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The challenge of innovation

ZERO HUNGER
Research points the way

ORGANIC AGRICULTURE
Long-term trials with promising results

DAIRY HUSBANDRY
Bridging smallholders' knowledge and skills gaps

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Dear Reader,

"Innovate or die" is a known mantra in the business world. It has already accompanied generations of entrepreneurs, reminding them that if they seek to survive on the market in the long run, "business as usual" cannot be an option. So innovations are a survival strategy. However, this premise has long not applied solely to the business world. For some time now, the stakeholders in development cooperation have been aware that resorting to tried and tested insights and methods simply isn't enough when it comes to coping with global challenges such as climate change and biodiversity loss, depletion of natural resources and a growing number of conflicts. And, at the latest, since the entire extent of harm done by the coronavirus pandemic has been revealed, for our food systems too, it has become clear that "business as usual" is no viable solution.

Now, it is not as if things had come to a halt over the past years. For example, CGIAR, the largest international agricultural research network, has been undergoing a process of permanent reform for two decades, seeking to adapt its organisational structure as well as its research agenda to changing global challenges. And in the scientific community, just like among the development cooperation actors, there is far-reaching agreement that progress in development in the rural regions of our world not being at the level desired cannot be put down to a lack of knowledge. Rather, the problem is that of implementing this knowledge – and hence the question of how new ideas get "from the lab to the field", how innovative solutions can be taken to scale. And how the overall process can be speeded up. So that we don't have to keep repeating that we are not on track regarding the achievement of the transformational Agenda 2030, with its 17 Sustainable Development Goals.

Leapfrogging could ensure that necessary developments are not only accelerated but are also sustainable. What this term, which comes from economics, refers to is that certain steps in a development process are intentionally omitted. Here, mobile telephones are frequently cited as an example. Thanks to this technology, many countries in Africa have simply leapfrogged the level of fixed-line phoning. Or the use of decentralised renewable energy supply solutions, which doesn't require the extensive and time-consuming establishment of fixed-line networks. In African agriculture, leapfrogging could contribute to avoiding harmful impacts such as those resulting from the Green Revolution in India as well as the intensification of agriculture in many industrialised countries.

Our authors have gathered many examples bearing the potential to initiate such leaps. Frequently, they are based on digital solutions, which can act as game-changers in particular in remote rural areas, where access to information and services – be it in the agricultural sector, be it in other important development sectors like health or education – is difficult. Here, the emphasis is on "can", for the examples show that an innovative solution, regardless of how so smart, promising and easy to handle it may be, need not turn into a sure-fire success.

There are a multitude of reasons for this adoption gap, ranging from inefficiencies in various markets (e.g. inputs and outputs, land, labour, financing) and information through unforeseen spill-over effects to individual character traits.

The successful implementation of sustainable innovations also requires breaking down traditional barriers between businesses and philanthropic projects. The growing significance of social businesses shows just how sensible it can be to make the most of both worlds. Their recipe for success is a mix of agility and flexibility, customer-oriented thinking and overcoming cultural orthodoxies. It is by no coincidence that development cooperation is also increasingly forming alliances with these enterprises and is training young entrepreneurs accordingly.

Some time ago, Zia Khan, Senior Vice President Innovation of the Rockefeller Foundation, said that innovations are important because "they solve problems today in a way that positions us to address the unforeseen problems of tomorrow". On this note, we wish you inspiring reading.

On behalf of the editorial team,

Silvia Richter

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You can change the game

By Florian Landorff and Franziska Kerting

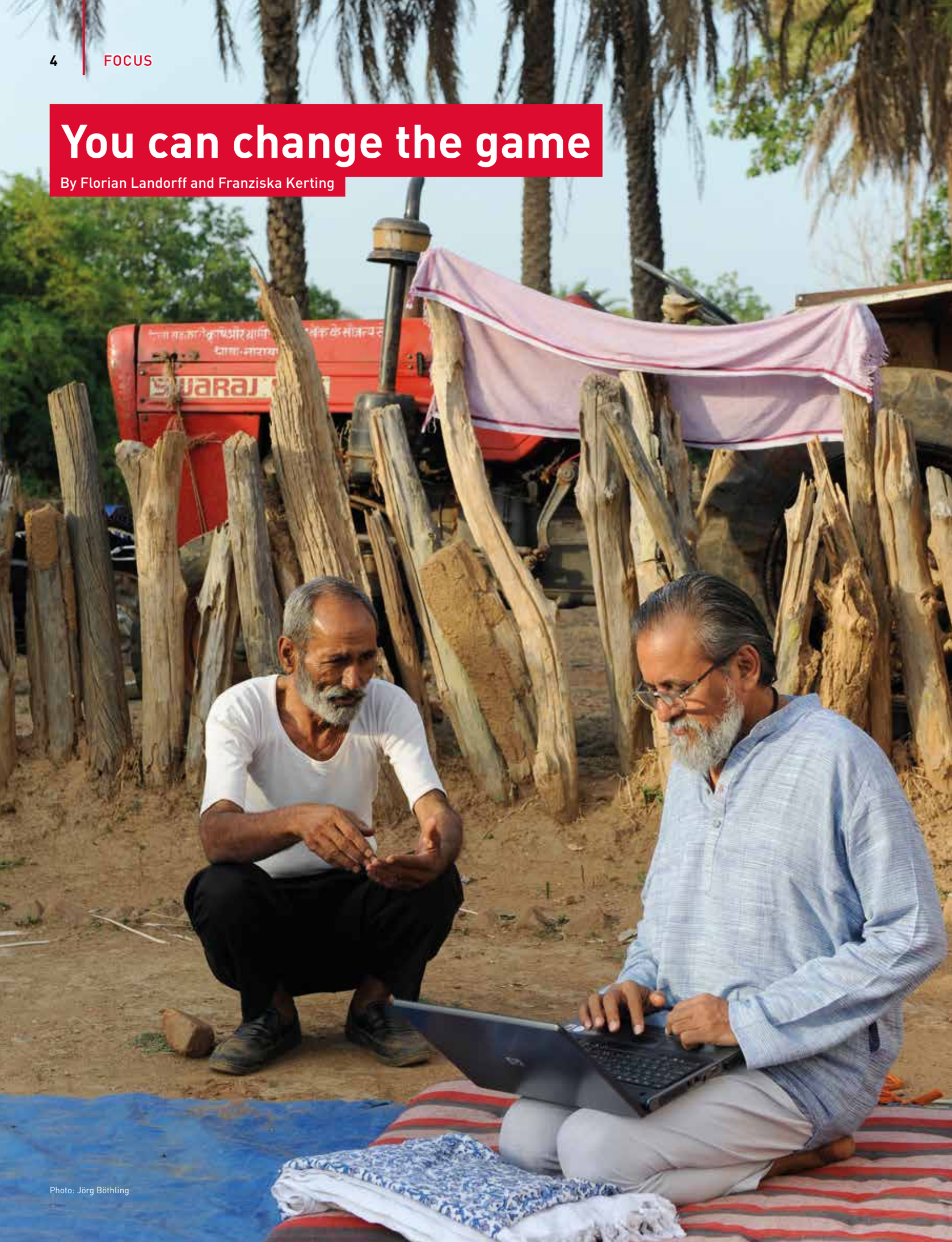

Photo: Jörg Böthling

Over the last few years, a strong trend to set up incubators, accelerators and innovation platforms has become apparent. Start-ups on digital technologies and social businesses are rapidly growing with the promise to reach those up to four billion people at the Bottom of the Pyramid. Is this just another fashion? Our authors explain why development cooperation must strengthen its innovative capabilities, and which experiences Welthungerhilfe has made in this respect.

Especially those actors in development cooperation with a strong and impactful track record will ask why they should change their existing modes of operation. But many achievements from the last decades are jeopardised. The hunger curve is moving up again, environmental degradation is getting out of control, while social and economic inequalities and conflicts are increasing in many countries. Core framework conditions are changing rapidly, and traditional methods and technologies to fight hunger and poverty are reaching their limits.

Climate change poses an unprecedented challenge to all humankind, affecting the most vulnerable first and hardest. It is a disruptor that requires disruptive reactions – faster and more innovative. Globalisation in combination with a growing world population is putting resources under pressure. Armed conflicts and crises are becoming super-regional. Fragmented answers do not suffice anymore. And finally, digitalisation is triggering new dynamics incredibly fast. Concerns over data protection and a "digital divide" between North and South – and within the developing societies – are rising. On the other hand, digitalisation provides opportunities such as access to markets and information, social mobilisation and transparency in the policy sector. Mechanisms of technical and financial assistance are not keeping the promise to create global justice. Communities in the Global South more than ever demand true eye-level cooperation and empowerment. And, especially younger generations in many countries of the Global North share this perspective.

"Innovate or die" is a known mantra in the business world. As it seems, it is becoming more and more relevant for development cooperation, too. The effectiveness of our sector will depend on our ability to strengthen our innovative capabilities. The present situation is:

- New opportunities for impact are not identified systematically.
- Sometimes ideas for great solutions are found, but they cannot grow for lack of support – financial resources, expertise and partnerships are not available.
- If a great solution for impact is developed, it often does not unfold the impact it could have as it is not scaled for maximum impact.

But innovation is not just an answer to a changing framework and to a desire for greater effectiveness. An increasing number of organisations understand innovation inherently as an opportunity to transform themselves and their working cultures. Looking at the leading business companies from the 1970s, how many of them have prevailed? Only very few, and only those that have managed to reinvent themselves permanently. And only those that were ready to enter new fields of action at the right moment.

Boosting digital innovations

Providing digital solutions poses such a promising innovative field of action in development cooperation. This can, for example, be products or services for market linkages, learning and information sharing platforms, tools for increased process efficiency or digital financial services. Scaling digital products is relatively easy, and transfer from one country to another is simple and considerably economical, if cultural and geographic differences as well as the context are understood. They can create good value for the users through simpler, faster and cheaper processes, new forms of social organisation and better access to networks, markets and information.

While the opportunities for digital apps in the Global North show signs of saturation, digital market gaps exist in the Global South. The Bottom of the Pyramid is either no interesting customer group for big tech firms or entry in these new markets has been significantly more challenging to them than they expected. This provides an opportunity for local tech start-ups and entrepreneurs in the Global South who are ready to catch up.

There are well proven concepts to identify powerful and, at the same time, profitable ideas. Take, for example, "innovation challenges" – a clear process to find new solutions to problems. It starts with the step of wide ideation, leading to a selection of the best ideas, testing them in simple prototypes and finally selecting and supporting the most promising concepts in order to turn them into a functioning product version. This process can be an inclusive and open invitation for grassroot innovators who might not even have thought of themselves as potential entrepreneurs. But lack of access to funding and technical support often disempowers the local actors. Financing, but also expertise in methodologies, building digital ventures, IT-skills and business planning are needed.

However, the uncertain success of new ideas often keeps supporters away. The formulation of stage gates, clear milestones that must be achieved for each step in the incubation process, can mitigate the risk. If an idea turns out to fail, it must be adjusted or abandoned quickly. This is the case for the majority of ideas, and is nothing bad. On the contrary, holding on to a weak idea would take resources from a potentially stronger one.

Finally, if a digital idea can be turned into a Minimum Viable Product (MVP), a very basic version that possesses the most essential product features, developing it further and scaling it up can produce great impact. Digital solutions can be easily equipped with additional functionalities and multiplied. Economic sustainability as well as the ownership and the use of data are important questions. An open-source policy should be a standard for greatest impact while the protection of user data must be guaranteed according to the highest standards.

Working in business formats

Social businesses are another growing field of action. For many years, businesses and philanthropic projects have been perceived as contrary worlds. And still, merging the good parts of both bears new opportunities for much bigger and long-lasting impact. Social businesses are rapidly gaining importance as a compliment for classic grant-based philanthropic projects. Although still not a very much tested and established format, social businesses are more than a trend. They are an opportunity to give the content of development cooperation a fundamentally new standard format.

Being businesses, they must be needs-oriented by nature, offering products or services that meet sufficient demand from their target groups. If they grow to a self-sustaining maturity level with the right governance structure in place, they can be both profitable and impactful.

Social businesses are not limited in terms of time and will adjust their offerings permanently to changing customer demand. Ideally, the businesses expand over time, scale and multiply their impact. They create local jobs and can have strong positive effects on local value chain creation. To survive, their offerings must stay relevant and qualitatively so good that they can compete with others. But these advantages must be weighed against the risks.

Obviously, establish a business is a complex challenge which is full of uncertainties. Many businesses fail in the first years, and invested money and work is lost. Certain prerequisites must be in place to create a successful social business. Amongst others, a good business case, sufficient start-up funding, access to markets, the right business partners and, most of all, a strong entrepreneurial business team are crucial factors for success.

What does it take?

Ultimately, innovation is much bigger than digital solutions and social businesses. It comprises physical innovations and non-for-profit solutions as well as a set of methodologies, and finally, it is a mind-set, too. Digital products and social businesses are just two examples of new ways to fight hunger and poverty. Some key ingredients can help to enter these fields:

Be agile: Using agile principles and methodologies can make our work more effective, interactive and creative. Many agile methods come from the IT and business world but can easily be adapted to classic project management. Transparent and flexible collaboration helps to adjust actions flexibly, instead of pulling through plans. The Scrum Methodology for product and project management is a good example of an excellent format that allows people from various parts of an organisation and external participants to work and co-create together.

Put the customer in the focus: Participation of target groups is a prerequisite for sustainability. It is an additional step to perceive the people we work with as self-determined "customers" and not as "beneficiaries". This has a truly liberating and empowering effect. Co-designing together with and for these customers creates real value. They have the freedom to demand and choose the best offerings. Proximity to customers is a decisive advantage in idea generation. User-centric design of apps or sales channels for impact products are good examples.

Act in partnerships: Multi-sector partnerships are crucial to scale social innovation. Innovative projects and social businesses are a perfect platform to bring diverse partners together from science, the private sector and impact-driven organisations. Each can contribute with its own set of resources and networks. Innovation is an opportunity to overcome traditional silos, to share insights and to join forces to achieve common goals.

Overcome cultural orthodoxies: Business approaches and even businesses terminologies have left a bitter taste among many impact driven agencies. Neo-capitalistic excesses have manifested a perception that "social" and "business" are contrary poles. But businesses hold the power to create sustainable impact and value for customers, and not only profit and shareholder value. However, the only way to make this evident will be through providing concrete proof.

Have courage: Change is the objective of Development Cooperation, but stability is a dominant feature of its culture. Its eco-system is built on carefulness and caution and tends to replicate proven solutions – for good reasons. As a result, the courage to try out new things, including the possibility to fail, is not strongly incentivised. Creating room to experiment and a culture where failure is not punished but learnt from will be a core task for the leaders in charge.

It takes courage to invest sweat and tears, money and other resources into something without knowing whether it will work. But it can change the world if even one out of a dozen experiments succeeds. Using our innovative potentials for maximum impact is a challenging and yet promising call to all of us.

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SOCIAL BUSINESSES AT WELTHUNGERHILFE

The German NGO Welthungerhilfe started to engage in social businesses in 2017. Today, the organisation is financially and operationally involved in five different purpose-driven companies in Africa which provide products and services that are designed and directed to vulnerable customer groups. Partly, these businesses have developed from own successful not-for-profit projects. In other cases, Welthungerhilfe is joining forces with already existing social businesses and supporting them with its operative structures, expertise in the rural context and markets. Also, most of its own digital products are meant to be managed in social businesses to guarantee their economic sustainability. All businesses have their own local executive management, while Welthungerhilfe is engaged in the Supervisory Boards.

AGRISHARE – BRIDGING A MARKET GAP IN AGRI TOOLS ACCESS

In many African countries, smallholder farmers lack access to necessary productive and transport machinery. Together with local partners in Zimbabwe, Welthungerhilfe has developed AgriShare, a digital platform for agricultural machinery. Bigger farms can rent out their tractors, lorries or other equipment to smallholder farmers or farmer groups. Food production and supply in the region have improved, and both sides benefit economically. The app was tested in Zimbabwe and is currently rolled-out to Uganda. It will be managed in local social businesses to guarantee economic sustainability.

https://www.agrishare.app

CHILD GROWTH MONITOR – A DIGITAL GAME-CHANGER IN THE DETECTION OF UNDERNUTRITION AND MALNUTRITION

Measuring children in order to detect malnutrition in all its forms is a physically difficult and costly process that involves scales, measuring boards and, often, middle upper arm circumference (MUAC) tapes. The results of the manual measuring processes are often inaccurate, and millions of children are never measured. Children often do not get the health and life-saving treatment they need.

The Child Growth Monitor was born as idea in Welthungerhilfe's first innovation challenge to find new approaches in the fight for zero hunger in 2017. It is an app that turns mobile phones into child scanning devices by using artificial intelligence and virtual reality. A 15-person tech team has been formed and is currently preparing the release of the first product version. Many partners from science, the non-profit world, tech companies and other private sector partners have joined this quest.

The first product version of the app is designed for use by health care workers. It will enable them to detect the nutrition problems of millions of children to safeguard their health and save lives.

https://childgrowthmonitor.org

SPOUTS OF WATER – JOINING FORCES FOR GREATER REACH

Unsafe drinking water has major negative health, economic and social effects for Ugandans. The Ugandan company Spouts of Water (founded 2014) is responding to these problems with the production of a locally manufactured Purifayaa ceramic water filter, which effectively takes out 99.99 per cent of bacteria. Since inception, Spouts of Water has distributed over 62,000 Purifaaya filters providing more than 375,000 end-users with long-term access to safe and clean drinking water. Welthungerhilfe started to cooperate with the business in 2019 to bring the product to new rural customer groups and support it on its path to broad impact creation.

https://spouts.org

WASAP – FROM PROJECT TO BUSINESS

Hygiene facilities such as showers, sinks, toilets or wells are unaffordable for many people in Sierra Leone, causing strong negative health and economic effects for the populations. Together with Emas International, a German-based association that promotes simple technologies for safe drinking water access, and a local entrepreneur, Welthungerhilfe has turned a former NGO project on affordable low-tech WASH (Water, Sanitation & Hygiene) solutions into a local low-tech start-up.

The Water Sanitation Promotion Company Limited (Wasap) was established in February 2020 and is now selling affordable products to poor customer segments in the country, including DIY (Do It Yourself) instructions and maintenance support.

www.wasap.life

Photos: Welthungerhilfe

Climate change and its impact urge stepping up innovation efforts. Kenya farmer Mercy Wambui measuring rain water on her farm. Photo: Georgina Smith/ CIAT

More, but not of the same – new funding for a new type of AR4D needed

Given the ambitious targets we need to meet to transform food systems under climate change, innovation efforts need to be significantly stepped up – both in terms of innovation practice and investment volumes. New approaches to financing action in food systems are there, but they have to be linked to innovation to drive rapid transformation.

By Ana Maria Loboguerrero Rodriguez, Bruce Campbell and Alberto Millan

The 2030 Agenda for Sustainable Development sets out an extremely ambitious and transformational vision, with a world free of poverty, hunger, disease and want. The Agenda emphasises the importance of structural transformation to strengthen the productive capacities of least developed countries in all sectors and urges the world to take the transformative steps needed to shift itself onto a sustainable and resilient path.

In this regard the 17 Sustainable Development Goals (SDGs) with their 169 associated targets were announced with the purpose of defining a framework to transform the world. We are not on track to achieve the targets. To provide some examples, we are not reducing child undernourishment fast enough, we are heading for a 3-4 °C warmer world, which would be a disaster for food production, especially for the over 500,000 smallholder farmers in the world. Furthermore, two billion people are overweight, and whereas 650 million people are obese, 690 million went hungry in 2019 (more than in 2018).

