree that current levels of consumption in most higher income countries, in some emerging economies and in segments of lower income countries qualify as overconsumption from a health perspective.[39]

Limiting and thereafter reducing future global demand for red meat from ruminants, especially from cattle, and producing it at a lower environmental cost are therefore two essential features of an overall transition to sustainable food and land use systems. However, the global numbers mask significant regional and national differences in consumption and production that need to inform a balanced approach to both issues.

First, while total global demand for ruminant meat should ideally be halted and then gradually reduced, consumption throughout the world should converge towards the levels recommended in the human and planetary health diet, with people in some areas (children and women of childbearing age in sub-Saharan Africa) eating more meat, while people in other areas (such as in the United States and Canada) eating less (see critical transition 1).

Second, the land use efficiency of beef production varies by a factor of 100 across the world.[40] This means there are opportunities to boost livestock and pasture productivity, especially in lower income countries. This would free up land for other purposes, including forest and other ecosystem restoration, and decrease pressure on remaining natural ecosystems.

More efficient livestock farming can greatly reduce greenhouse gas emissions while boosting soil health and farmer incomes. The efficiency of beef production in terms of greenhouse gas emissions per kilogram of

BOX 16 - Continued

protein produced varies by a factor of 30, giving sizeable scope for improvement.[41] Actions farmers can take include improving pasture fertilisation, boosting feed quality and veterinary care, raising improved animal breeds, and using improved management systems and practices such as rotational grazing or silvo-pasture. Improving manure management and using technologies that prevent nitrogen in animal wastes on pastures from turning into nitrous oxide can reduce manure-related emissions. New inputs such as the feed additive 3-nitrooxypropan (3-NOP) can reduce enteric fermentation.

In summary: what is needed is to halt the growth in and thereafter gradually reduce global demand for ruminant meats, divide what is produced more evenly across the global population, shift production practices to ensure that all ruminant meat production is as close to best practice as possible, and invest in R&D and encourage innovation to drive emissions down even further.

Produced and consumed in limited amounts and according to best practice – the "right animals, in the right places, raised in the right conditions", in the words of one farmer – ruminants can continue to play an important though eventually more limited role than today in sustainable food and land use systems.

The regenerative agriculture movement faces a number of barriers, however. Government subsidies often support more input-intensive forms of agriculture and do little to drive better nutrition and environmental outcomes. There is little or no pricing or regulation of external factors to penalise unsustainable practices. Farmers face a transition risk and lack confidence that means that shifting to regenerative practices will not reduce yields in the short or long term. There is insufficient R&D in new biological inputs, and not enough open platforms for sharing knowledge across the multiple pilots and experiments taking place across the world. Logistics systems are not yet set up to segregate at scale more from less sustainably produced crops. And the large off-takers and food companies and traders are not making regenerative agriculture a priority, in part because it is not a priority for their investors. Natural capital is not explicitly on the financial balance sheet of most food companies or lenders (see Box 17 and Box 6 in Chapter 2).

BOX 17

Capitals thinking

Investment decisions are based largely on financial information. They do not consider the value of essential relationships between nature and people. But a growing number of organisations around the world are now applying "capitals" thinking to their strategies to take the value of those relationships into account. This movement has developed approaches to broaden the definition of capital to include natural, social and intangible assets alongside more conventional categories of physical and financial capital.[42]

Olam International, one of the world's largest suppliers of cocoa, coffee, cotton and rice, has a smallholder programme in India that is focused on water stewardship. By using a capitals approach, Olam has increased productivity and reduced its impact on water supplies. Rabobank, a Dutch bank committed to be a leading bank in the field of food and agriculture worldwide, has applied capitals thinking to develop a way to measure the influence of individual dairy farms on biodiversity, and the Australian government is starting to use capitals thinking to address drought stress.

Many of these barriers have been recognised. A number of coalitions and public-private partnerships aiming to promote regenerative practices are forming, among them Nature for Business Coalition, the One Planet Lab Business for Biodiversity (OP2B) Coalition (Box 18), the Natural Capital Coalition and a coalition led by the Consortium of International Agricultural Research Centers (CGIAR) to pull together the different research communities.