A new approach in agricultural research for development is needed

At the heart of this transformation is innovation. Many actions can be taken to align agriculture and food systems on a pathway that is more sustainable, inclusive, healthy and climate-resilient. However, these actions have to enable innovation across all food systems actors – that is all 7.7 billion of us. Agricultural research for development (AR4D) is a major part of the innovation system, but it cannot be business as usual AR4D.

Current AR4D and innovation systems are often fragmented, inefficient, overly supply-based and siloed. Innovation can be hampered by fear of failure, perverse incentives that may result in duplication and redundancy, short-term orientations and a focus on "publish or perish". In such circumstances, it is difficult to deliver

end-to-end, sustainable solutions to problems. By end-to-end, we refer to approaches that work across the innovation system for agriculture (from early-stage development to product development to large-scale deployment), where research efforts are targeted towards end-user needs and underpinned by robust partnerships with private, public and civil society actors to ensure adoption and societal outcomes. The approach also implies working on the institutions and incentives that ensure uptake and scaling.

One of the eleven actions for transforming food systems proposed by the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) is to significantly change the approach of public AR4D by 2025, with at least 50 per cent of public investment in AR4D providing end-to-end solutions. We will also need to offer researchers the right incentives so that they can embark on this new way of doing AR4D, where, for example, publications are not the dominant metric of success. Mechanisms such as outcome-based budgeting – where resources are allocated based on demonstrated ability of science groups to generate outcomes – should be considered as enablers of change.

Fostering new types of investment in food systems

The days when the unique challenge was to increase agricultural productivity are long gone. The challenge now is different and more complex. We need to satisfy increasing food demand while dealing with climate change impacts, increase incomes for farmers while reducing the ecological footprint from food systems, reduce inequality, enhance animal welfare and ensure better diets. Moreover, the challenges are magnified when dealing with small- and medium-sized farming enterprises, where finance, resources and information are often lacking, where poverty, vulnerability to climate change and food insecurity intersect, and where transaction costs are extremely high to reach millions of small farms.

Traditional sources of funding for AR4D have often not been sufficient; and are definitely insufficient for the new agenda. For example, in the 2014 Malabo Declaration on Accelerated Agricultural Growth, African governments committed to allocate at least ten per cent of public spending to agriculture, but few countries have met that target. According to the Biennial Review published recently, ''the continent as a whole is not on track to meet the goals and targets of the Malabo Declaration...''.

Felistus Chipungu, orange-fleshed sweet potato breeder and scientist with the International Potato Center (CIP), working at a CIP facility in Blantyre, Malawi.

Photo: Chris de Bode/ CGIAR

Farmer Sita Kumari uses mobile phone apps to enhance her yields and get access to market and labour. Here she is with scientist Pratima Baral and her friend Nilam (r).

Photo: Georgina Smith/ CIAT

Another example is CGIAR – the Consultative Group on International Agricultural Research – which although relatively well funded, has an AR4D budget which is less than that of some of the large agricultural companies (also see article on pages 11-13). To date, most finance for adaptation to climate change and other actions for small-scale farmers comes from public sources, such as development finance institutions, bilateral donors and climate funds. A key question is whether such funds could be used to leverage manifold more private capital. Traditionally, a number of barriers such as lack of pipeline/investable projects, high investment risk and lack of primary data and information as well as lack of intermediation to efficiently connect different pools of capital to investments has prevented private finance from flowing to food systems initiatives at scale. Public finance can help reduce the bottlenecks so that private finance flows.

Some current trends provide hope. Food and agriculture companies, investors and financial institutions are increasingly realising the climate-related risks they face, as climate change affects markets, assets, infrastructure, investments, workforce, etc. They are also being put under growing pressure from their customers, shareholders and the public at large to rise to the new challenges. Many have already started assessing their exposure and risk/return profiles, designing strategies to capitalise on new business and sustainable finance opportunities, and they have been shaping their business to improve their social and environmental standing. Thus, the time is ripe for new approaches to financing food systems innovations.

According to the Business and Sustainable Development Commission, business opportunities in the implementation of the SDGs related to food could be worth over 2.3 trillion US dollars (USD) annually for the private sector by 2030. The investment required to realise these opportunities is approximately 320 billion USD per year. Innovations in how public sector funding is used can pave the way to unlock the billions needed to realise these business opportunities. But what could these investments look like?

Innovations in sustainable finance

Blended finance – the use of catalytic capital from public or philanthropic sources to increase private sector investment – is an innovation that is moving rapidly forward. It allows different types of organisations to invest together in a structured way such that each accomplishes their own financial return and/or development impact objectives. To date, approximately 140 billion USD in capital for sustainable development in developing economies has been mobilised through blended finance, with agriculture representing approximately 16 per cent of this. One nice example in relation to this innovation is The Global Innovation Lab for Climate Finance that brings public and private actors together to turn innovative ideas into investable mechanisms for climate adaptation and mitigation. The Lab's over 60 members provide expertise as well as capital for its instruments. They comprise both public-sector institutions such as the Netherlands Ministry of Foreign Affairs or KfW Development Bank and private-sector actors like BlackRock, Allianz or the Rockefeller Foundation. The Lab has launched 35 innovative financing instruments to date, enabling a mobilisation of 1.5 billion USD. Several instruments have focused on smallholders, including the Climate-Smart Lending Platform by F3 Life and the Smallholder Forestry Vehicle.

Considering the massive challenges that society faces, **impact investing** is a growing market. Many investors are incorporating measurable social and environmental impact targets

alongside their financial return targets in their investment portfolio. This growing market provides resources to address the world's most urgent challenges as demonstrated by the case of Netherlands-based Actiam Impact Investing, who decided to invest in Pro Mujer Bolivia (a microfinance institution) in an effort to provide them with the additional working capital needed to expand their client base to provide access to financial services for impoverished women in Bolivia. One fundamental aspect of impact investment is the commitment of the investor to measure and report the social and environmental performance and progress of the investments, ensuring transparency and accountability.

Tech-enabled finance also provides an opportunity to develop innovative financial and market delivery channels. Digital technology reduces transaction costs and creates economies of scale, supports transparency and risk management, and speeds and smoothes cash flows. Examples such as Hello Tractor, a US- and Nigeria-based agtech social enterprise which, through digital tools, connects tractor owners with farmers in need of tractor services, demonstrate the case of this innovation as a way to reach many smallholder farmers that lack the capital to purchase machinery. The emerging data economy and big data analytics offer the opportunity to analyse, understand and address the underlying risks of market failures. In the same manner, big data analytics can be used to more accurately evaluate farmer risk profiles. Blockchain technology can improve the credit system and the information asymmetry, build a smooth information transmission channel, improve the transaction reliability, and reduce the cost of the traditional agricultural financing. It is also consolidating as an innovation for product tracing, emissions monitoring and carbon market finance. As these technologies continue to advance, policy protecting data privacy and incentivising data usage will be necessary to prevent misuse and lack of use of data.

Promoting financial inclusion. Whereas investors may deal in hundreds of millions of dollars, an individual small-scale farmer may only be looking for a few hundred dollars in a particular season. Channelling large investments into small amounts for millions of small-scale farmers is challenging, but digital approaches – as mentioned above – will help bridge the divide. Financial inclusion is essential and can be targeted via the metrics developed for impact investing. It will also be crucial to create and implement innovative approaches to finance that move beyond private collateral as the basis for lending. Empowered local organisations as platforms for increased access to finance through initiatives such as revolving credit, collective savings and finance mobilisation are a crucial part of the ecosystem if scale is to be achieved. Bundling financial services with inputs, training, knowledge-sharing, climate-informed advisory services, etc. can be an important mechanism to leverage economies of scale, minimise cost of delivery, and maximise accessibility for the most vulnerable groups, including women, youth and the impoverished.

Examples where financial systems have gone the last mile include mobile money in Kenya, which has given women more control over their finances, and has supported 194,000 households in leaving poverty, the majority of which are female-headed. **Value Chain Finance** constitutes another mechanism to promote financial inclusion (see Box).

AR4D empowering and leveraging sustainable finance

The ultimate innovation is embedding AR4D in sustainable finance for food systems transformation. The vision is reorienting and leveraging large volumes of capital into food systems that drive transformation. As indicated above, investors and food companies are looking for innovative solutions, thus embedding research into sustainable finance initiatives is key.

We see this starting to happen. For example, a new impact investment fund for climate-smart food systems is being established, where CGIAR/CCAFS partners with the Swiss enterprise responsAbility Investments AG to design a structure and innovative investment solution that can help leverage and deploy private capital at scale in low-carbon and climate resilient food systems. Under this mechanism, CGIAR/CCAFS works with an impact investor to develop its investment strategy, identify and assess key risks and investment opportunities and provide pre-investment and post-investment technical assistance. AR4D can play a profound role in terms of advancing the science towards accurately measuring the social and environmental performance of these investments. AR4D could also engage in developing guidance to rigorously assess and prioritise the major risks affecting actors along agricultural value chains and identifying actionable components of an integrated risk management strategy for the value chain.

The Agenda in food systems has to be ambitious, and we have argued that the funding for AR4D is insufficient and that AR4D cannot be business as usual. Innovations in finance to transform food systems can be the cornerstone for new ways of funding a new type of AR4D.

VALUE CHAIN FINANCE

Value Chain Finance (VCF) refers to financial products and services that flow to or through any point in a value chain enabling investments that aim at increasing actors' returns and facilitating the growth and competitiveness of the chain. It is an approach that fosters understanding of the financing opportunities within a value chain and the way in which finance should be tailored to a specific value chain. As an example, the VCF approach was used in a simulation for plantain production in Nigeria, covering the period from 2016 to 2040. Plantain is considered a "high-value crop". Nevertheless, given a variable and low production, farmers usually lack access to reliable financing measures to grow the crop. In Nigeria, a VCF approach could unlock plantain production, improving the livelihoods of many small-scale farmers. Considering four phases for the implementation of the approach (identification and evaluation of potential value chains, facilitation and leveraging of market linkages, designing of financial products and evaluation of capacity to pay, and granting, monitoring, and collection of loan), analyses show that investment in VCF for plantain in Nigeria could start yielding benefits in the third year, with benefits equalling the cost of investment in the ninth year and a total economic surplus of 2,173,900 USD at the end of the 25-year period.

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Moving towards "One CGIAR"

When the Consultative Group on International Agricultural Research was founded in 1971, its most urgent task was to raise agricultural production to feed the world's rapidly growing population. While this task has not lost its urgency since then, global challenges today are significantly more complex. This has also had an impact on the organisational structure and the research agenda of the Group. Here, our author gives an account of how CGIAR developed and the process of reform which it has been undergoing since the beginning of the millennium.

By Uma Lele

Today, finding climate-smart solutions for agriculture is right at the top of the CGIAR research agenda. Photo: Georgina Smith/ CIAT

CGIAR, the largest international agricultural research network, was once seen as the heart of the global food system. It still remains important particularly for the poorest people in the world, although its relative significance has declined. Other research systems have grown, and support for the CGIAR has stagnated, while the challenges it is expected to address of environmentally sustainable, healthy food systems have multiplied and become more complex.

Originally, the Consultative Group on International Agricultural Research, now simply known as CGIAR, was established in 1971, around the time of the first world food crisis. It was based on the work of two iconic international centres, the International Rice Research Institute (IRRI) and the International Maize and Wheat Improvement Center (CIMMYT), established respectively in 1960 and 1963 to develop high-yielding, disease-resistant varieties, and both supported by the Rockefeller and Ford Foundations. Their work dramatically increased production of staple cereals, and turned countries like India, perpetually facing food shortage in the 1960s, into a net exporter of cereals by the late 1970s. But these investments were not enough to feed the world's rapidly growing population.

A world-wide network of agricultural research centres

So, in 1970, the Rockefeller Foundation proposed a worldwide network of agricultural research centres under a permanent secretariat. Supported and developed by the World Bank, the UN Food and Agriculture Organization (FAO) and the United Nations Development Programme (UNDP), CGIAR was established to coordinate international agricultural research efforts aimed at reducing poverty and achieving food security in developing countries. Implicit in the CGIAR model, rarely well-articulated but practised with conviction in Asia by the likes of Norman Borlaug and Sir John Crawford, was that CGIAR would produce international and regional public goods, with large spill-overs and calling for considerable state-of-the-art scientific expertise and resources, whereas developing countries would invest to strengthen their own research systems to "borrow" new knowledge from CGIAR. As shown below, regrettably, that model has been practised by only a few developing countries.

The System grew from the original four centres, besides CIMMYT and IRRI the Interna-

tional Center for Tropical Agriculture (CIAT) and the International Institute of Tropical Agriculture (IITA), to include many other centres. The research scope also expanded – from rice, wheat and maize to cover cassava, chickpea, sorghum, potato, millet and other food crops, and encompassed livestock, farming systems, the conservation of genetic resources, plant nutrition, water management, policy research, and services to national agricultural research centres in developing countries. By 1983, 13 research centres were operating under its umbrella around the world, and by the 1990s, the number of CGIAR centres had grown to 18. Mergers between the two livestock centres (the International Laboratory for Research on Animal Diseases (ILRAD) and the International Livestock Centre for Africa (ILCA)) and the absorption of work on bananas and plantains into the programme of the International Plant Genetic Resources Institute (IPGRI; later called Bioversity International) reduced the number of centres to 16. Later, another centre, the International Service for National Agricultural Research (ISNAR), was absorbed into the policy research, reducing the total number of supported centres to 15.

This consolidation was not enough to address system-level problems, which consisted of a large number of centres, the increasingly complex research agenda, often short-term funding to carry out long-term research, funding tied to numerous small individual research projects, and the growing demand from donors to "show impacts on the ground", despite little or slow growth in funding. At the same time, in large emerging countries like China, India, and Brazil, major research systems had evolved with formidable cadres of agricultural scientists, while small, low-income countries faced weak national systems with diseconomies of scale.

Public sector research in industrial countries was stagnating as private sector research was increasingly taking up the space, so that the share of developing countries' public research expenditures in global research had increased with increasing differentiation of research systems within them – a few large national agricultural research systems (Nars) in emerging countries, and a large number of small, weak Nars.

The reform process

In response to the changes in the external environment, CGIAR has been in an almost perpetual state of reforms from the start of the new millennium. From 2001 to 2007, it took initial steps to formalise governance and management, adopting a movement towards a centralised model as well as large system-wide challenge programmes.

From 2008 to June 2015, it adopted transformational changes in governance and management. The CGIAR Consortium of International Agricultural Research Centers was established in April 2010 to coordinate and support the work of the 15 international agricultural research centres. The CGIAR Strategy and Results Framework (SRF) was established to guide the work of CGIAR-supported centres. The work of the CGIAR Consortium was governed by the Consortium Board, a ten-member panel that has fiduciary responsibility for CGIAR Research Programs, including monitoring and evaluation and reporting progress to donors. CGIAR Research Programs are approved and funded by the CGIAR Fund on a contractual basis through performance agreements.

Avoiding fragmentation and duplication of effort

In 2008, CGIAR embarked on a change process to improve engagement between all stakeholders in international agricultural research for development – donors, researchers and beneficiaries – and to refocus the efforts of the centres on major global development challenges. A key objective was to integrate the work of the centres and their partners, avoiding fragmentation and duplication of effort.

Thus the CGIAR components included the CGIAR Consortium of International Agricultural Research Centers, the CGIAR Fund, the CGIAR Independent Science and Partnership Council (ISPC) and partners. Research is guided by the CGIAR Strategy and Results Framework. The CGIAR Consortium unites the centres supported by CGIAR; it coordinates limited research activities of about 15 research projects among the centres and provides donors with a single contact point to them. The CGIAR Fund aims to harmonise the efforts of donors to contribute to agricultural research for development, increase available funding and promote financial stability. The CGIAR ISPC, appointed by the CGIAR Fund Council, provides expert advice to the funders of CGIAR, particularly in ensuring that CGIAR's research programs are aligned with the Strategy and Results Framework. It provides a bridge between the funders and the CGIAR Consortium. The hope was that the Strategy and Results Framework would give the strategic direction for the centres and CGIAR Research Programs, ensuring that they focus on delivering measurable results which contribute to achieving CGIAR objectives. However, the research programmes were designed prior to the Framework being ready, so now some retrofitting had to take place to get the programmes in line with it. A biennial Global Conference on Agricultural Research for Development (GCARD) provides a forum for closer engagement of developing countries and partners in developing and guiding the research and development agenda of the CGIAR Consortium and the CGIAR Fund. The first GCARD was held in Montpellier, France, in March 2010.

Developing an integrated System-level research programme

From June 2015 to July 2016, and from then on to the present, further changes to governance and management have been in progress, including the 2019 (November-December) One CGIAR concept – a unified governance and management approach incorporating a reconstituted System Management Board and a new Executive Management Team. These various organisational changes have been intended to develop an integrated System-level research programme across the System's 15 independent research centres, challenged by centre autonomy and donor sovereignty, with different research mandates, and accountable to its 15 independents boards with multiple, fragmented sources of funding for research programmes. At the time of writing this paper three of the 15 centres were in two minds about whether to join the reformed One CGIAR. Second, CGIAR has sought to promote research innovations that transform food, land, and water systems, in the context of climate change, to ensure a scientifically sound programme under circumstances in which the role of an independent scientific advisor has inadvertently become secondary to donors' desire for choice of projects which would promise short-term impacts. Third, by linking research to the realisation of SDG 2 (zero hunger), CGIAR has been working to reduce hunger and foster diet diversification by addressing issues of micronutrient deficiencies. The increasingly complex research agenda has had to be undertaken under conditions of uncertain financial resources tied to numerous small projects. Finally, CGIAR has faced the challenge of reducing the consumers' growing reliance on basic staple crops and livestock (wheat, rice, maize, beans and root crops) for food security, since, historically, CGIAR's main research thrust has been that

The CGIAR System Organization headquarters in Montpellier, France. Photo: CGIAR

of meeting the calorie gap. This has implied incorporating biodiversity into the farming systems to increase resilience to climate change and resource pressures and promote dietary diversity, as opposed to the previous practice of monocropping of high yielding varieties.

Responding to funding and management challenges

In the light of these strategic imperatives, CGIAR has responded to its funding and management challenges creatively. In funding programmes, it has attempted to create "Windows" of completely unrestricted funding (via Window 1), funding directed to centres and programmes (via Window 2) and completely restricted funding (via Window 3). The various reforms were intended to both increase the level of overall funding and the level of unrestricted funding. However, CGIAR has been only partially successful in mobilising increased and unrestricted funding, which increased until about 2014, after which it has declined.

The 2018 CGIAR Annual Performance Report noted that 105 policies, legal instruments and investments were modified in their design or implementation, informed by CGIAR research which involved 1,003 partnerships (CGIAR 2018b, 10).

The 9th Systems Council (November 2019) approved yet another institutional innovation of a unified and integrated "One CGIAR", to adapt to the rapidly changing global conditions, while also making the CGIAR system more relevant and effective. The fragmented nature of CGIAR's governance and institutions had limited the System's ability to both respond to increasingly interconnected challenges and to consistently deliver best practice and effectively scaled, research solutions needed to maximise impact. The expectation is that by integrating and improving, CGIAR can further leverage its role as the leading research and technology partner in agricultural research for development. The process of moving to "One CGIAR" was agreed to at the Extraordinary General Assembly of the Centers (Rome, December 2019). It includes a unified governance and management through a reconstituted System Management Board and a new Executive Management Team. An established unifying mission of "Ending hunger by 2030 – through science to transform food, land, and water systems in a climate crisis," is focused on five impact areas: nutrition, poverty, gender, climate, and environment in support of the SDGs (CGIAR 2019e, 2020).

The new management structure of the "One CGIAR" is now in place, with three qualified managing directors. Additionally, the new structure is formed of three divisions, sub-divided into ten global groups and six Regional Groups, with the Global and Regional Directors reporting directly to the One CGIAR Executive Management Team, who in turn are accountable for institutional performance to the System Board.

The 'Research Delivery and Impact' Division ('RD&I') will consolidate research capabilities into three global 'Science Groups' with five cross-cutting 'Impact Area Platforms'. Science Groups will be the primary operational units of CGIAR research, managing and delivering the CGIAR portfolio of research and innovation, designing research initiatives and bilateral projects, allocating research staff and assets, balancing research budgets, supporting global and local research engagement and fundraising, and providing global scientific leadership to all staff.

The results of this latest ambitious restructuring will take time to materialise. Meanwhile, CGIAR rests on its laurels of well-demonstrated widespread impacts of its past research, mostly in the areas of germplasm improvement, and some policy research.

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Leapfrogging for Africa's agri-food sector

Affordable and effective solutions are being applied in a wide range of areas in which Africa has been lagging behind in terms of key development indicators. Development leaps are above all crucial in the fields of health, education, and agriculture and food, our author argues, concentrating on the two latter items.

By Sabine Sütterlin

Sacks made of three layers of polyethylene with an airtight closure can trigger a great leap in development. Purdue Improved Crop Storage bags, or PICS bags, were originally invented to tackle the problem of seed beetles that were ravaging the stored cowpea harvest in Cameroon; they work by depriving the insects of air. PICS bags and similar containers are now available in most African countries, enabling grains, legumes and other crops to be stored without risk of damage by pest or mould and without the use of pesticides until the farmers are able to market their produce at a good price.

This is leapfrogging for Africa: a technically simple, affordable, direct and permanently effective solution to a problem which, according to conventional understanding, requires significant investment and wide-ranging measures. The fact is that up to one-fifth of the food produced by farmers in sub-Saharan Africa is lost before it can fill hungry stomachs. One of the reasons for this is the absence of the technology and infrastructure needed to dry crops and store them safely so that they can later be processed into durable products and transported to consumers.

Leapfrogging is the term used to describe the bypassing of inefficient, environmentally damaging and expensive steps in the development of achievements that improve and simplify people's lives.

Africa supplies some impressive examples of leapfrogging. For example, just 20 years ago telephoning was still impossible for the majority of Africans. Laying cables everywhere would have been technically too demanding. In addition, the investment costs could not be justified given the limited number of users who could afford to pay. When cheaper mobile phone technology arrived, the continent simply leapfrogged the landline era. Today 477 million people in sub-Saharan Africa – 43 per cent of the population – have a mobile phone, while 272 million use mobile Internet. Mobile phones are used not just to make phone calls but also to make cashless purchases and to take out loans and insurance policies.

Leapfrogging is not confined to technical and scientific breakthroughs; it also applies to apparently simple inventions and social innovations. Africa needs leaps of all sorts, because it lags behind almost every other part of the world on virtually all development indicators. At the same time, its rapid population growth often frustrates or even reverses economic development. On top of this there now comes the global health and economic crisis caused by the novel coronavirus. This could hit Africa hardest of all: the impacts are already noticeable.

Development leaps in Africa are particularly crucial in three key areas: health, education, and the agriculture and food sector.

Today, 43 per cent of the population in sub-Saharan Africa have a mobile phone.

Photos: Jörg Böthling

If they are not healthy, people cannot participate in society or access education and employment – and hence contribute to socio-economic development. But some African countries – and rural areas in particular – lack universally accessible and affordable primary health care. Trained lay health assistants can bring about significant improvements, especially if they can keep in touch with experts via smartphone or telemedicine.

Education in turn paves the way for better health; it also makes it easier for people to find work and generate income. But in many African countries neither the number of teachers nor their level of qualification is sufficient to provide primary and secondary schooling across the board. Gaps can be identified using electronic data collection systems and, to some extent, remedied with the help of digital learning aids.

Raising agricultural productivity

Rapid development leaps are particularly needed in agriculture – partly to create food security and partly because a productive agriculture and food sector can become a driver of broader socioeconomic development.

Until the 1960s, Africa's farmers were still able to produce enough food to feed the continent's population, which then numbered around 300 million. Today, Africa has higher rates of undernourishment than any other part of the world. It is estimated that around 20 per cent of the 1.3 billion people in Africa have less food than the amount needed "to lead a normally active and healthy life".

And yet the continent has at least a quarter of the world's agricultural land and pasture, which ought to suffice to feed a sixth of the world population. But for decades government programmes and investment largely ignored the agricultural sector and the modernisation of rural regions. Even now, farming and livestock husbandry largely take place on family-run smallholdings whose yields are far below what could be achieved with modern farming methods.

The farmers work hard but rarely produce more than they need for their own use, which means that they are unable to generate an income. They are trapped in a cycle of poverty and high population growth: without money they cannot buy quality seed that achieves better results than the self-saved seed they have retained from the last harvest. Because they are poor and often have no secure land rights, banks will not give them the loans that they could use to buy fertiliser, hire a tractor or rent additional land. Agricultural services and advice are often lacking.

The situation is exacerbated by the fact that it is in the Global South that climate change is becoming particularly noticeable. Rainy periods are shifting, and droughts, heavy rain, floods and soil erosion are leading to crop failure on a large scale. In the Sahel region, increasing aridity and rapid population growth are intensifying the frequency of conflict between farmers and nomadic pastoralists who are having greater difficulty finding feeding grounds and water for their animals. In many parts of sub-Saharan Africa, armed terror groups and civil wars put agricultural production and farmers' livelihoods at risk. Thirty-four of the 54 (recognised) African countries are currently dependent on food aid as a result of the impacts of climate change, poor economic performance or conflict. Governments spend valuable foreign exchange on importing basic foodstuffs.

A crucial role for smallholders

The continent's small-scale farmers could be the key to food security. They need innovations of all sorts in order to produce more and to farm more efficiently. This does not mean that they should pursue the model of industrial agriculture that is widespread in large parts of Europe, America and Australia. In industrial agriculture, productivity is achieved at the expense of the environment and the world's climate: it involves massive consumption of water and makes a significant contribution to greenhouse gas emissions. In addition, the large-scale use of nitrogen fertilisers, whether mineral or organic, pollutes groundwater and surface waters with nitrates. Monocultures and synthetic chemical pesticides and herbicides drastically reduce biodiversity. And in the former developing countries of Asia, the Green Revolution has led to undesirable developments and damage, such as soil salination as a result of increased evaporation on irrigated fields without adequate drainage.

African agriculture must therefore "intensify sustainably". This means that it must produce more while also being climate-resilient and not damaging the environment. In addition, Afri-

LEAPFROGGING METHODS ARE USEFUL AND PROMISING IF …

- they make the construction of expensive infrastructures redundant, such as the copper cables for fixed-line telephony or large power plants for electricity supply;
- the need is great enough, for example when many people without prior access to a bank branch benefit from mobile banking;
- they can be used in many ways, for example if smartphones are also used for consulting services, e-learning programmes or for collecting medical data;
- they solve problems efficiently and create new opportunities for socio-economic development, for example when learning programmes enable or improve schooling where there is a shortage of trained teachers;
- they promise a direct benefit for the users, for example if herders can find available pasture land via an app;
- they are easy to use and facilitate difficult tasks, such as drones monitoring the ripening progress of crops and the water content of soils or controlling breeding sites of mosquitoes and other disease vectors;
- they rapidly become cheaper, as was the case with the electronic storage of data.

Source: "Leapfrogging Africa" (2020)

High-quality crop storage bags help minimise harvest losses.

Decentralised solar power renders expensive, less environment-friendly energy systems superfluous.

can enterprises must do more to process raw products into marketable foods for the continent's population – especially for the growing cities and their burgeoning middle class. Establishing value chains means creating jobs and sources of income in rural areas. Around primary production there then emerges an agri-food complex that can drive further economic development.

Leaps are possible in all these areas. Many possible innovations are being trialled or are already in use, and there is no lack of further ideas. A lot of ideas come from Africa itself. This is important, because there are rarely one-size-fits-all solutions. The continent is characterised by a wide range of different ecological conditions and specific local needs.

At the very beginning, the smallholders must be enabled to share the existing knowledge on issues such as sustainable, soil-conserving farming methods and marketing channels. This applies in particular to women, since they shoulder the majority of the work but often have little to say and are cut off from information. In many places, universally available agricultural advice services are in themselves equivalent to a leap forward. SMS services such as the Wefarm platform provide relatively simple digital means of communicating knowhow. Wefarm is based on the idea that for almost every problem that arises on a farm there will be another smallholder somewhere who has already found a solution. Questions sent by text message to Wefarm are quickly answered by other farmers who are happy to pass on their experience.

Reliable tractor services can ease hard work in the fields for farmers.

Wefarm was developed by two British development workers. So far, it is used by one million smallholders in Kenya and Uganda alone; according to the platform operators, more than 40,000 questions and answers are shared by the farmers every day.

Minimising risks

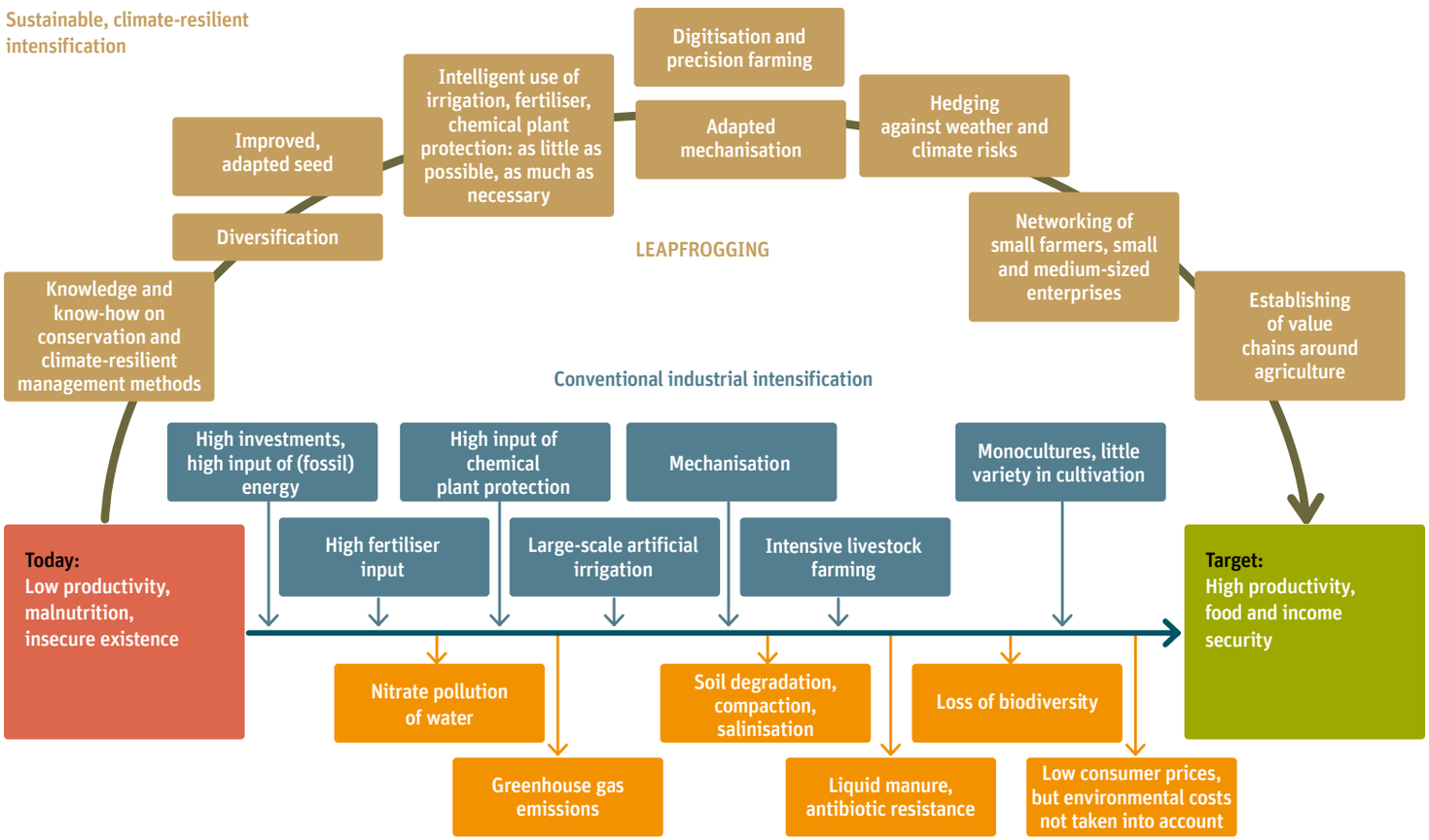
Better weather forecasting and disaster warning systems enable farmers to make preparations and, for example, to adjust sowing and harvesting timetables. Weather data and positioning systems also let farmers insure themselves against risks that they have previously been completely at the mercy of, such as when weather anomalies lead to crop failure, or when their animals starve or die of disease. Until now, agricultural insurance schemes have been virtually non-existent and those that do exist are often rejected by African farmers because they suspect them of being costly and complex to administer. The organisation ACRE Africa (Agriculture and Climate Risk Enterprise) has found a way of overcoming these obstacles: it has developed insurance products based on weather indexing that are tailored to the needs and habits of smallholders, and it sells them partly through the agricultural trade. When customers buy certified seed, they receive a quick code. All they need to do in order to register is send this code by mobile phone to the local insurer. The insurer localises the insured farmer and tracks rainfall in the corresponding area by satellite. If the seed does not germinate because the amount of rain is above or below a certain index value, the insurer refunds the cost of the seed to the farmer or provides a voucher that can be used to buy new seed – all by mobile phone.

Securing income and making work easier

In Nigeria, the social enterprise Babban Gona is utilising economies of scale to help farmers boost their yields and income. By buying in bulk and raising capital, the enterprise enables farmers to acquire fertiliser, quality seed and bags with an airtight closure for the safe storage of produce, all at low cost. Babban Gona also offers advice and collects the bags in central warehouses so that they can then be sold at the best possible price. With the help of Babban Gona, the farmers have on average been able to increase their maize yields to 2.3 times the average national yield.

In Senegal, a young vet has beaten new paths for poor pastoralists in the north of the country

Leapfrogging in agriculture: towards a "greener" Green Revolution



Source: author's own representation

by opening up a market for their milk production. His business collects the milk regularly and takes it to Dakar in refrigerated trucks. There it is made into yoghurt and other products for which there is a ready market in the capital. Using waste from regional rice and sugar production, the entrepreneur has also made additional sources of feed available for the animals. This means that the farmers and their herds no longer need to travel further and further south – and into crop-growing areas – when grass becomes scarce in the north. In addition, the young entrepreneur has introduced new cattle breeds that cope well with conditions in the Sahel but also give more milk. A dairy of its own is an enormous leap forward for the West African country. More than half the milk and milk products that Senegal uses are imported, almost entirely in the form of milk powder from the European Union's excess production.

Various innovations serve to ease the hard work in the fields. One example is Hello Tractor, a sort of "Uber for agricultural machinery" (see also interview with Hello Tractor founder and CEO Jehiel Oliver at www.rural21.com). The Nigerian electronics company Zenvus has developed simple sensors specifically for smallholders. The mushroom-shaped devices, placed in the soil at regular intervals, measure the soil's moisture, acidity and nutrient content at those points. Using solar power, the recorded values are transmitted wirelessly to the main sensor and then to a cloud server. The server processes the data and sends detailed information about the state of the farmland to the farmer's mobile phone.

Taking advantage of innovations

Many ideas for scientific, technical and social innovations can potentially be rolled out on a broad scale. They can serve as a blueprint for other organisations and countries. Benefiting from successful projects and the experience acquired through them is nothing other than successful leapfrogging. However, the conditions must be right: necessary elements are good governance, reliable institutions and legal certainty, the creation of necessary infrastructure (including a distributed energy supply system, roads and an Internet connection), equal rights of access to information and financing instruments, and an investment-friendly and business-friendly climate. It is the task of the African governments to lay the foundations for these things.

"Africa should itself produce what it eats, and it should create added value with its products," says the Nigerian Akinwumi Adesina, who is a farmer's son, an agro-economist and, since 2015, head of the African Development Bank. "I want young people to enter an entrepreneurially oriented agricultural sector. Because nobody drinks oil, nobody smokes gas, but 1.3 billion people eat food. That is the biggest and the most profitable market."

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This article is based on two reports of the Berlin Institute, which Sabine Sütterlin has co-authored, "Leapfrogging Africa" (2020) and "Food, Jobs and Sustainability" (2018).

For more information: **www.rural21.com**

Silicon Valley for Africa's agricultural start-ups

The project "Scaling digital agriculture innovations through start-ups" (SAIS) supports Africans going into business in the agricultural and food sector in scaling their digital innovations and thus reaching out to a larger number of users. The scaling potential of the innovations and their positive impact on income are important criteria in selecting the start-ups.

By Michel Bernhardt

The agricultural and food sector holds the potential to become the driving force behind Africa's economic development. In order to harness this potential, innovations are needed that can kick-start production and productivity in the agricultural sector, multiply value added and thus generate both jobs and income. In Africa, it is digital innovations in particular that drive agriculture, which is currently still often performed at subsistence level. Despite steadily growing venture capital investments in the continent, start-ups frequently lack capital in their early stages of development. However, this is an important basic prerequisite for taking businesses and innovations to scale. Acquiring sufficient capital is difficult for many young start-ups, with 80 per cent of them already failing after the launch of their first product.

It is in this potential "valley of death" where the project "Scaling digital agriculture innovations through start-ups" (SAIS) sets in. With tailored company development measures implemented by international venture builders, the investment readiness of the start-ups – i.e. their capacity to understand and meet the specific needs and expectations of investors – is improved. This raises the prospects of success for the start-ups being able to obtain the capital needed for scaling or to tap further markets with the aid of new business partners. Here, SAIS adapts processes of existing innovation systems and appropriately applies them to the African context.

By supporting a targeted 30+ start-ups, digital innovations are to directly reach the true target group of the project, the rural population linked to agriculture and food value chains. By the end of the project period, at least 100,000 additional users are to have been gained and earned more income. In this manner, SAIS contributes to Sustainable Development Goals (1) reducing poverty, (2) combating hunger, (8) decent employment and economic growth and (9) industry, innovation and infrastructure.

The project comprises three action areas and covers a term of five years (2019–2023). The German Federal Ministry for Economic Cooperation and Development (BMZ) has commissioned Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) to implement SAIS.

Crossing the valley of death in three steps

Step 1: Choosing start-ups. The initial step is to identify, assess and select start-ups in Africa. The start-ups are chosen according to a catalogue of criteria in a selection process comprising several phases. Start-ups are eligible if they are in the post-seed or second stage: they have already successfully set up a business, introduced a digital innovation on the market and attracted their first customers. In addition, with regard to the size of the market and the target group, they have to bear a high scaling potential and generate a positive income effect among their users. In its second year of implementation, SAIS has already recorded more than 250 applications from founders, representing a plus of just below 20 per cent, which speaks for a good standing of the project in Africa's start-up ecosystem.

Step 2: Investment Readiness Programme. In the second step, which forms the core of SAIS, the start-ups join a nine-month Investment Readiness Programme (IRP) with tailored business development measures.

With the aid of the Ugandan platform Bringo Fresh, farmers can sell their goods in spite of contact restrictions. Customers are able to order food directly via the app.

Photo: Bringo Fresh

START-UP APPLICATION AREAS SUITABLE FOR SUPPORT

- E-Commerce for farmers (e. g. selling produce, inputs)
- Information & consulting services (know-how, consulting, weather data)
- Fintech for farmers (financing, credit services, crowd funding)
- Farm supply chain management (farm management, transport, warehousing)
- New technologies (Internet of things, artificial intelligence, etc.)