BOX 18

Business for Biodiversity

Businesses are starting to understand their dependency on a healthy natural world and the economic opportunities that a shift towards a sustainable economy will create. To support this shift, businesses are coming together in coalitions to rally for the nature agenda:

1. **The Business for Nature coalition** brings together a diverse group of organisations working with business on environmental issues such as the World Business Council for Sustainable Development, the World Economic Forum, the International Chamber of Commerce, We Mean Business and others, and is calling for action to reverse nature loss and for governments to create a positive policy feedback loop to encourage further business actions. The objective of this collaboration is to amplify and galvanise a business movement for nature by:

   - Convening a united business voice calling on global decision makers to commit to halt the loss of nature.
   - Demonstrating business ambition to protect and enhance nature by uniting, amplifying and helping scale existing business commitment platforms.
   - Showcasing business solutions that are already driving business action and translate commitments into actions for meaningful impact.
   - Communicating that nature protection makes economic sense: Nature provides over $125 trillion worth of environmental services per year to our economy.[43]

2. **One Planet Business for Biodiversity (OP2B)** is a business-led coalition aimed at contributing to the agenda and pillars of the Convention on Biological Diversity of the United Nations (UN) (1992): conserve, restore, transform. Its ambition is to propose solutions to prevent the ongoing loss of biodiversity. OP2B's members commit to work through their supply chains to:

   - Create an innovative framework that gathers companies, public bodies, academia, civil society and other groups to work together to preserve and restore biodiversity
   - Adopt concrete, transformational and scalable objectives for implementation throughout their own supply chains within three streams:
     i. Scale up regenerative agriculture practices for livestock and crops at farm level, with an emphasis on soil health, to preserve and restore biodiversity
     ii. Enhance cultivated biodiversity by offering consumers a more diversified portfolio of products
     iii. Develop local integrated approaches to protect and restore the most biodiverse and fragile ecosystems, including forests
   - Develop an advocacy and communication framework that will shape the global ten-year business, government and finance agenda for nature, connect climate-biodiversity-agriculture ambitions with SDGs, take part in UN and other international events and broadcast the coalition's commitments globally

Priority actions

To achieve a global transition to regenerative farming at speed and scale, governments, business, finance and civil society need to work on five priorities.

Shift agricultural subsidies towards regenerative farming

Research conducted by the Food Policy Research Institute (IFPRI) for this report indicates that only around 15 percent of public support is directly linked to the public benefit.[44] There are promising examples of progress, however. Between 1986 and 2016, European Union Common Agricultural Policy reforms resulted in market price support being reduced from 92 percent to 27 percent, nitrogen oxide emissions from fertiliser use fell by 17 percent and yields increased by 28 percent.[45] China is phasing out support for fertilisers and learning how to avoid their use without compromising yields. And the United Kingdom is shifting its agricultural support policies more explicitly to environmental public goods.

But there is a long way to go. These perverse subsidies need to be rapidly redirected or phased out.[46] One promising avenue to explore is repurposing them as payments for ecosystem services for farmers who increase soil carbon - a good proxy for soil health.

Use other public finance to incentivise regenerative farming

Governments have a range of other tools to deploy, such as taxing undesirable outcomes and subsidising desirable outcomes. They could start by levying payments on greenhouse gas emissions and over time extend levies to other types of pollution. Public procurement, at city and municipal levels of government, can also be used to encourage local producers using regenerative practices. Apart from the environmental benefits, this provides an opportunity to engage consumers in the transformation.

Share information through better open source networks and training

The combinations of farming practices and technologies that unlock yield productivity and natural capital regeneration are as diverse as the planet's crops, landscapes and farming systems. To disseminate the most effective practices and technologies, governments and businesses need to target agricultural extension services – including making seed banks drivers of both high productivity and agrobiodiversity – and training programmes tailored to specific farmer contexts. Farmer-to-farmer peer learning is also a powerful mechanism for sharing knowledge and helping to mitigate the perception that reforms are being imposed from above.[47]

As farmers innovate, there is growing awareness of profitable models that regenerate natural capital while increasing yields. These need to be further disseminated to farmers. For example, it has been demonstrated that large-scale, highly productive farms in Europe can transition gradually over five years to practices that regenerate soil health while achieving 30 percent reductions in the use of agrochemicals.[48] For a cereal farm in the United Kingdom, this translates into a 17 percent improvement in gross margin.[49] Precision agriculture technologies can also support regenerative agriculture by reducing fertiliser, pesticide or irrigation water use through careful targeting. Halting overuse of fertilisers would be a far-reaching measure to cut greenhouse gas emissions.