First of all, needs assessments of the individual start-ups are made. Their potential for optimisation is defined, and individual development plans are drawn up with the founders. Building on this, the start-ups are then provided with advice on the further development of their business. Here, depending on respective needs, topics such as strategic development, specifying the business model, improving marketing, finance management, acquisition of new groups of customers or technology consulting are addressed. In addition, the pitch decks – brief presentations of the start-ups for potential investors – are optimised, customs in communicating with investors are imparted, and basic aspects of business appraisal are explained. In 2021, 16 start-ups are being supported in this manner.

Step 3: Networking. The third step involves networking the start-ups with potential business partners and investors. In order to better integrate the selected start-ups in their local ecosystems before and during company development, SAIS is working with a network of local innovation hubs. This network forms an important basis for the recruitment of investors and the formation of strategic partnerships. These may be both financiers such as business angels, venture capital funds or impact investors and business partners or development cooperation projects. Initial contacts are already established during the company development phase. In a check-in after the first half of the programme, the start-ups are acquainted with potential investors and business partners and informed about further financing options. On the Demo-Day at the end of the IRP, the contacts with investors and potential business partners are intensified with the aim of establishing concrete partnerships and business relationships. Especially promising start-ups can join the SAIS Masterclass, which addresses matchmaking with potential investors and partners in detail.

SAIS START-UPS IN THE CORONA CRISIS

The corona pandemic is causing considerable problems for African agriculture since central markets have shut down and travelling to the commercial centres is hardly possible. As a consequence, farmers are losing income, while food supplies for the population are becoming tight. Some of the African start-ups supported by SAIS are addressing these challenges with digital solutions. With the aid of the Ugandan platform Bringo Fresh, farmers can sell their goods in spite of restrictions. Customers need not go to the markets but can order food directly via the app. Orders are freshly packed and immediately delivered by moped. During the corona crisis, Bringo Fresh has succeeded in more than doubling its turnover compared to the previous year. In contrast, the Zambian company eMsika is a virtual marketplace for agricultural input. Seed, fertiliser and state-of-the-art technologies such as solar-powered water pumps can be ordered online and delivered to remote areas. Around 2,100 Zambian farmers are being provided with input by eMsika.

Both start-ups are already planning their next steps. Bringo Fresh is working on its expansion to Kenya, and eMsika is developing an online academy in which farmers are trained in improved cultivation methods.

The first cohort of start-ups at the Kick-off Event in Nairobi, Kenya.

Photo: GIZ

Outlook

The SAIS project has established itself as an important partner for Ag- and FoodTech start-ups in African ecosystems. Africa's start-up landscape is clearly heading for growth. Young people are seeking solutions to existing challenges with technology, with the desire to contribute to the continent's economic development. Despite strong growth in the AgTech sector, many developments are still in their infancy. In particular, available investment in the field of venture capital is still at a comparatively low level, complicating scaling for start-ups with good ideas and good teams. Less than one per cent of venture capital worldwide (at approximately 220 billion US dollars in 2019) is currently invested in Africa. While investments roughly double from year to year, they are still too low for the challenges and opportunities which the continent faces, leaving valuable potential lying fallow. SAIS seeks to generate additional capital options for African start-ups through matchmaking and to also make the market attractive for investors from Germany and Europe. Here, the SAIS team have opted for various channels such as business clubs, investor data banks and contacts they have established themselves as well as renowned foundations.

Despite existing challenges such as the "valley of death", a paucity of investment and the corona pandemic, African start-ups and SAIS are optimistic about the future. Start-ups offer a clear potential to make important contributions to achieving the SDG agenda if they aim at social impact, too. This is why SAIS has started to focus also on the Francophone region, where it seeks to raise start-up potentials and offer tailored support measures for start-ups in the programme. Furthermore, SAIS will extend its efforts in the promotion of female founders with awards tailored to female-led start-ups and increased attention on network building for female founders throughout the programme.

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Smallholders' adoption of innovations – an agenda for learning

For an agricultural innovation to become widely adopted by smallholders, there must be a good match between the properties of the innovation and the goals, objectives, and constraints faced by the population of farmers. Our authors look at recent research using large-scale experiments and new approaches to measuring adoption at scale which together can help agricultural researchers understand more about this important process.

By Karen Macours and James Stevenson

In every sector of our economies, the rate at which productive innovations spread is a key determinant of growth and development. This is particularly true of the agricultural sector. There is a long history of research on the adoption and diffusion process in agriculture, going back to the 1950s and the seminal work of economist Zvi Griliches. Griliches studied how hybrid maize seeds diffused through the farming population of the United States in the prior decades, examining how varied this process was across different states. In this context, the term "adoption" refers to the decision by a farmer to use a particular agricultural innovation.

Understanding the process of adoption

Agricultural researchers – the plant breeders, agronomists, soil scientists, hydrologists, livestock researchers, or aquaculture scientists – work to develop new innovations that can be adopted by smallholder farmers. The

The African Chicken Genetic Gains Project aims to increase the access of poor smallholder farmers in sub-Saharan Africa to high-producing but agro-ecologically appropriate chickens.

Photo: Apollo Habtamu/ ILRI

MARKET FAILURES THAT CONSTRAIN ADOPTION OF AGRICULTURAL INNOVATIONS

- **Externalities** – Some technologies create spillovers that affect others. If farmer decisions ignore these spillovers, then technologies that create benefits for others may not be adopted, while technologies that impose costs on others may be adopted too widely.
- **Input and output market inefficiencies** – Problems with infrastructure and with supply chains, compounded by weak contracting environments, make it more costly for farmers to access input and output markets and access the benefits from technology adoption.
- **Land market inefficiencies** – In settings where land tenure is weak and property rights insecure, farmers may not have an incentive to invest in beneficial technologies.
- **Labour market inefficiencies** – New technologies need different types and timing of labour input. Restrictions on labour mobility and high costs in the labour market will interfere with adoption opportunities.
- **Credit market inefficiencies** – Many farmers have difficulty accessing credit and face high interest rates, which prevents investment in profitable technologies. Financial decisions may be difficult for farmers without high levels of financial literacy.
- **Risk market inefficiencies** – Technologies that carry a small risk of a loss may not be worth large expected gains if risks cannot be offset. Psychological issues around risky decisions further lower levels of adoption.
- **Informational inefficiencies** – If an individual does not know that a technology exists, does not know about its benefits or does not know how to use it effectively, then that technology will not be adopted.

Source: ATAI White Paper by Professor Kelsey Jack.

"impact pathway" articulates a theory for how the researchers hope to make a difference in the world. Adoption of these innovations by smallholders is often a crucial stepping-stone in this pathway, particularly in Africa.

This raises the question of how well we can evaluate the potential of new innovations from the perspective of the farmers. One school of thought on this topic is that action research, working with farmers to help understand objectives and constraints, is critical. We agree. It is through this process that hypotheses are formed. We also think it is important to put these hypotheses to an empirical test to study what kinds of interventions are necessary and sufficient in bringing about positive changes for farmers in large numbers. Economics offers three important insights here.

The first insight comes from research on how farmers evaluate technologies as compared to the perspectives of agricultural researchers. For example, it is common for agricultural researchers to dedicate their career to finding ways to increase the yields of specific crops or systems. And while farmers also care about yields, the major concern for many of them is the expected profitability from any change in their operations, while other aspects that can contribute to their utility (such as nutritional benefits) may also factor in. An innovation that increases yields but also raises the costs borne by the farmer may not be adopted – the farmer first must learn whether the change is worth it. But let's assume the innovation is indeed potentially profitable for many farmers to adopt. What next?

The second insight is that farmers face numerous constraints to adoption. An innovation that is potentially profitable under controlled research conditions may not be feasibly adopted under real world conditions, owing to one or more constraints. The Agricultural Technology Adoption Initiative (ATAI) laid out seven areas where "market failure" may result in innovations not being adopted that would be profitable under ideal conditions (see Box). Lifting those constraints could hence lead to increased adoption. The beauty of this scheme is its simplicity. We can theorise about what causes low adoption, but then we can rigorously test those theories in large-scale experiments with farmers. By introducing innovations alongside a complementary programme that alleviates one or more constraints, we can learn about farmers' behavioural responses. ATAI is one of several specialised initiatives, including Precision Agriculture for Development (PAD), the Feed the Future Innovation Lab for Market Risk and Resilience (MRR) and the CGIAR (Consultative Group on International Agricultural Research) Standing Panel on Impact Assessment (SPIA), which support this kind of structured learning about constraints to adoption of agricultural innovations. Using experimental methods, a series of papers by researchers at the International Rice Research Institute (IRRI), the University of California at Berkeley and Tufts University in Massachusetts, both in the USA, gradually tested for different mechanisms that could help increase adoption and diffusion of stress-tolerant rice varieties, including peer learning, demonstrations and farmer-field days, and partnerships with private suppliers. They also demonstrated that when key constraints are lifted, additional gains can be obtained if farmers crowd in effort and other inputs.

The third insight is that not only differences between agronomical trial results and outcomes in real-life-conditions, but also differences between the way agronomists and economists conceptualise yield gains further help understand low real-world adoption of technologies thought to be promising. Researchers from the International Institute of Tropical Agriculture (IITA), the Universidad de Los Andes in Bogotá, Colombia, and France's Paris School of Economics show how parcel and farmer selection, together with behavioural responses in agronomic trials, can explain why yield gain estimates from trials may differ from the yield gains of smallholders using the same inputs under real-life conditions. Adjusting for selection, behavioural responses, other corrections and estimates of yield gains can lead to both higher and lower returns. These results suggest that testing new agricultural technologies in real-world conditions and without researcher interference early in the agricultural research and development process might help with identifying which innovations are more likely to be taken up at scale.

ADOPTION OF CGIAR-RELATED INNOVATIONS IN ETHIOPIA – SUMMARY OF RECENT EVIDENCE

A recent study by the CGIAR Standing Panel on Impact Assessment (SPIA), the World Bank Living Standards Measurement Study and the Ethiopian Central Statistical Agency (CSA) documents the reach of CGIAR-related agricultural innovations in Ethiopia. The data collection effort cut across the core domains of the CGIAR research portfolio: animal agriculture, crop germplasm improvement, natural resource management and policy research. An initial "stocktaking" exercise documented 52 agricultural innovations and 26 claims of policy influence from the past two decades of research cooperation in Ethiopia. CGIAR scientists and their national partners have generated a plethora of new ideas, many of them leading to agricultural innovations and policy changes.

Quantitative evidence on the adoption of 18 of these innovations was obtained by integrating data collection protocols, including DNA fingerprinting for maize, sorghum and barley, into the Ethiopian Socioeconomic Survey (ESS). It is estimated that in 2018/19, between 4.1 and 11.0 million Ethiopian households were reached by agricultural innovations linked to CGIAR research. The lower bound estimate (4.1 million households) includes only those innovations with clear observable features in survey data and for which their adoption can be strongly linked back to CGIAR research efforts. The upper-bound figure (11.0 million) should be interpreted as the 'potential reach' of CGIAR in the country: it captures the number of households that in theory could benefit from CGIAR research.

Piecemeal assessments of diffusion provide an incomplete picture, as different innovations reach different types of farming households and regions. Analysis of the socio-economic characteristics of the adopting households shows that innovations often do reach the types of household that CGIAR researchers target, with substantial adoption among smallholders, poor households, and young and female farmers. However, there is substantial heterogeneity when comparing across different innovations (farm size, market access, socioeconomic status, gender, age, and region). Diffusion levels for some innovations are lower than expected, and the theories of change for these innovations may need to be revisited.

Tracking adoption at scale

Accurately quantifying the diffusion of agricultural innovations at scale requires addressing complex measurement and sampling challenges. Consider farmers' adoption of an improved variety of cassava. Typically, the evidence on adoption of cassava varieties has relied on either asking experts' opinions or using survey data collected from farmers. Both are imperfect if we want accurate estimates. In recent years, the use of DNA fingerprinting for identifying specific crop varieties has been piloted and is now being implemented in farm surveys in several countries. As a result, we can now compare the data reported by farmers to the DNA fingerprinting data: there often is a big mismatch (see Table).

Remote sensing is another example of a breakthrough in measurement that is being leveraged to track adoption of innovations. As sensor accuracy improves and data costs from remote sensing fall, it is now possible to detect adoption of some natural resource management innovations using remote sensing.

SPIA is working to mainstream these insights into large-scale, well-institutionalised agricultural surveys. Our strategy is to focus on countries that are high-priority for CGIAR, in order to generate reliable, independent data at a national scale which documents the reach of CGIAR and Nars (National Agricultural Research System) partners in the country. In particular, we have been working with the World Bank and the statistical agencies of both Ethiopia and Uganda to integrate new data collection protocols into their nationally-representative household surveys. In Ethiopia, we recently documented widespread adoption of soil and water conservation practices, improved maize varieties and cross-bred chicken. At the same time, many other innovations showed much more limited adoption (see Box for a summary). This highlights the need for more experimentation and testing of scaling strategies to maximise the returns to agricultural research and innovation.

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Adoption of improved varieties of cassava: Comparing estimates from farmers' statements to DNA fingerprinting of leaf material from their plots

Country	Survey year	% agreement between DNA fingerprinting data and farmer-reported data (on whether farmer is cultivating improved variety)	% improved varieties estimated by DNA fingerprinting	% improved varieties estimated by farmers	Percentage point bias of farmer-reported estimates
Ghana	2013	55	4	6	+2
Colombia	2014–15	27	9	17	+8
Nigeria	2015–16	67	77	60	-17

A reality check for digital agricultural extension tool development and use

ICT-driven digital tools to support smallholder farmers are arguably inevitable for agricultural development, and they are gradually evolving with promising outlook. Yet, the development and delivery of these tools to target users are often fraught with non-trivial, and sometimes unanticipated, contextual realities that can make or mar their adoption and sustainability. This article unfolds the experiential learnings from a digital innovation project focusing on surveillance and control of a major banana disease in East Africa which is being piloted in Rwanda.

By Julius B. Adewopo, Mariette McCampbell, Charles Mwizerwa and Marc Schut

Farmer promoters were involved in the technology design of the BXW App. Photos: IITA

Smallholder farmers are often faced with the challenge of making farm-level decisions based on terse information, which can be unproven or even outrightly wrong or incompatible with their need. In most developing countries, the extension delivery systems are either overwhelmed by the number of farmers to be served, or, in many instances, non-functional or non-existent. Yet, to improve farm productivity and livelihoods for millions of smallholder farmers, it is critical to ensure farmers' access to actionable information at the right time and for the right context and condition. This requirement is often a tall order for traditional extension systems, especially under conditions where rapid response is required to mitigate immediate threats or risks to crop production (including pests and diseases) across diverse farming systems. However, the fourth agricultural revolution has been characterised by the innovative and unprecedented use of smart systems and devices for agricultural decision support. This presents a tangible leverage for extension delivery that transcends current constrains in terms of capacity to reach farmers, ability to standardise and deliver context-relevant advice, and opportunities for multi-directional data and information exchange for broader learning and impact.

Smart digital tools for disease surveillance and control

Pests and diseases pose major threats to smallholder farmers. According to figures from the UN Food and Agriculture Organization (FAO), they cause an estimated global annual loss of 290 billion US dollars, and are severely impacting livelihoods across millions of farming households. To mitigate or minimise these losses, it is imperative to monitor and control the incidence and spread of such threats. However, conventional surveillance systems, which are usually dependent on visit(s) by trained staff to selected farms or locations within target geographies, are incapable of generating timely and robust data that can be translated into early warning alerts or timely advice for farmers. Therefore, the emergence of smart digital devices and applications that can enable rapid acquisition and transmittal of data has created new opportunities for timely surveillance through various digital channels,

while easing farmers' access to information on control or preventive methods.

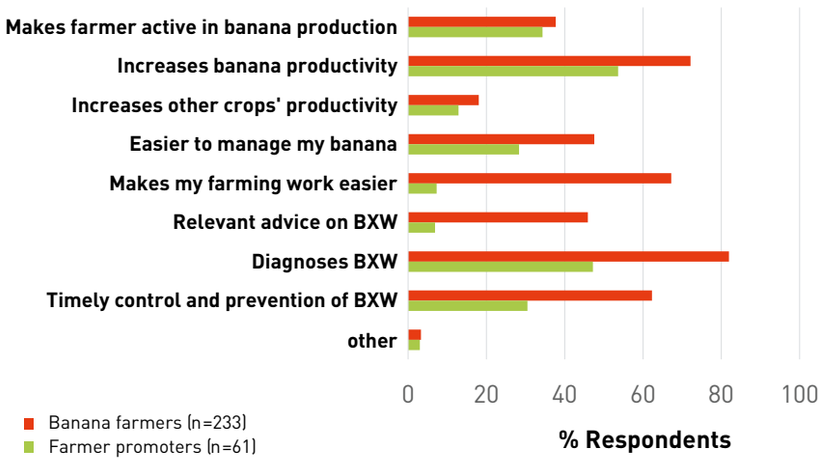
Within the past five years, researchers and developers across institutions have been exploring various innovative uses of digital tools and methods for diagnosis and control of crops pests and diseases, including short messaging service (SMS), interactive voice recording (IVR) and smart applications (also called "apps") which are often embedded with sophisticated algorithms such as artificial intelligence or machine learning models for rapid diagnosis of specific disease or identification of pests. Yet, as most of these tools mature for delivery to farmers, two major concerns are pertinent prior to broad dissemination. The first relates to the ability of the tools to meet the needs of the users as perceived by the developers/researchers, and the second relates to the readiness of the target end-users to apply the tools. These two major elements were brought to focus under a case study among smallholder banana farmers in Rwanda.

Developing a smart digital tool for Banana Xanthomonas Wilt (BXW) – a redefined paradigm

Banana Xanthomonas Wilt (BXW) disease is a major threat to banana production across many countries in East Africa. This bacterial disease can cause 100 per cent loss of yield per banana stand, when infected, and can spread to uninfected banana stands, causing massive losses to smallholder farmers. Controlling the spread of the diseases requires timely information on appropriate control methods and active surveillance to target severely impacted areas, thereby enabling the allocation of limited extension resources to support most vulnerable farmers. The ICT4BXW project (www.ict4bxw.com) was conceived and implemented to meet this critical need in Rwanda by developing a one-stop digital tool that serves both purposes. The BXW App (see Photo), an android-based smart application, was designed to empower users (next-users and end-users) and stakeholders to combat BXW in an efficient and cost-effective manner. The tool also enables the crowdsourcing of data on the incidence of BXW, based on a standardised and stepwise diagnostic module, which feeds into a back-end dashboard for near-real-time visualisation of current threat level within focal geography.

In this project, a participatory and inclusive technology design (PITD) approach was adopted to evolve a functional and sustainable digital solution for BXW control. This redefined design paradigm involved four major stages of intensive co-development with farmer promoters, who are considered as the next-users of the envisioned tool. In the first stage, an interactive session was convened with representative selection of the next-users to document their perception, concern, and current practices regarding BXW threat. This stage also involved discussions about the prospects of digital tools and mapping of viable entry points for advancing innovative digital solutions. The second stage was focused on co-defining the potential user-journey for the digital tool and co-creation of mock-up versions, with focus on understanding the major functions that will be relevant for the users, and how such functions will be used to enhance farm-level decision-making. The third stage involved the design and limited testing of the beta-version, with hands-on feedback sessions between developers, researchers, extension officials, and the selected next-users. In the fourth (and final) stage, a field co-validation was conducted to test the tool under actual field conditions, and assess the confidence and competence of the tool end-users (farmers and farmer promoters).

Importance of the BXW App to farmers and farmer promoters



Based on response to end-line survey that was conducted among smallholder banana farmers in Rwanda.