In 2018, the Andhra Pradesh state government in India launched a financing and training programme to help six million farms, many of them smallholders, to transition to zero-budget natural farming (ZBNF) practices[iv] by 2024.[50] The programme is intended to reduce farmers' input costs while increasing their incomes, restore ecosystem health and support production of a more diverse range of crop species. The programme recognises farmer-to-farmer knowledge dissemination as the most effective means of driving the changes.

[iv] ZBNF is a holistic alternative to the present paradigm of high cost chemical inputs-based agriculture and to address the negative and uncertain impacts of climate change. This is closely aligned to the principles of agro-ecology but is also rooted in Indian tradition. ZBNF is pioneered by Shri. Subhash Palekar, a Padma Shri Awardee, who is regarded as the "Father of zero budget natural farming" across India.[51]

Left: Farmer Usha Rani from Agripally village in Krishna, India, district showing seeds from inside drumsticks at a Zero Budget Natural Farm.
Right: A farmer uses Ghana Jeevamrutham as organic input in his Banana plantation in Agrapally village, India.

Brazil´s Low-Carbon Agricultural Plan is attempting to do something similar at scale with larger farmers. It aims to incentivise efficient integration of crops, livestock and forestry in the same farming unit, along with technologies that reduce the use of inputs.[52]

Increase R&D spending and innovation

A host of research areas have the potential to expand agricultural productivity and natural capital regeneration but are currently underinvested. They include research into regenerative agronomic practices, bio-fertilisers and other compounds that enhance soil health. There is growing interest in applying Internet of Things (IoT) technologies to agriculture, including in-field sensors and passive monitoring devices that complement remote sensing from satellites. Further out, there may be a role for gene editing, such as that pioneered by the Salk Institute to enhance nitrate fixation of root structures.[53]

Governments and the private sector need to increase investment and R&D spending in these areas. Investments in infrastructure, such as irrigation water recycling systems or nutrient recycling systems to make the most of animal manure as fertiliser, are also critical. More generally concerning innovation, much more public-private collaboration and a stronger emphasis on rapid field testing and open data sharing would be helpful. Much good field research is locked away in hard-to-access public databases and impossible-to-access private ones.

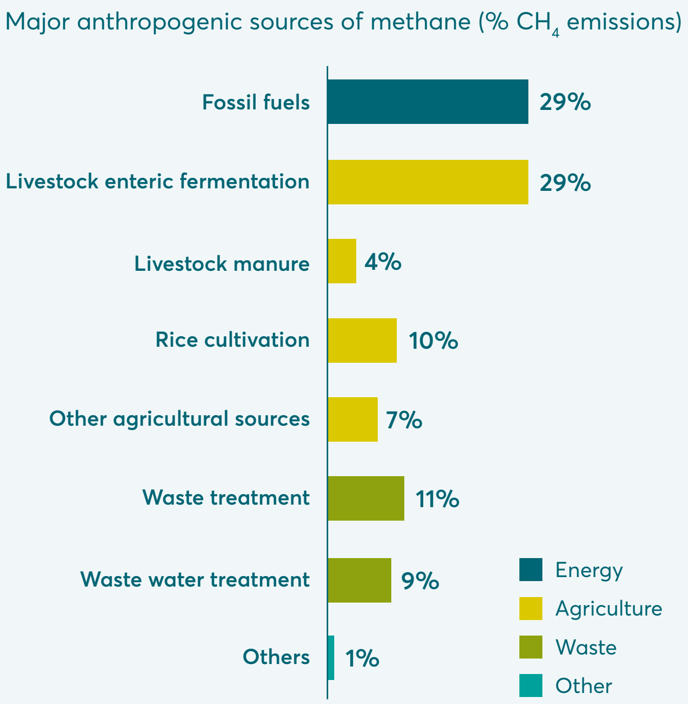
Governments have a distinct role to play in encouraging R&D focused on reducing the external environmental factors related to agricultural production and on the rapid dissemination of best practices. It would be essential for governments to put in place a mix of sticks and carrots (externality pricing, regulation, transitional incentives or feed-in type mechanisms) to drive private sector innovation to increase resource productivity and reduce the environmental footprint. Viable innovations could then be systematically rolled out at scale, where necessary supported by additional targeted or auto-ratcheting regulation.