The BXW App is an android-based smart application.

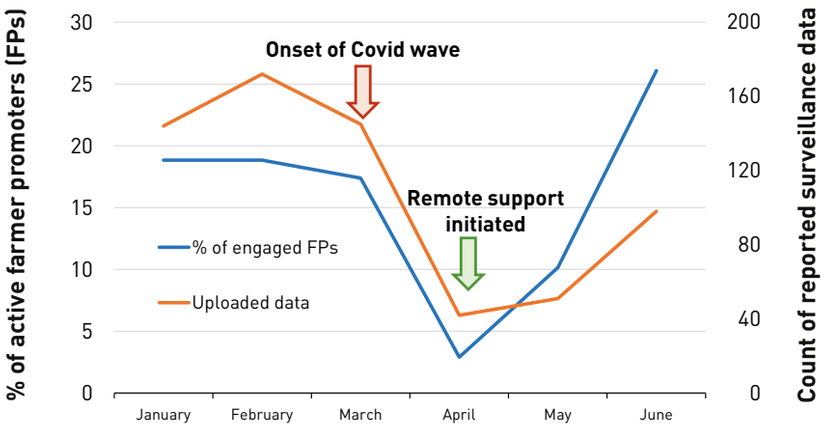
Non-trivial realities of digital tool development and deployment

Generally, the diffusion and sustainability of technological innovation is contingent on meeting user needs and preferences at the right time and within the right environment. Yet, achieving this in practice, especially in smallholder farming systems, is a tall order due to various factors, including limited consideration of contextual realities, inadequate or no engagement with relevant stakeholders, and time constraints for testing and validation of assumptions. The participatory co-development and co-deployment of the BXW App in Rwanda unravelled mixed-bag realities, with nuanced dimensions, that may be relevant to guide future efforts to deliver innovation in smallholder farming systems. As the project progressed from the conceptual phase to the tool development phase, some of the initial assumptions became invalid, and relevant decisions were made in consultation with the stakeholders and/or next-users who were involved in the project.

The Good: The initial baseline and final survey of 600 smallholder banana farmers provides a compelling basis to advance ICT-based solution for control of BXW disease. Approximately 75 per cent of the respondent farmers indicated that they use or have access to a phone, which is a major entry point for crowdsourcing data on BXW incidence and democratising access to reliable information about control practices. Further, 72 per cent

of the farmers declared willingness to pay for digitally-delivered advisory services while more than 70 per cent stated that they consider digital tools important to help mitigate BXW threat and increase banana productivity (see Figure on the left). Within the co-validation period, over 2,000 farmers have been registered and 3,500 rounds of BXW diagnoses completed by the cohort of farmer promoters. The successful co-development of a tool that empowers farmer promoters and farmers to detect BXW threat and take immediate action is a major milestone towards sustaining the food system in Rwanda, and within the East African region as a whole. Also, multiple interactions between researchers developed, and the target users fostered an iterative evolution of the tool and its functionalities. For instance, the translation of the content into the local language (Kinyarwanda) and embedding of user-focused videos in the app occurred based on prioritisation of user-demand during the participatory process.

Performance of farmer promoters (FPs) as next-users of smart ICT tool for surveillance and control of BXW in Rwanda



During the first co-validation period (first 6 months of 2020).

The Bad: Relatively, the aspiration for extensive development and deployment of smart ICT-based tools for decision support in smallholder farming systems is at its infancy, especially in sub-Saharan Africa, where internet penetration and smartphone usage is still low in rural farming areas. The initial baseline survey of banana farmers in Rwanda revealed that barely three per cent of the respondent farmers possess or have access to smartphones. This invalidated the initial assumption that farmers would be ready to access and utilise the digital tool for surveillance and control of BXW, and thereby prompted the team to consider alternate content delivery channels such as Short Messaging Service (SMS) or Interactive Voice Recording (IVR) for broader impact. Further, not all enlisted farmer promoters (as next-users) actively engaged with the farmers (as end-users) in their respective villages (see Figure above). Despite the role of the farmer promoters in the national extension delivery system, they are not adequately equipped or incentivised to support farmers with ICT tools. Yet, due to their positioning as a critical link to reach millions of farmers with digital advisory contents, it is likely that a blend of incentives may be required to nudge them towards optimal commitment and performance. For instance, since they are officially reporting to the government extension system, a combination of smartphone access, internet data provision, financial micro-reward to cover transportation costs (for in-field diagnosis/ support), and assigning of performance targets can catalyse the activity of the farmer promoters and enhance their transfer of ICT-based knowledge/ skills to farmers.

The Nebulous: The stepwise implementation of a participatory ICT-tool development for smallholder farmers is inevitably marked by grey areas in terms of representing the overall population, measuring actual outcomes and isolating the influence of external factors. For instance, baseline survey data showed that 63 per cent of female farmers have access to phones, compared to 79 per cent male farmers who have access. Similarly, young farmers (aged 20–40) reported higher phone ownership, around 80 per cent, compared to older farmers (aged 60–80) whose phone ownership stands at roughly 60 per cent. Since the BXW App is intended to foster equitable access to relevant actionable information on the BXW threat, it is uncertain if disparity in phone ownership, access to the internet, or the education level – amongst others – can constrain such a desired outcome. Alternatively, it may indirectly and organically generate waves of interest and interventions towards an upward inclusiveness of farmers to improve their engagement in the digital ecosystem as users and as a source of data/ information.

Conclusion

The development of the BXW App as an ICT-based innovation to control a major banana disease is a pivotal learning experience for subsequent endeavours that are geared towards advancing decision support systems for smallholder farmers. Notwithstanding the inherent complexity of smallholder farming systems, the increasing improvement in internet coverage and use of low-cost smartphones offer compelling justification for further investments to ensure readiness of the technologies/tools and readiness of the end-/ next-users. More so, in the immediate future, the capabilities of this type of tool can be enhanced to deliver ancillary benefits, such as (near-) real-time intelligence on cropland dynamics, markets prices and socio-economic indicators. Finally, progressive iteration and diversification of tool functions in response to user demands, and with focus on optimising user experience, are indispensable for sustainable impact within target geographies.

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References: **www.rural21.com**

Using personalised digital extension services to improve agriculture performance – an example from India

Many farmers already benefit from digital extension services in several areas. Personalising such structures gives them an additional edge and can result in advantages such as better input allocation and higher productivity, as a recent study in India found.

By Pallavi Rajkhowa

More than 1,100 households participated in the survey in eastern India. The digital extension services had positive impacts on production diversity, intensity of input use, crop productivity and crop income.

Photos: Pallavi Raikhowa

Smallholder farmers are often trapped in a vicious cycle of low productivity and subsistence-oriented farming due to inadequate access to information, technologies, and financial services. Thus, an important policy question that arises is how information and market access constraints that smallholder farmers face can be overcome.

Traditionally, the main method for the diffusion of knowledge and innovation in many developing economies is public sector-supported agriculture extension services. In this system, extension agents train smallholder farmers directly regarding best practices or work closely with selected 'model farmers' who try out suggestions on new agricultural inputs and cultivation practices and then communicate these to other farmers. However, the effectiveness of this approach has been limited because of insufficient funding and information that is not personalised to farmers' requirements.

In the past two decades, with the rapid spread of mobile phones in developing countries, information and communication technologies (ICTs) such as text messages, training videos, and interactive voice response services have been used to improve the delivery of market and weather information to farmers. Further, in recent years, the rapid rise of high-speed internet connections and smartphones has led to the evolution of the use of new digital extension approaches. Cloud services, low-cost open-source software and big data analytics have made it possible for emerging economies to invest in pioneering 'agriculture technology platforms' that can tailor the extension information based on farmers' individual needs and conditions. This is possible because predictive analytics and machine learning algorithms can combine data on weather forecasts, soil conditions, market prices and individual farmer characteristics to develop and deliver site-specific agricultural recommendations.

How can personalised digital extension benefit smallholder farmers?

Digital extension services can benefit smallholder farmers through several pathways. First, they can reduce information barriers by providing personalised advice on which types of crops to grow in which season, the appropriate types and quantities of inputs to use and the best timing for the different operations and input applications. Second, digital extension services can link farmers to new input markets by giving transparent information on market prices and reputed brands and suppliers. Third, they can increase farmers' bargaining power by giving more options for purchasing inputs from several vendors. Fourth, access to new information and quality inputs can result in a shift from subsistence crop cultivation towards more market-oriented farming by altering the pattern of production and structure of input use. This may provide direct benefits in farm productivity and crop income.

In a collaborative research project between the Center for Development Research (ZEF) and the University of Göttingen, both in Germany, we analyse whether such positive effects can be observed using the example of a concrete digital extension platform started in India by e-Kutir, a social business enterprise. This agriculture technology platform offers real-time agricultural extension services and a marketplace for seeds, fertilisers and pesticides. The application enables its users to plan season-wise cropping activities and provides information on best practices for growing specific crops. It also makes recommendations on the types and quantities of inputs to use and provides information on relevant pests and diseases and how to control them.

Bridging digital illiteracy and trust gaps

In India, the average landholding of farmers is about 1.08 hectares, and 86 per cent of holdings are less than two hectares in size. Because of the small-sized landholding, farmers are often unable to reap the benefits of economies of scale. To improve farmers' bargaining power and access to information, technology and markets, the developers of the digital platform work in collaboration with farmer collectives or farmer producer organisations (FPO). The adoption of digital technologies in rural areas is often limited due to low levels of education and lack of farmers' trust in accepting new technologies; thus the model takes a 'human-centric' approach to bridge digital illiteracy and trust gaps by creating a 'local for local' development model.

> Entrepreneurial models that provide digitally enabled solutions to small and marginalised farmers in developing countries are yet to fully mature.

The developers of the digital platform train trusted members of the community (also called micro-entrepreneurs) who serve as advisors to farmers based on the information that the platform provides. In the example we study, the farmers do not directly receive the extension services on their mobile phones. Instead, farmers keen on digital extension services contact the head of the FPO, who then operates the internet-based application on the farmer's behalf. Thus, the head of the FPO takes on the role of an extension agent equipped with digital technology which enables him to provide tailor-made agricultural advice and services to the other members. When a member of the FPO wants to use the digital extension services, the FPO head creates an individual account of the farmer by entering personalised data, including farm-specific details such as location, land size, types of crops currently grown and soil conditions. These details in conjunction with the application's algorithms on weather forecasts, market conditions and optimal production decisions help provide personalised advice on crop selection, the schedule of agricultural activities and input regimes. After every season, the micro-entrepreneur enters additional data on the actual inputs used by each farmer, the yields obtained and the prices to further improve the algorithms' predictions and advice for future seasons. When the survey was conducted, the digital platform was voluntary for farmers and free of charge. However, over time, there may be a subscription fee for a package of services. Further, in the current format of the model, e-Kutir incentivises the micro-entrepreneur to get new customers on board by paying a commission fee of 15 rupees (equivalent to 0.12 US dollars) per farmer.

The gains to smallholder farmers

The research conducted in eastern India (Odisha) in early 2019 surveyed around 1,105 households, out of which 603 were members of the FPO and 502 were not. The digital extension services are accessible only to FPO members. However, as adoption for FPO members is voluntary, not all FPO members adopted the digital extension services. Of the 603 FPO members in our sample, 465 (around 77 %) adopted digital extension services, while the others did not although they would have been eligible. The study finds that the main types of information that were requested through the digital platform were the types of crops to grow, the method of cultivating selected crops, and the type and quantity of inputs to be used. We also see this information translating into better agriculture performance in several ways. The study finds that the digital extension services increased the production diversity of adopters as well as the intensity of input use by 15 to 20 per cent. Further, crop productivity increased by around 18 per cent, whereas the degree of crop commercialisation was up by five to seven percentage points. Finally, we find that using digital extension services increased crop income by 25 to 29 per cent. These results suggest that digital technologies that use data from farms to provide personalised information are effective in terms of helping farmers to make better cropping, technology, and input decisions and allocate their resources more efficiently.

The way forward

Technological advancements in areas such as open-source software, artificial intelligence and machine learning are likely to increase investments in innovative agriculture technology platforms in developing countries. The Indian example suggests that personalised digital extension services can be used to augment the public sector's efforts to provide agriculture-related information in rural areas. However, for such digital extension services to be an effective tool, some basic infrastructure such as roads, electricity, a telephone network and internet coverage needs to be accessible, which may require support from the government. Besides, a minimum level of computer and digital literacy is required either among farmers or at least among local intermediaries. Further, from a business point of view, entrepreneurial models that provide digitally enabled solutions to small and marginalised farmers in developing countries are yet to fully mature. Providing these services for free requires significant market-building investments that may not be readily accessible to agri-tech start-ups. Thus, the long-term viability and scalability of these solutions depend on the ability to charge for these services, but farmers may be reluctant to adopt a new technology if the expected benefits are perceived as low. However, given the magnitude of the benefits we find in our study, farmers may be willing to pay a certain amount for such digital services. From a policy perspective, investments in rural road and ICT infrastructure, in promoting digital literacy among rural households and in creating an enabling business environment for related entrepreneurial activities are important steps towards fostering agricultural innovation and equitable growth in the small-farm sector.

Using digital extension services increased crop income by up to 29 per cent.

Photo: Jörg Bötling

Pallavi Rajkhowa is pursuing her PhD in Agricultural Economics from the University of Bonn, Center for Development Research (ZEF). Her current work seeks to understand the impact of digital technologies on agriculture performance, agro-based commodity markets, non-farm sector, and gender outcomes. Specifically, she is analysing the effects of three types of digital technology: personalised digital extension services, electronic marketplaces and mobile phones.
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Mobile-based solutions lagging behind their possibilities

Financial services that can be accessed and managed through a mobile phone hold promise for expanding financial inclusion among smallholder farmers. Recent research from Kenya shows that the overall uptake of services such as mobile money and mobile banking by farmers is considerable. However, most farmers are not yet integrating these services into their agricultural activities. In the following article, our author explains what this could be due to.

By Martin C. Parlasca

Mobile money is widely disseminated among farmers in Kenya, with M-Pesa being the most used service. Usually, however, agricultural activities continue to be handled with cash. Photo: Jörg Böthling

Resilient and efficient agricultural production requires access to decent financial services. Especially for smallholder farmers in developing countries, however, the choice of affordable, trustworthy, and accessible financial services has been fairly limited in the past. Rapid advances in the technology and telecommunications sector over the last two decades have now produced several innovative digital financial products that could help bridge this gap. In particular, digital financial instruments that are primarily accessible via mobile phones, so-called mobile financial services (MFS), are potential game changers for agricultural finance. Providers can design MFS so that even people with little integration into the formal financial sector and in areas with weak infrastructure can use such services. Operation and handling of MFS can be made relatively simple so that MFS do not require much training or prior knowledge of financial instruments. Therefore, especially in rural regions where infrastructure and education levels are comparatively low, MFS should be more suitable to the needs and resources of smallholder farmers than financial services from other providers such as formal banks. In an ongoing study, I analysed if and how farmers generally use different MFS and whether they use MFS within their agricultural operations. The study represents joint work with two colleagues from the University of Göttingen, in Germany, and uses a nationally representative survey of Kenyan farmers from 2018. The MFS that we consider in our study – which contains data from 3,041 interviewees – include mobile money and mobile banking. We assess if farmers use these services for payments, savings and credit. Kenya is a world leader in digital innovations around financial services. Yet, we are confident that the results are also of interest for the development prospects of MFS in many other developing countries where similar services are available as well.

Mobile money trails far behind cash as a means of agricultural payment

We found that mobile money is widely disseminated among farmers in Kenya with more than 75 per cent of the respondents having used it within the time span of one year. Even farmers who work in traditional supply chains – i.e. farmers who mainly sell their produce on the nearest market or to neighbours/friends/family members – and mainly grow food crops have considerable rates of use. While there is still room for progress and not all farmers use mobile money (yet), the service appears to be quite inclusive and in line with the needs and resources of most farmers.

However, the general use of mobile money often does not translate into the integration of the technology as a means of payment for agricultural activities. Instead, cash is still by far the most common means of payment; only for less than two per cent of the farmers does mobile money represent the most important channel in this regard. Over the course of a year, 15 per cent of farmers made or received an agricultural payment via mobile money; among farmers who work in modern supply chains, i.e. those who directly sell to companies, manufacturers, factories, or exporters, this share was at 25 per cent, while among farmers in traditional supply chains, it was only eight per cent. There is still a substantial discrepancy between general use of mobile money and use of mobile money for agricultural payments. In our opinion, the reason for this is the business situation in which farmers typically interact with sellers and buyers. When inputs and outputs are bought and sold in comparably small quantities, buyer and seller often meet in person. This is typically the case for smallholder farmers offering their products on local markets or selling them to friends and neighbours. The incentives to use mobile money over cash are low in these circumstances, especially since every transaction above 0.75 euros entails a transaction fee.

When inputs and outputs are bought and sold in bulk quantities, as would often be the case for farmers who sell cash crops to cooperatives, exporters, companies, or factories, two other factors limit the usefulness of mobile money payments: first, mobile money services have single and daily transaction limits. With Kenya's most popular mobile money service,

M-Pesa (see Box), these limits doubled in March 2020 and now stay at approximately 1,150 euros for a single transaction and 2,300 euros for all transactions over one day. Second, mobile money transaction may be susceptible to fraud. For example, a buyer of farm produce may reverse a genuine transaction shortly after having received the produce. While only few farmers in our study who use mobile money to make agricultural payments mention fraud as an issue, we do find that bank transfers, which are less prone to fraud and do not have transaction limits, are used by nearly half of all farmers who sell to companies, exporters, cooperatives or factories. For these farmers, bank transfers even seem to be replacing cash as a primary means of payment.

We argue that mobile money can be useful for medium size payments when business partners are located in different places or are very mobile. Overall, however, mobile money is currently more of a niche tool for agricultural payments. As with the integration of farmers into modern value chains, they seem more likely to shift from cash to bank transfers rather than from cash to mobile money, we do not expect mobile money to see much use outside this niche in the near future.

Digital savings are a viable option for agri-finance

While mobile money transfers are an important function of mobile money services, we find that the ability to hold and save money in one's mobile bank account is arguably more important for farming activities. More than 44 per cent of Kenyan farmers generally use mobile money as a tool for saving and about nine per cent of farmers reported that mobile money savings were their main source of financing farming activities. Saving money on a mobile money account usually neither requires a minimum balance nor does it entail any maintenance fees. However, mobile money savings do not yield any interest, and M-Pesa, for example, has a maximum account balance of 2,300 euros (see Box). Although most farmers still use other main sources of finance for their agricultural activities, such as family gifts, sale of livestock or income from salaries, the accessibility and low costs of saving in a mobile money account seem to make it a viable option for agri-finance for some farmers. Nevertheless, when farmers have access to a bank account, mobile money savings lose some of their relevance. As a result, we observe higher rates of mobile money use for savings among farmers in traditional supply chains, as these are more likely not to have access to other formal savings than farmers in modern supply chains. Interestingly, only one per cent of Kenya's farmers use savings through mobile banking as a main tool to finance farming. Farmers are therefore much more likely to use mobile money savings for farming than mobile banking savings. This is surprising as saving through a mobile banking account has several advantages over saving through the mobile money provider, most notably even higher interest rates than those offered by most formal banks and no maximum account balances.

We find that farmers have significantly more trust in mobile money providers than in mobile banking providers. However, for most farmers, the provider of both services is the same company (see Box). We therefore suspect that the difference in trust most likely results from farmers' longer experience with mobile money, which was introduced in 2007, compared to mobile banking, which was introduced in 2012. As experience with mobile banking and its services will increase over time, we expect this difference in trust to diminish. Mobile banking savings should then become increasingly relevant for agri-finance.