BOX 19

Reducing methane emissions from agriculture

EXHIBIT 18

Agriculture makes up 50 percent of anthropogenic methane emissions



Source: "Methane," Climate & Clean Air Coalition, accessed August 30, 2019, https://ccacoalition.org/en/slcps/methane.

Cattle. Cattle are responsible for over half of methane emissions from agriculture. A 30 percent reduction could be achieved if global best practice, currently implemented by the ten percent of producers with the lowest emissions intensity, were adopted worldwide.[54] These practices include using better-quality feed and feed balancing, improving breeding and animal health to shrink herd losses, and manure management. Innovation through targeted R&D holds the potential for further reductions.

Rice. Flooded rice fields are responsible for roughly ten percent of total anthropogenic methane emissions. Methane emissions from rice can be reduced by up to 70 percent – without losses in productivity – using climate-smart agricultural practices such as removing the rice straw between harvests, alternate wetting and drying techniques and improved fertiliser application. Further R&D, field testing and rapid dissemination of best practice hold the potential to drive down emissions even further. The Sustainable Rice Landscapes Initiative, which brings together public and private partners to increase resource use and reduce greenhouse gas emissions from rice production, is driving forward this work in the Association of Southeast Asian Nations (ASEAN) region. If the approach can be standardised and scaled, it could be extended to other rice-growing regions in west Africa or Latin America.[55]

Engage business and investors

Most food companies purchase commodities on the spot market or through short-term contracts. This reduces incentives along the value chain for investment in preserving and valuing natural capital. There are good reasons, though, for businesses to make longer-term investments in farmers and landscapes that incentivise natural capital protection and regeneration: it can enhance their security of supply, mitigate reputational risks and give farmers greater certainty. Procurement models that value natural capital involve helping farmers to meet regenerative procurement standards, investing in farmer training in strategically important production regions and providing off-take guarantees to encourage regenerative production practices. Such models remain a minority, however, partly because too few mainstream investors are challenging business on their approach to natural capital or demanding specific metrics on regenerative sourcing strategies.

BOX 20

Business case for nature-based solutions in the watershed of Pasuruan, Indonesia (Danone and the World Agroforestry Center (ICRAF))

Pasuruan is home to Danone's second largest bottled water facility in Indonesia. The flow from the Rejoso natural spring that feeds Pasuruan has fallen by more than 20 percent since 2007.[56] Experts estimate that failure to conserve water benefits in this watershed will result in zero water discharge in this area by 2040. It is crucial to rebalance the watershed to ensure water security for all: economic and agricultural activities as well as communities.

Danone, the Danone Ecosystem Fund (DEF) and ICRAF have joined forces with public authorities to invest in land management to improve water quality and quantity and generate multiple long-term benefits for people and nature such as soil fertility improvement, increased yield or biodiversity preservation. Actions consist of featuring horticulture (10 percent) in upstream, complex agroforestry (25 percent) in midstream and rice fields (29 percent) in downstream of the 62,773 hectares of the Rejoso watershed.[57]

Maintaining and rehabilitating tree-based farming systems in the upstream and midstream of Rejoso will support an infiltrate water rate increased up to 9-23 percent and sequester about 43 tonnes of carbon dioxide per hectare or about 678,000 tonnes of carbon dioxide annually. Moreover, the water and soil conservation will increase soil health and smallholders' farming productivity, expected to result in an increase up to 40 percent of farmers' income on horticulture and 15 percent on agroforestry.[58] In addition, the implementation of System of Rice Intensification (SRI) method downstream is a promising option that significantly reduces methane emission, uses less water, minimises cost of production and increases the yield by up to 20 percent.[59]

To help farmers change their practices and adopt innovations while ensuring farm resilience, appropriate support will be provided to the farmers (technical skills, sharing of experiences) to cover the risk involved in the transition phase.

This example demonstrates the multiple benefits of appropriate watershed management beyond rebalancing the source and proves the importance of agriculture in supporting farmers resilience and climate change mitigation.

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