Very few farmers use digital credit for farming

Unlike mobile money services, customers of mobile banking services can apply for credit. Credit approval is determined by algorithms relying on various indicators of mobile phone and money usage and does not require collateral. Digital credit could therefore be particularly valuable for farmers living in rural areas where banks are far away, farmers who may not be able to obtain credit from banks due to a lack of credit history, or farmers who are reluctant to put up any collateral.

We find that approximately eight per cent of all farmers in Kenya have indeed taken at least one digital loan over one year. Yet a minimal proportion of less than one per cent of all farmers has taken out a digital loan to finance an agricultural activity. Farmers' general reluctance to use credit for agri-finance in sub-Saharan Africa is well-known, yet this negligible rate of digital credit use is surprising. It seems that the current form of mobile loans is either not expedient for farmers, or that the usefulness of mobile loans has not yet translated into actual adoption by farmers. We assume it is a combination of both. Arguably the biggest drawback of mobile loans that were available during the time period of the survey were the high interest rates of 7.5 per cent per month, as well as the short repayment period of one month. A key purpose of agricultural credit is to bridge the time between investment and cash inflow. In most crop production systems, the timespan between planting and harvest is much longer than one month, which makes credits with short repayment periods unattractive for such purposes.

Whether farmers start using digital credit on a larger scale will depend mainly on the ability and efforts of MFS providers to tailor digital credit products to agricultural investments. Recently, new credit schemes with repayment periods of 30 to 90 days have been developed by Safaricom in Kenya, which were supposed to fit better to the needs of farmers. Yet the merit of such credit schemes remains questionable. The digital credit market in Kenya is generally characterised by high default rates, and it remains to be seen whether and how farmers can benefit from mobile credit. It is important to emphasise that consumer protection must not be sacrificed to prevent farmers from over-borrowing and blacklisting. Otherwise, digital credit could be a barrier to financial inclusion for farmers, which is exactly the opposite of the original hope placed in MFS.

MOBILE FINANCIAL SERVICES IN KENYA

The mobile money service M-Pesa of Kenya's mobile telephone company Safaricom is the best known and by far most used mobile money service in Kenya. The two market dominating mobile banking services M-Shwari and KCB M-Pesa are collaborations between Safaricom and the Commercial Bank of Africa and Safaricom and KCB Bank Kenya respectively. M-Pesa is therefore closely connected to both mobile banking services. After six months of subscription, an M-Pesa user is automatically eligible to open an M-Shwari and KCB M-Pesa account. Transfers from a user's M-Pesa account to his or her mobile banking accounts and vice versa are free of charge. Opposed to M-Pesa, mobile banking accounts offer savings accounts with interest, lock savings accounts, as well as small loans. Credit scores and loan eligibility are determined through a set of mobile phone and mobile money usage indicators.

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Returnee migrants as agricultural innovators in Nepal

In recent decades, foreign labour migration has been a key source of income for as many as half of all rural Nepalese families. Returnee migrants often bring dynamism, new ideas, and – if they are lucky – some capital to invest. This is contributing to a revival of farming in the country's mid hills, using innovative practices and new crops.

By Jane Carter and Sudha Khadka

Rajesh Thapa Magar casts an eye over his trellises covered in kiwi vines, and smiles. The trellises stand on numerous terraces of his small farm, while further below, there are also polytunnels housing various varieties of chilly, tomato and aubergine plants. Cardamon bushes green the banks of a small stream, shaded by fodder trees that feed his goats, and various other crops are being tested in small plots. But it is the kiwi fruits that are proving to be the most profitable. "I learned the basics of market gardening when I was in Malaysia," he says, "and all through the years that I was there, I dreamed of coming home and putting some of my knowledge into practice on my own farm." This is exactly what Rajesh has done in his village of Gogane in Diprung rural municipality. He is perhaps exceptional in that his experience as a migrant worker was relevant to his current livelihood, but he readily admits that he also learned many new things on his return. It was the rural municipality that identified him as an innovative farmer, encouraging him to develop his skills and transform his farm into what is termed an agriculture learning centre. The municipality was supported in this by the SDC Nepal Agriculture Services Development Programme (NASDP), or Prayas by its Nepal name (see lower Box on the right).

The cultivation of kiwi fruit is a relatively recent phenomenon in Nepal, but a very promising one so far. Rajesh was careful to investigate the market before he invested too much. His enquires showed that the fruit was and remains in high demand in the capital Kathmandu – this is largely because of public awareness of its high vitamin C content. Facilitated and supported by the municipality and Prayas, Rajesh attended a course on kiwi cultivation in which he learnt about grafting, pruning and the establishment of trellises. By the second year, his vines were producing fruit, and in 2020, he harvested 900 kilograms from which he earned 140,000 Nepalese rupees (nearly 1,200 US dollars). This is a handsome amount for a farmer in his position. Rajesh is also demonstrating cultivation

Ganesh Kafle – posing here with his wife by a new and more efficient method of cucumber cultivation – spent four years working in Dubai and Qatar. He has turned his farm into an agriculture learning centre.

Photo: Jane Carter

methods to other farmers – not just regarding kiwi vines, but other crops, too. As an innovator, he believes in diversifying his options, although he is also keen that other farmers follow his example. The more his neighbours produce, the easier it is to organise common transport to market. When his kiwi vines began production, he and his family members, sometimes aided by hired labourers, had to rise before dawn each morning to headload baskets of kiwi fruit to an awaiting vehicle. This entailed a steep climb of over 30 minutes, each of them with 50 kilograms on their backs. The dirt road running by their house was in such a poor state that it was unpassable. With others in the neighbourhood, Rajesh requested the municipality to allocate funds for road repair. Recognising the potential for transporting agricultural produce (and the eventual tax revenue from profits), the municipality obliged. There is no longer a need to carry heavy loads uphill; instead, a vehicle comes to the farm gate.

Combining individual innovative knowledge and municipal support

When one meets a farmer in rural Nepal who is trying something different or has a particularly well managed farm, it often transpires that there is a connection to migration (also see upper Box). Maybe it is a man who spent some time abroad and has returned to his ancestral land with a wish to innovate. Maybe it is a woman whose husband has sent back money from his overseas job, giving her the chance to invest. Sometimes it is the woman herself who has travelled, although this is far less common.

The Prayas project team recognised the innovation potential of returnee migrants and, as part of their advice to municipalities, recommended that special focus be given to such individuals. In the first fiscal year that municipalities were established (2017 – 2018), Prayas provided a small amount of seed money to them to support agricultural activities – including one budget line reserved for working with returnee migrants. This sparked a variety of activities that have expanded in subsequent years, with the municipalities using their own budgets. Examples of these activities – mainly encouraged through the provision of training but also some subsidised equipment – are outlined in the Table on page 32.

As can be seen from the table, Prayas has aimed to encourage innovations that are climate-smart, as well as improving animal welfare. At the same time, the development of an appropriate marketing strategy has been an essential part of most endeavours. Municipalities can play an especially important role in this respect – from ensuring the necessary physical infrastructure of rural roads, collection points, and local market stands to networking with buyers, identifying promising products and organising appropriate training. Municipal support for marketing went one step further during the period of COVID-19 lockdown in 2020, when private transport providers were unable to operate; the municipalities themselves organised so-called agricultural ambulances to transport produce to urban markets.

The ultimate objective: inclusive agricultural services

The goal of Prayas was not simply to increase agricultural production through better services provided by diverse actors, it was to do so in an inclusive manner, ensuring opportunities for disadvantaged women and men with very limited resources. In this respect, singling out returnee migrants for support may be questioned. They are not, generally, the poorest members of the community, and the very fact that they often have some savings to invest implies the opposite. It could be argued that as individuals with an innovative disposition, ready to take risks, they are the last people who need support – they will probably manage to make a livelihood anyway.

There are three counter arguments to this viewpoint. The first is that, left to their own devices, returnee migrants might invest in something other than agriculture or (more likely) invest in farming without thoroughly assessing the options. Like any other business venture, agricultural enterprises require sound knowledge of production and marketing aspects as well as good financial planning. Adequate technical support for the incubation and nurturing of new ideas can be crucial to success.

The second argument is that successful returnee migrants can serve as an inspiration and example – taking risks that can be copied with potentially less risk by other farmers. Rajesh Thapa Magar illustrates this well; he is someone who comes from a very modest background and is respected both within his community and more widely for his hard work and dynamism. Others have come to his farm to learn from him and have followed his lead.

FOREIGN LABOUR MIGRATION – INTERRUPTED BY COVID-19

Every day, some 1,500 individuals – mainly young men – used to file through Kathmandu's airport on their way to overseas employment. The Gulf countries and Malaysia were the prime destinations. When the Covid pandemic took hold, flights halted – stranding some migrants abroad against their will and preventing others from leaving. More recently, air travel has recommenced, but there is considerable hesitancy in the overseas job market. Many would-be migrants – whether first-time or "seasoned" travellers – are having second thoughts.

NASDP/ PRAYAS IN BRIEF

The Nepal Agriculture Services Development Programme (NASDP) operated from 2016 to 2020, eventually covering 61 municipalities in different parts of provinces 1, 3 (Bagmati) and 6 (Karnali). A bilateral project of the Swiss Agency for Development and Cooperation (SDC) and the Government of Nepal, it was implemented with technical assistance from Helvetas. The project was designed before Nepal's federalisation – a major political and administrative change that swept away the former system of 75 (eventually 77) districts reporting to a central government and replaced it with 753 municipalities, 7 provinces, and one federal government. Exclusive responsibility for agricultural extension services, formerly organised through the districts, was devolved to municipalities. The implementation of federalisation meant that the approach adopted by Prayas also had to change – to focus on supporting municipalities in their new role. This was no easy task, given that they lacked appropriate policies, laws and systems as well as having inadequate numbers of trained staff. However, the project was able to give substantial technical assistance.
More information: **www.rural21.com/english/from-our-partners.html**

Innovative agricultural activities adopted by returnee migrants

Type of activity	Innovation	Comment
Floriculture	• Marigold cultivation for making floral garlands, appropriate cultivation techniques – especially ensuring as long a flowering season as possible using different varieties. • Development of marketing linkages, post-harvest management, collection and transport strategy.	Marigolds are widely used for offerings at temples and for garlands at festival times. Until recently, much of the demand was met from Indian imports; floriculture was an innovative concept for Nepalese farmers.
Kiwi production	• Introduction of different kiwi varieties, grafting techniques, marketing support, etc.	As described in the example of Rajesh Thapa Magar.
Dragon fruit production	• Introduction of different dragon fruit varieties with appropriate cultivation and management techniques. • Use of rainwater harvesting for irrigation in arid areas (practised in Halesi Tuwachung municipality, in collaboration with the local research station).	This relatively unknown fruit is increasingly demanded in urban markets (notably Kathmandu) as a high value product. However, its commercial development in Nepal is still at a pilot stage.
Vegetable production	• Construction of protected structures (plastic and net houses) and associated cultivation and management practices including protection measures. • Modern, water-saving irrigation techniques (drip irrigation, etc.). • Development of marketing linkages, post-harvest management, collection and transport plan.	Commercial vegetable cultivation in Nepal's mid hills only really began in the last 20 years and has tended to be opportunistic rather than strategic. Project support has focused on developing a good marketing strategy alongside innovative technologies.
Sustainable mushroom cultivation	• Construction of improved mushroom sheds. • Management practices to minimise waste and ensure integrated pest and disease management. • Development of marketing linkages, ensuring local market demand, implementation of post-harvest management and value addition (drying).	Mushroom cultivation for the urban market has boomed in recent times but can result in poor environmental management (large quantities of plastic waste, poor quality mushrooms that cannot be sold, etc). Innovations focus on sustainable production.
Free range poultry	• Raising chickens in appropriate, open pens that favour bird health. • Ensuring quality feedstuff, unadulterated with antibiotics or hormones. • Climate-friendly management of dung for fertiliser ensuring minimal nutrient run-off.	The intensive raising of chickens for meat and eggs has become big business in Nepal but is marred by very poor animal welfare and hygiene. Chicken eggs and meat produced under humane conditions can fetch premium prices.
Turkey production	• Introduction of turkeys to farmers and appropriate raising techniques. • Development of marketing linkages, collection and transport strategy.	Turkey meat is relatively unknown in Nepal, but there is a growing seasonal demand from the expatriate community (for Thanksgiving, Christmas) and from middle-class Nepalese.
Improved goat production	• Use of pedigree bucks for genetic improvement – rotated between farmers. • Cultivation of varied fodder plants for a mixed, healthy diet. • Specially constructed climate-smart stalls to maximise the capture of dung and urine for fertiliser. • Strict animal hygiene and health check-ups.	Goats are very widely kept in rural Nepal; castrated males fetch an especially good price for slaughter at festivals. However, under traditional rearing methods, animal welfare standards can be poor, and production limited by inadequate fodder and poor breeding stock.

The third argument is that returnee migrants generate opportunities for others. During the peak season of three months a year, Rajesh hires up to ten daily labourers. This valuable local employment, which often goes to women, is replicated by many other returnees. Municipalities can also insist that subsidies provided to innovative farmers are shared within farmer groups. For example, if one farmer is subsidised in the purchase of a power tiller or planting device, the municipality will oblige him or her to lend it at a favourable rate to other group members who thus gain access to equipment without having the burden of making a capital investment or taking a loan.

To conclude, we would like to stress that working with returnee migrants is not simply conceived in terms of "trickle-down theory" – helping the most dynamic so that others follow. Rather, it is one strategy amongst others adopted by municipalities, with Prayas support, to foster agricultural opportunities. This article simply focuses on one part of that overall approach.

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Towards a world without hunger: research points the way

Increasingly complex global challenges are also making more and more adjustments necessary in combating hunger and poverty. But new scientific evidence can help us make the right decisions, our author claims.

A glance at the 2020 Global Hunger Index (GHI) might give us cause for hope: worldwide, the food situation is by no means as serious as it was 20 years ago. Malnutrition in children has fallen and agricultural productivity has increased significantly in many countries. And yet the number of undernourished people has been on the rise again since 2016 and has now reached close to 690 million. The majority of the world's undernourished – 381 million – live in Asia. Around 250 million live in Africa, where the number of undernourished is growing faster than anywhere in the world. Some three billion people simply cannot afford a healthy diet. Armed conflicts, extreme weather events induced by climate change and the recent plague of locusts in East Africa are the main drivers of hunger and malnutrition. Then there are the challenges caused by the current pandemic, which is reversing much of the progress made, making it impossible to cultivate fields or harvest crops. Up to 130 million people are falling back into hunger and poverty as a result of coronavirus. Each day, 15,000 children die from hunger.

In response to the growing global challenges, the G7 leaders, at their 2015 summit in Elmau, pledged to lift 500 million people out of hunger and malnutrition by 2030. That amounts to 72 per cent of all undernourished people in 2019 and 60 per cent of all undernourished people in 2020 if COVID-19 projections are factored in. Also in 2015, the international community signed up to the 2030 Agenda, with its specific goal of ending hunger and malnutrition worldwide. Today, six years after the adoption of the 2030 Agenda and our G7 target, we need to recognise that we are not on track to achieve SDG 2 (zero hunger) by 2030. In fact, if the latest trends continue, the number of hungry could rise above 840 million by 2030.

As the world's second largest donor to food security, we believe we have a responsibility to map the right course towards reversing this negative trend. With that aim in mind, the German Federal Ministry for Economic Cooperation and Development (BMZ) has commissioned leading scientists to find out what is the most effective package of measures to achieve SDG 2 – and what it would cost. This question is being addressed by a team of researchers from Cornell University, the International Food Policy Research Institute (IFPRI) and the International Institute for Sustainable Development (IISD) in Ceres2030 – Sustainable Solutions to End Hunger. Another study by the Center for Development Research (ZEF) at the University of Bonn, and FAO scientists looks at trends since 2015 and the incremental costs of specific interventions.

SDG 2 – is it money that matters?

The studies reveal a clear upward trend in investment in food security and agriculture. The G7 countries alone more than doubled their spending between 2000 and 2018 to around 17 billion US dollars (USD), with the funds mainly benefiting countries with particularly high rates of undernourishment. But at the same time, the challenges have become larger and more complex, so we need to step up our engagement. According to the studies, the developed countries could spend an additional 14 billion USD a year between now and 2030, roughly double their current level of expenditure, in order to fund the required level of investment. But action is required from the developing countries as well: they need to prioritise the agri-food sector and make a comparable level of investment. Once these sums are available, it will be possible to lift 500 million people out of hunger, double the incomes of small-scale farmers and build climate-resilient agriculture by 2030.

The first step is to prioritise cost-effective interventions that boost food security for a relatively large number of people, such as measures to increase the efficiency of agricultural research and development, expand agricultural extension, boost investment in ICT, particularly agricultural information services, promote small-scale irrigation schemes in Africa and improve education provision, especially for women.

What we need to do

The researchers are largely in agreement on how this should be done as well. It is not about prioritising individual measures but about identifying the right mix to achieve SDG 2 and its targets. The Ceres2030 team approached this task by using specially developed artificial intelligence to conduct a comprehensive analysis of scientific studies and evaluated more than 25,000 articles from 3,500 journals and relevant databases (including FAO, CGIAR and World Bank). The recommended measures fall into three categories:

a) Interventions to increase participation – e. g. membership of farmers' organisations, expansion of social security programmes. **b)** Interventions to benefit farms – e. g. precision irrigation to boost agricultural productivity, implementation of environmental protection measures based on financial incentives for small-scale farmers. **c)** Post-harvest interventions mainly aimed at strengthening supply chains, such as measures to reduce post-harvest losses, and reforms to increase intra-African trade and facilitate smallholders' access to markets.

As the studies show, we are heading in the right direction. A world without hunger is possible. With consistent implementation of the recommendations, the international community can still achieve its targets. The BMZ remains firmly committed to this sector – through our projects, for which we already provide around 1.7 billion euros per year, and as an international agenda setter. As an example, we plan to use the UN Food Systems Summit in 2021 as an opportunity to continue our lobbying for the transformation of food systems and to work collaboratively on multisectoral solutions. The message is clear: we need to act now. Not only will a delay have dramatic impacts on living conditions in our partner countries; the longer we wait, the higher the costs of achieving a world without hunger will be.

Gunther Beger wrote his article in his role as Head of the Global Health, Economics, Trade and Rural Development Department at the Federal Ministry for Economic Cooperation and Development (BMZ). Since February 2021, he has been German Executive Director of the World Bank.

Closing the adoption gap

It can easily take years for agricultural innovations to find real-world practical application. There are a wide range of reasons for this which are familiar to the agricultural research community. But how can innovations succeed in making it from the development stage in the lab to being applied in the field? By the agrifood sector following the example of the health sector in opting more for implementation research practices, our authors maintain.

By Manfred Denich and Cory Whitney

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The volume of scientific knowledge in the agricultural sector is growing unabatedly, and there is widespread agreement that rural development is hampered not by a lack of knowledge, but by a lack of implementation of that knowledge. It is important to consider that billions of euros are spent each year on research and development (R&D) in the agricultural and food sector, not only in the Global North, but also in the South. These investments are directly linked to raising agricultural productivity and food supply, but they also include R&D on environmental and social issues. However, it is not always clear that the investments will ultimately pay off. Indeed, it can take decades to observe the impact of research and respective investments on agricultural practices, i.e. research-based innovations (technologies, practices and policy or institutional concepts based on R&D that are new to their users) and scientific knowledge find their way into practice either very slowly or not at all. It often takes several years for an innovation such as a new crop variety to be adopted by farmers, or even several decades, e.g. when mechanisation or irrigation facilities are concerned.

It goes without saying that researchers want their findings to have impact, and that funding agencies expect measurable effects and seek mechanisms to assess the contributions of research for development. The primary method for measuring impact on agricultural practice is to determine adoption rates, i.e. the number of farmers adopting a given innovation in a particular research area (see article on pages 20-22). So far, the results of the majority of such assessments have been dismal. Recent CGIAR studies found that the adoption rates regarding natural resources management, animal agriculture, improved crop varieties and government policies are predominantly in the single digit percentage.

The lack of adoption of R&D innovations by farmers may stem from a number of factors, such as lack of access to the innovation, lack of appropriate services and training and other socio-economic conditions that were overlooked in the R&D process. A positive attitude towards innovative agricultural practices alone does not mean that land users will adopt them. However, extension services can only contribute to achieving research-based agronomic objectives if farmers perceive the advice provided as relevant and useful. Farmers may also dismiss innovations out of hand as irrelevant or incomprehensible (whether rational or not).

Research for implementation

The agricultural R&D sector is familiar with the issues listed above and, accordingly, has implemented a variety of research approaches that aim to increase the practical relevance of research-based findings and thus facilitate their implementation. For example, it has become a standard in recent times that research targeting farmers' needs and rural development is interdisciplinary. Interdisciplinary research involves different scientific disciplines, whereby the disciplines are brought together in an integrative manner to solve problems. Another approach is transdisciplinary research, which goes a step further by involving target groups and end users ideally in the planning, execution, discussion, and interpretation of research, i.e. it combines scientific and practical knowledge. Both types of approach, inter- and transdisciplinary, should ultimately help to make the implementation of research results in practice more successful. When it comes to experimental studies, approaches described as 'researcher-managed on-farm research' and 'farmer managed on-farm research' are common. Such participatory or collaborative research approaches exist in a wide variety of forms including approaches known as Follow the Technology (FTT) and Follow the Innovation (FTI) and extend to field research with strong action research components.

Although inter- and transdisciplinarity are often applied in research projects, the lion's share of research is disciplinary. Usually, disciplinary research facilitates specific research questions to be answered. However, in many cases, it is difficult for the findings make it into practice. Thus, often relatively short-term research is contrasted with long time lags before implementation. It can also happen that innovations are never implemented in practice. Complicating matters further, the immediate target group of research is often not the farmer but rather

> The lion's share of research is disciplinary.

extension services or policy-makers. Therefore, to ensure that research efforts do not fizzle out without effect, a connecting step must be inserted between research and operational practice, which may be described as 'implementation research'.

The agricultural research community can learn from the processes and methods applied in the health sector, where implementation research, also known as translational medicine, is common. With the so-called "bench-to-bedside" approach, in translational medicine, researchers and practitioners transfer new diagnostic approaches and treatments from the research laboratory into practical application. Translational research is occasionally encouraged in agricultural and landscape research, primarily for the transfer of research findings from basic to applied research, providing the link from the laboratory to the field. However, this is rarely applied, with few exceptions, including the detailed discussion of translational research and knowledge exchange and its application in a study on UK wheat value chains a decade ago.

The notion of implementation research

Implementation research is a collection of scientific inter- and transdisciplinary approaches aimed at identifying barriers to the implementation of research-based innovations and developing solutions for the implementation of research outputs in practice. Accordingly, implementation research attempts to understand which innovations have to be applied where, when, how and for whom. An important aspect of implementation research is the iterative linkage of research and practice that provides researchers, as innovation developers, with information about the applicability of the innovation or useful modifications.

Implementation research is transdisciplinary by nature. Concerning the agricultural sector, it requires the cooperation of not only agronomy, economy and social science, but also of disciplines such as psychology, education research and communication science, among others. Besides researchers, stakeholders to be included are farmers, extension workers, the authorities, companies from the life sciences, plant breeding, agrochemistry and agricultural engineering as well as banks, the trading sector and consumers. Implementation research in agriculture has to adequately capture the complexity of the farmers' personal, social, economic and ecological conditions. Furthermore, psychological, pedagogical and behavioural aspects have to be considered when it comes to the implementation of newly developed agricultural technologies and concepts – these seem to receive little attention at present. From the researchers' perspective, implementation research is a logical consequence of research-based development of innovative technologies and concepts. Unlike adoption research, which is preceded by the dissemination of research-based innovations by agricultural extension services or via farmers' networks, and later assessed as to whether or not or to what extent it has been adopted by the target group, implementation research represents the direct continuation of formal research, i.e. the research community holds the reins and can use the findings to implement the innovation in accordance with the research hypotheses originally established. Maintaining a practice-orientated view can be particularly useful when innovations emerge from a large number of small-scale and potentially disparate, disciplinary research projects (e.g. doctoral theses).

Implementation research in practice

Funding mechanisms aimed at research-for-development provide a fertile environment for putting implementation research into practice. For example, the research-for-development (R4D) continuum of the CGIAR system, also adopted by the German Federal Ministry for Economic Cooperation and Development, is divided into four phases: discovery, proof of concept, piloting and scaling up. The transitions from 'proof of concept' to 'piloting' and from 'piloting' to 'scaling up' represent gaps that can be the focus of implementation research. Implementation research applied before the piloting phase addresses the barriers and corresponding issues regarding the transition from the experimental field to farm reality. Implementation research applied after the piloting phase addresses aspects of the broad implementation of the innovation into the local farm sector or beyond. In this way implementation research covers the transition of the innovations from smaller protected, monitored and supervised spaces to the larger scale. Thus applied, implementation research helps shape the transition from one phase to the other and ensure widespread implementation of innovations. Furthermore, the implementation research approach is flexible and can also start together with disciplinary solution-oriented research where innovations are developed. In this case, the extent of implementation research would increase over time, while the activities of solution-oriented research would decrease as innovations are rolled out and scaled up.

Implementation research for agriculture R&D not only benefits farmers, but also satisfies researchers and donors. National and international funding mechanisms that aim to have impact should include the expectation that implementation research is practised in funded projects. The international research community should be supported in applying implementation research through targeted support programmes.

Further reading: **www.rural21.com**

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Implementation research is transdisciplinary by nature.

Encouraging children's love of trees

Forests, the lungs of the Earth, are disappearing at an alarming rate. In Nigeria, less than two per cent of the forest cover remains. Restoring and conserving what is left is crucial, and is a collective effort if we are to cope with global warming. In any sustainable tree planting exercise, involving youth, teenagers and children is important. With this in mind, the Forestry Research Institute of Nigeria (FRIN) established the Go-Green project. It was designed to create conservation consciousness among young people and show them the benefits of tree planting and its impact on the environment.

By Oluseyi Olutoyin Olugbire, Deborah Olubunmi Oke, Olumide Awofadeju and Ayanfe Samuel Adisa

About half the land in Nigeria used to be covered with trees. Today, all but about two percent of them have been chopped down, and less than one per cent exists as frontier forests. Most of the trees have been lost to unsustainable timber felling, converting into farmland, industrialisation and urban development. In addition, more than 70 per cent of Nigeria's rural population use firewood, a key contributor to deforestation.

Nigeria's forests have been declared among the most threatened on the planet, given high population growth rates impacting heavily on forests and resources derivable from them. As early as 2008, Kabiru Yammama, head of the Nigerian National Forest Conservation Council (NFCCN), had warned that "Nigeria will lose all of its remaining forests in the next twelve years if the rate of deforestation remains unchecked". Deforestation – removing trees without replacing them – has social, economic and environmental effects on the ecosystem and livelihoods of the people. Its effects include loss of animal and plant species habitats, loss of shade from sunlight, fertile land becoming a desert and water scarcity. Cutting of trees also exposes the soil to erosion and flooding, resulting in loss of soil nutrient, land degradation and loss of livelihoods depending on forest products. Collective and concerted efforts are therefore needed to properly manage and conserve the remaining existing forests in the country in order to safeguard the future.

The Go-Green Project and the Young Foresters Club (YFC)

To contribute to increasing Nigeria's forest cover and reduce the effect of climate change in the country, the Forestry Research Institute of Nigeria – FRIN – decided to extend its conservation efforts to younger people. Saddled with the mandate on training, extension and outreach, FRIN launched the Go-Green Project. The project was designed to develop collaborations with schools on environmental conservation measures and support the students in establishing the stand of trees in their respective schools. It involves among others public and private schools, the Institute's extension service and technical officers. Ten primary and secondary schools have successfully been adopted in the Southwest geopolitical zone, while other zones are to follow.

Students carrying their tree seedlings for planting.

Within the framework of the project is the formation of the 'Young Foresters Club' (YFC), created to arouse conservation consciousness among the young and bring interested students in the adopted schools together for environmental education, in-depth training and demonstration of tree planting exercises as well as micro-level production of other resources derivable from the forest, such as mushroom and snail rearing. The YFC is to inspire young people and imbibe the culture of tree planting and environmental protection in them so that they grow up with it. In the long run, this is intended to reverse environmental degradation in our communities and ensure economic development and better living standards.

For the formation of the Young Foresters Club, a multi-stage sampling procedure was used to select 30 schools in each of the geopolitical zones in Nigeria. The first stage involved a random selection of three states in each zone. Next was the random selection of five local governments from each state. A primary and secondary school were then randomly selected from each local government in the third stage, yielding a total of ten schools per state. Adoption of each selected school was based on acceptance of the school management after an official letter was sent and follow-up visits made to the management of the schools. Membership of the YFC was made voluntary, depending on the interest of the students.

Club meeting days were held at intervals of two weeks. Here, students were taught how to plant a tree correctly using simple tools with general on-the-field discussions on the importance of trees. Trees were planted within the school premises, with the choice of location jointly made by the YFC members, agricultural science teachers and the forest extension officers of FRIN. Members of the club participated fully in the tree planting exercise, and transfer of knowledge was enhanced. The Institute provided each participating school with 50 tree seedlings to encourage demonstration practices.

Getting the young forester to love trees

The primary aim of engaging the students was to make them love and protect trees. They were taken through the step-by-step procedure of planting trees with a demonstration method involving them in planting, nurturing and tending the trees. At the club meetings, the students learnt about various types of tree species and their economic importance. During a symposium at the Institute, a quiz

Young Foresters Club Members at the Institute's International Day of Forest Celebration.

Photos: Oluseyi Olutoyin Olugbire

competition was organised for the participating schools to assess the knowledge acquired during club activities.

FRIN's extension and technical staff, the head of each participating school and students were involved in the planting exercise. The schools were supplied with tree seedlings for planting. Most sites had already been cleared. Planting holes were dug in rows at spacing of 3m by 3m. The planting was first demonstrated by FRIN staff, after which the heads of the schools and the students planted up the seedlings.

The students participated fully in the monitoring of tree growth. All students in the YFC were given a tree seedling to plant and tend, and so the tree became their 'Baby', and they were told that 'the Baby must not die'. This made them become more committed and devoted to tending the trees.

The extension team adopted a participatory approach which enabled school management, teachers and students to learn new perspectives on conservation and work together. Continuous sensitisation was carried out on the effects of deforestation and benefits of tree planting (see lower Box). Thus, participating schools developed a sense of ownership of the project and became interested in the tree planting exercise.

Lessons learnt, and what next?

The project was conceived because of the dire need to involve the youth in conservation, thereby imbibing the culture of tree cultivation and nurturing into them at tender ages. Project activities were planned around the availability of students because they would play key roles in the activities by providing their time and labour. Students participated fully from the very first stage of sensitisation and awareness to preparing the sites, planting, monitoring tree growth and other activities.

School management cooperating in releasing their students for extra curriculum activities was a key factor in the success of the project. Organising training in a way not interfering with students' academic periods was also important for the effectiveness of the exercise. Extra-curriculum activities slated during off-periods yielded more success, and increased student participation was recorded. Involving the youngsters at a tender age will go a long way towards imbibing the culture of tree planting in them. With the successful implementation of the Go-Green Project in the Southwest zone of the country, replicating it in other geopolitical zones is not expected to be a challenge. Tree planting through a participatory approach has proven to be effective, and, contrary to expectation, the young ones' perspectives towards conservation and tree nurturing is unprecedented – in other words, the children love trees!

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*With contributions from **Lucy Orumwense** and **Titilope Olarewaju**, who are both Research Fellows 1 at Forest Economics and Extension Services Department at FRIN, Ibadan, Nigeria.*

THE FORESTRY RESEARCH INSTITUTE OF NIGERIA

The Forestry Research Institute of Nigeria (FRIN) was initially established as the Department of Forestry in 1954. It is the only Research Institute under the supervision of the Federal Ministry of Environment. Its mission is to ensure, through scientific research and outreach activities, human resource and community development, sustainable forest resources production and utilisation, management of soil and water resources, environmental conservation and protection, reclamation and rehabilitation of degraded lands for environmental sustainability, and self employment and poverty alleviation. The Institute has Research Departments located at its headquarters in Ibadan, as well as Colleges and Research Outstations in all the geopolitical zones of the country. To disseminate its technologies among the rural communities, FRIN has adopted villages across the country. In a bid to reach out to the young ones, the Institute has also adopted primary and secondary schools in the country.

BENEFITS OF TREE PLANTING

Tree planting is an engaging environmental activity providing an opportunity for community involvement and empowerment which improves the quality of life in our neighbourhoods. The importance of trees in human life cannot be overemphasised. They help clean the air we breathe by absorbing pollutant gases and sweep up particles like dust and smoke, and contribute to reducing the effects of climate change by trapping greenhouse gases. Trees play a key role in capturing rainwater and reducing the risk of erosion, flooding and landslides, and provide habitats for hundreds of species of insects, fungi, moss, mammals, and plants. They bring economic benefits to an area by raising house prices on aesthetic grounds. Trees provide food such as apples, pears, cherries, plums, etc., and their leaves, branches and barks can be used in medicine. Trees planted in the cities can have a positive impact on mental health and well-being, reducing stress and encouraging outdoor activities. They also provide shade, serve as windbreaks and can moderate the heat effect caused by pavement and buildings in commercial areas.

Organic agriculture – a viable solution to achieving the SDGs

Results from long-term trials established by FiBL and its partners in Kenya, India and Bolivia reveal that the profitability and productivity of organic agriculture can equal conventional agriculture. Furthermore, this long-term research demonstrates how well-managed organic farming systems relate to achieving the Sustainable Development Goals.

By Beate Huber, David Bautze, Eva Goldmann and Laura Armengot

Agroforestry (left) and monoculture farming system (right) at the trial site in Bolivia. Photo: FiBL

Climate change, biodiversity loss, and depletion of natural resources are urging society to change the prevalent way of farming. Several alternative production systems, such as organic farming, promise environmental and social benefits. Organic farming refrains from using synthetic pesticides and fertilisers, relying on crop rotation and intercropping, and emphasising closed nutrient cycles. Therefore, organic systems prioritise locally adapted crop varieties and locally available resources. Organic agriculture aims to sustain and enhance the health of the environment and humans. Nonetheless, it has been questioned whether organic agriculture can contribute to sustainable development. Several studies conducted in temperate environments (mostly in Europe or Northern America) have established the benefits of organic farming over conventional farming. However, the results cannot be directly extrapolated to tropical conditions, and here, only little scientific evidence is available regarding organic systems' performance in a different climate, crop and socioeconomic context. Recognising this gap, the Swiss Development Cooperation (SDC), together with the Swiss-based COOP Sustainability Fund, the foundation Biovision and the Lichtenstein Development Service (LED), supported the programme "Long-term farming systems comparisons trials in the tropics" (SysCom; see Box on page 40).

With this support, SDC was seeking evidence for the assumption that organic farming could be a viable option in the tropics and increase the resilience of ecosystems and smallholder livelihoods by promoting low-external input-based production strategies. Scientific evidence allows putting the debate on transformation pathways towards sustainable food systems on a more rational basis. The programme could become a reference for this debate, influencing policy decisions towards more agroecological and sustainable approaches, also with regard to various Sustainable Development Goals (SDGs).

The SysCom programme has been running for over a decade in diverse agroecological environments. Four long-term experiments were established in Kenya, India, and Bolivia between 2007 and 2008 to evaluate organic and conventional production systems' performance (see Figure). Additionally, participatory on-farm research was performed which aims to develop technological innovations and management practices, ensuring that organic farmers' needs are addressed directly. Together, the long-term trials and participatory research offer a unique platform to address critical questions on the viability of various production systems and their contribution to sustainable agricultural development at the local, national and international levels. The following conclusions are drawn to illustrate how organic farming can contribute to achieving several of the SDGs and what action is needed to develop organic farming in the tropics.

Yield and profit of farming systems

To contribute to the SDGs "Zero Hunger" (Goal 2) and "No Poverty" (Goal 1), agricultural production systems need to be produc-

tive and profitable. Therefore, we compare the yields and the profit gained in organic production systems to what conventional systems achieve.

The yields of organic production systems can equal those of conventional systems, although this depends on the crop type and the management practices (see upper Figure on page 40). For instance, legumes (e.g., soybeans or common beans) achieve similar yields in organic and conventional systems. They do not rely on the external nitrogen inputs since they can fixate nitrogen from the atmosphere. On the other hand, yields can be lower in cereals (e.g. wheat or maize) or cotton. These crops do depend strongly on fertilisation in their crucial growth stages, and even though organic inputs can build up soil fertility in the long run, they are often less easily accessible for plants than synthetic fertilisers. In organic vegetable production, yields were lower than in conventional systems due to the challenge of successfully managing pests and diseases. This is especially true when the organic systems try to mimic conventional methods and only substitute conventional pesticides with bio-pesticides/ botanicals.

We also learnt that the complexity of the production systems could significantly affect yields, i.e. a well-thought-through crop rotation, intercropping, or border-cropping of plants attracting beneficial insects and repelling pests not only increases the biodiversity but also helps to manage pest and diseases better. Such management practices had a greater impact than the effect of conventional or organic production. For instance, in cacao production, we found strong differences between monoculture (i.e., cocoa trees growing alone) and agroforestry systems (i.e. cocoa trees growing together with other companion trees), although whether monocultures or agroforestry systems were managed organically or conventionally had much less impact. While in complex systems such as agroforestry the yields of cocoa for instance are lower, we achieve higher total productivity and a higher diversity of products when we consider the whole yields from the field, e.g. including plantain, banana, other fruits, cereals or tuber crops.

The profitability of a production system is, simply speaking, the result of the yields achieved and the prices for marketable products minus the production costs. Costs for organic fertiliser or (bio-) pesticides are often lower in organic systems. Additionally, organic produce can fetch higher market prices, compensating for the economic loss due to lower yields in certain crops. However, labour demands, e.g. for compost preparation, contribute strongly to production costs in organic systems. Partially, organic systems can achieve higher returns on production costs and equal returns on labour, making them a suitable option, particularly for capital-poor smallholder farmers.

Site description and trial design of the SysCom trial sites

	Kenya	India	Bolivia
Site	Sub-Saharan Africa – Kenya Central Highlands	South Asia – India Madhya Pradesh, Nimar Valley	South America – Bolivia Sara Ana
Climate	Sub-humid, two rainy seasons	Semi-arid, monsoon rains (June–September)	Tropical-humid, winter dry (June–August)
			
Crops	Maize-based systems, 3-year crop rotation with maize, vegetable and potato	Cotton-based systems, 2-year crop rotation with cotton, wheat and soybean	Cocoa-based systems, cocoa trees with plantain, coffee and timber trees
Production systems	Organic vs conventional at low and high input level	Organic and biodynamic vs conventional with/without GMOs	Organic vs conventional as full sun (monoculture) or agroforestry

Sustainability beyond yield

To assess the sustainability of a production system, one needs to look beyond yield and profit. When it comes to SDGs such as "Life on Land" (Goal 15) or "Climate Action" (Goal 13), we found that organic agriculture has several comparative advantages compared to conventional agriculture. For example, residues of synthetic pesticides could even be detected in the crops and environment of the well-managed conventional production plots, whereas this was not the case in the organic plots, where only organic pest control products were applied. Another benefit of organic agriculture is its comparatively higher biodiversity: bird species diversity and earthworm abundance were higher in organic production systems. We found evidence that the build-up of soil fertility (e.g. higher carbon content in the soil and aboveground biomass – see lower Figure on page 40) over the long term is enhanced in organic systems. Carbon plays an important role in mitigating climate change and increases resilience.

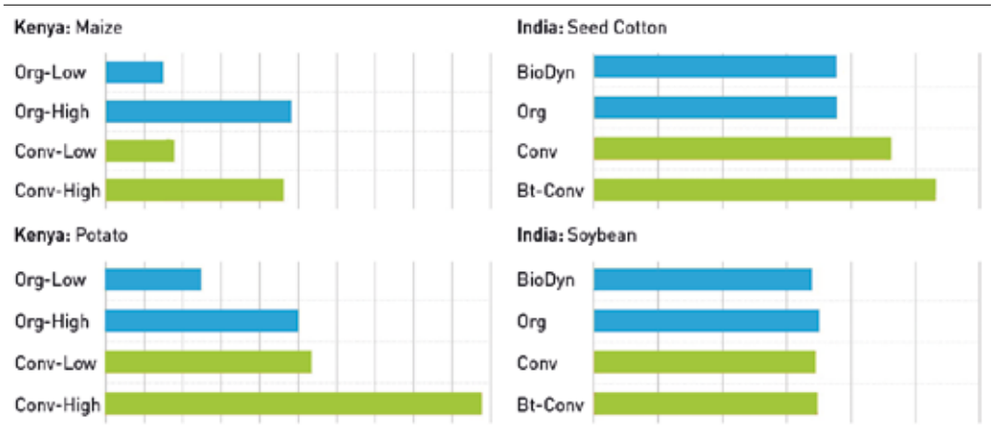
Fostering organic farming in the tropcis – policy recommendations

Based on the SysCom programme's evidence, organic farming can be seen as a viable solution to achieve several SDGs by 2030. The following recommendations are relevant to agricultural policies at the national and regional level, actors in specific commodities, sectors and value chains to develop organic farming in the tropics.

System-oriented pricing: For many organic farmers, premium prices are only available for certain cash crops destined for export markets (such as cocoa and cotton), and not for other crops in the rotation. A conducive policy environment providing production system-oriented pricing and compensation schemes will support profitable organic production systems that enhance livelihoods.

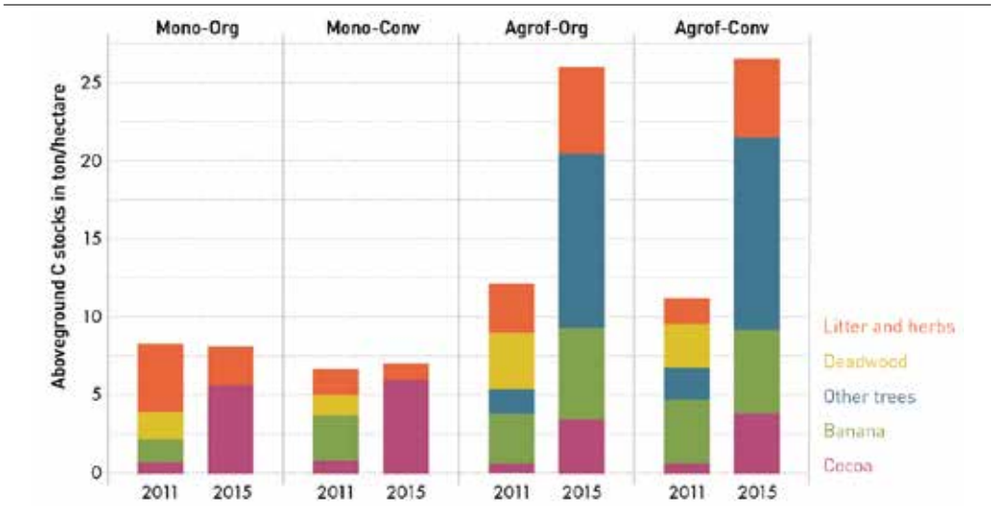
Market linkages for diversified production: Organic farming and agroforestry systems offer a wider range of products than conventional farming based on monocultures. Therefore, organic farmers need to sell the different products they produce as 'organic'. Reducing farmers' dependency on particular (mostly export-oriented cash) crops will improve their livelihoods and support diversified farming systems. This requires a stimulating business environment that fosters market innovations and primes local markets for a diversified range of organic produce.

Crop productivity in Kenya and India



Crop yield for maize and potato in Kenya and for cotton and soybean in India.
Org = organic; Conv = conventional; BioDyn = biodynamic; Low = low input level; High = high input level; Bt = Bacillus thuringiensis (GMO)

Carbon sequestration in Bolivia



Carbon sequestered in biomass of the trees (cocoa, banana and other trees) and on the herbs and death biomass in two different trial years in Bolivia.
Mono-Org = monoculture, organic; Mono-Conv = monoculture, conventional; Agrof-Org = agroforestry, organic; Agrof-Conv = agroforestry, conventional.

Capacity building and extension services: Farm performance varies widely across different agricultural management practices and production systems, suggesting a lack of best practice implementation. Capacity building on good management practices improves yields and reduces losses due to pests and diseases. Policies should recognise the importance of know-how to manage sustainable farms successfully and prioritise capacity building for farmers. Organising farmers into cooperatives and (self-help) groups can build capacities, e.g. through peer-to-peer learning and development and dissemination of innovative solutions.

Technical innovations and medium-scale mechanisation: Challenging labour requirements and declining labour availability force smallholders to either scale down their activities or opt for simpler farming systems, threatening food security and livelihoods. Technical innovations and medium-scale mechanisation adapted to the local conditions reduce the need for manual labour and are thus key to empowering small-scale organic farmers. Such innovations can help farmers sustain and increase their activities, lower their production costs and improve their livelihoods and food security.

Closing the research gap: Over the last decades, research focused on the intensification of conventional production systems. Holistic systems design, building on diversified and interlinked production patterns, was neglected. Research on optimising nutrient management, carbon storage, and tillage practices and implementing a systems approach for pest and disease management is needed to address critical organic agriculture challenges in the tropics. Research and technology development must acknowledge that resilience increases with the complexity of a system and strengthens farming to face the threats imposed by climate change.

Provision of public goods: Organic farming sustains public goods by providing ecosystem services such as supporting carbon sequestration, conserving biodiversity and improving nutrient cycling. Awareness among consumers and decision-makers for these benefits of organic farming enables an environment in which organic farming can grow and contribute to truly sustainable food systems, providing healthy food for a growing population without damaging human and environmental health.

The DOK trial in Switzerland

The SysCom programme was inspired by the famous DOK Trial ("Dynamisch-Organisch-Konventionell" – dynamic-organic-conventional), an experiment comparing farming systems running in Switzerland since 1978 and managed by the Forschungsinstitut für Biologischen Landbau (FiBL) in collaboration with Agroscope, the Swiss centre of excellence for agricultural research. The trial provided scientific evidence that organic arable farming can achieve good, high-quality yields and contributed significantly to the general acceptance of organic farming both at policy level in Switzerland and at international scientific level.

The authors are members of the SysCom team, led by **Beate Huber**, at the Forschungsinstitut für Biologischen Landbau (FiBL) in Frick, Switzerland. **David Bautze** works mostly in SysCom Kenya, and **Eva Goldmann** with SysCom India, while **Laura Armengot** is Scientific Coordinator of the programme and works with SysCom Bolivia.
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The SysCom programme is implemented in close collaboration with partners from research, farmer organisations and NGO's. Key partners for managing the trials are icipe, KALRO, KOAN, Kenyatta University and KIOF in Kenya, Ecotop, Instituto de Ecologia and El Ceibo in Bolivia as well as bioRe in India.

For more information: **www.rural21.com**

Training participants baling hay using a hay box/ crate.

Photo: Chrilukovian B. Wasike

Bridging the knowledge and skills gap in dairy husbandry

Smallholder dairy production in Kenya has been identified as a key pathway to food and income security by the government. However, there is a lack of adequate knowledge and skills for effective milk production. In the context of the Green Innovation Centres for the Agriculture and Food Sector Programme of GIZ, 1,400 smallholder farmers in Western Kenya were trained in several husbandry-related practices. Our authors analysed the impact of the training programme.

By Chrilukovian B. Wasike, Caroline C. Wambui, Joan Awino and Ulrich Schmidt

Smallholder dairy production units account for over 80 per cent of total milk produced and marketed in Kenya (MoLD, 2010). Past efforts have been geared towards transformation of these units into market-oriented dairy production in line with key national policy development agenda items. Despite these efforts, the sector is still faced with a myriad of challenges at the primary production level, especially the knowledge and practical skills gap in general husbandry practices, which undermines milk production (SNV, 2013; Ojango et al., 2019).

On behalf of the Green Innovation Centres for the Agriculture and Food Sector (GIAE) programme of Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), GFA Consultants is implementing a dairy value chain component aimed at increasing productivity and income from smallholder dairy farmers in selected counties of Western Kenya, through innovations and alleviating technical challenges. The programme aims at bridging knowledge and technical skills gap in dairy husbandry practices. Four training modules were developed and used for training: "fodder production", "feed formulation", "feeding the dairy cow" and "calf rearing". This paper assesses the impact of the training programme on elevating technical competencies in smallholder dairy units and technology adoption.

Questionnaire survey and data analysis

A total of 1,400 smallholder farmers were trained in Bungoma, Kakamega and Siaya counties of Kenya on the four topics using a four-topic by four-day training cycle approach in May 2018. These farmers were evenly distributed in 27 sub-counties of the counties with a near parity gender participation of 52 per cent male and 48 per cent female. A questionnaire survey was carried out six months later, by randomly sampling 432 trained smallholder dairy farmers proportionately distributed among the three target counties. The questionnaire captured: a) innovations in the training content, b) its adoption, c) qualitative and quantitative evaluation of impact on farmers, d) comprehension of training content and e) other socio-economic benefits of training in addition to suggestions for improvement of future trainings. Data obtained was subjected to descriptive statistical analyses of frequency counts, percentages and means to determine the level of adoption, limitations to adoption and the impacts thereof.

Impact of training on smallholder farmers' husbandry practices

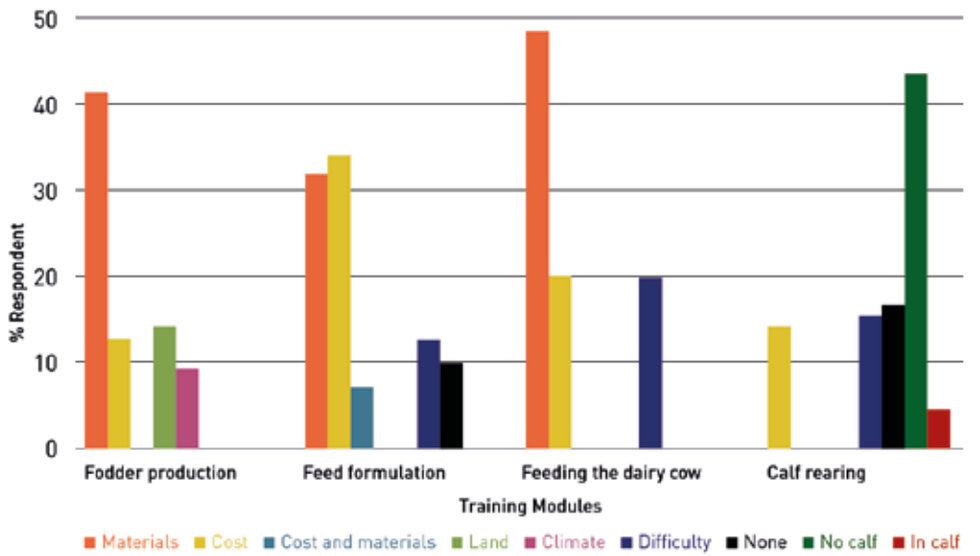
Fodder production

This training module entailed varieties of fodder crops, their propagation, harvesting and conservation. The participants in fodder production training comprised farmers who had no knowledge at all (2.8 %) as well as those

who were highly knowledgeable (9.6 %). All the ten topics delivered during training on fodder production except one (multi-purpose trees – MPT) had new lessons/ innovations for the producers. A respective 43.3, 33.5, 31.9, 25.2 and 20 per cent of the producers learned new concepts on new varieties (VAR), conservation (CONS), establishing fodder plots (PLOT), stage of harvesting (STAGE) and propagation (PROP).

Other concepts such as silage (SIL), hay (HAY), planting using the Tumbukiza method (TUM) and harvesting were fairly familiar to producers, with fewer than 20 per cent of producers viewing them as innovations. Adoption of innovations was highest in PLOT (65.6 %). Adoption levels above 20 per cent were also reported in VAR, PROP, STAGE, CONS and TUM innovations. The biggest hindrance to the implementation of innovations, especially silage making, on farms was the availability of material (MAT), which accounted for 41 per cent of non-implementation (see Figure).

Hindrances to adoption of various training modules on the farms



Feed formulation

This module comprised calculation and formulation of rations to provide a balanced and nutritive ration. Feed formulation was a fairly new concept, with 20 per cent of participants having had their first interaction with it during trainings. Only 4.4 per cent of participants had knowledge of all aspects of the feed formulation module. Calculations (CALC) was the concept least known to participants, with 56.7 per cent of them viewing it as new. Over 20 per cent of participants considered Formulation (FORM), Composition (COMP) and Ingredients (ING) as innovations. Formulation (FORM) had the highest adoption and non-adoption proportions of 29.8 and 23.2 per cent, respectively (see Figure).

Dairy cow feeding practices

Emphasis here was on dairy cow husbandry and feeding at different stages of development and lactation. Concepts of feeding dairy cows were fairly well known to training participants with only 16.1 per cent of producers perceiving all the content taught in the module as new. Challenge feeding (CHF), total mixed ration (TMR) and weight-based feeding (WBF) were new innovations to over 40 per cent of participating farmers. What to feed when (WFW) and Categories/ type of feed (CAT) were new to 18 per cent of participants, while wilting (WIL) and performance-based feeding (PBF) were not new to any farmer. Total mixed ration (TMR) concepts of cow feeding had the highest adoption rates (40 %), followed by CHF (29 %), WBF (27 %), WFW (27 %) and CAT (22 %). Only 1.6 per cent of participants adopted all the concepts, while 17 per cent of participants did not adopt any of the innovations. Adoption of concepts was hampered mainly by the availability of materials (MAT; 48.3 %), difficulty of the topic (DIFF; 20.1 %) and cost of inputs (COST; 20.1%) (see Figure).

Calf rearing

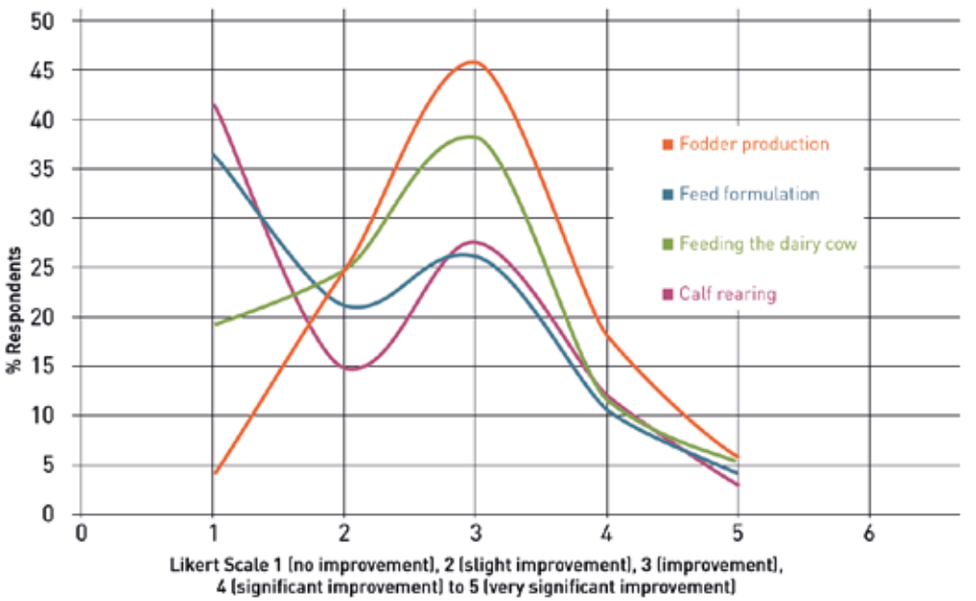
The focus here was on pre and postnatal management to avoid losing the calf and to guarantee a highly productive adult cow. Preparation of the cow in late lactation through steaming up (PREP), the importance of colostrum (COLO), the amount of milk fed according to growth (MILK) and the weaning of calves (WEAN) were new concepts to a majority of training participants who took part in the calf rearing module. 10.3 per cent of participants had no knowledge of rearing calf cows/ heifers. On the other hand, concepts delivered were not new to 12.4 per cent of participants of training. Helminth control was the most widely adopted innovation by 29.6 per cent of participants. Other innovations adopted included PREP, COLO, WEAN and MILK at a respective 25.9, 25, 20.2 and 17 per cent.

A large proportion of participants in the training (37.4 %) did not put into practice the

Quantitative impact of dairy husbandry training on production

Training module	Measured production impact	Rate of change	
		Unit change	% of farmers
Fodder production	Increased milk production	1–4 litres/day	90 %
	Increased acreage of fodder plots	0.5–0.7 acres	70 %
	Increased number of bales of hay	Up to 10 bales	34 %
		Up to 50 bales	34 %
		Up to 250 bales	32 %
	Increase in amount of silage	10–200 kg	23 %
		250–1,200 kg	36 %
		2–18 ton	41 %
Feed formulation	Increased milk production	0.5–1 litre/day	16 %
		2–4 litres/day	70 %
		4–5 litres/day	14 %
	Reduction in feeding costs	20–40 KES	16 %
		100–230 KES	23 %
		250–750 KES	24 %
		800–1,750 KES	37 %
Feeding dairy cow	Increased milk production	0.5–1.5 litres/day	50 %
		2–4 litres/day	15 %
		4–6 litres/day	18 %
		> 6 litres/day	17%

Qualitative impact of dairy husbandry training on production



concepts they learned. This was primarily due to the participants not having calves on their herds at the time of training (40.4 %) and difficulty in implementing the innovations, e.g. weighing of the animals to calculate the amount of milk to feed.

Constraints to adoption of training modules

Adoption rates of training content by farmers were at a respective 64, 37, 43, and 39 per cent for fodder production, feed formulation, dairy cow feeding and calf rearing modules respectively. Consequently, the fodder production module was the most adopted of the four modules of training. This was corroborated by a respective 77, 69, 66 and 67 per cent average comprehension of training content for the four training modules. Apart from comprehension of content, other factors influencing the rate of adoption of the module content taught included availability of material, cost of material, land, climate (weather), and difficulty/complexity of content. Availability of material (MAT) and cost of material (COST) were the main hindrances to adoption of module contents, except for the calf rearing module (see Figure on page 42).

Impact assessment of training modules by farmers

The training resulted in an increase of up to 0.7 acres of land surface under fodder production per farm among 70 per cent of trained participants. Consequently, there was increased milk productivity (up to 4 litres/day), and farmers explored conservation of fodder by baling hay and ensiling. An increase of up to 50 bales of hay was reported by 34 per cent of participants, while 41 per cent of respondents reported an increase in silage output from 2,000 to 18,000 kg.

Farmers also earned extra income from the sale of fodder (up to 4,500 Kenyan Shillings, KES), and formulated feed rations at farm level. An increase in daily milk yield of up to 4 litres and a reduction in feed costs of up to KES 1,750 was reported respectively by 80 per cent and 37 per cent of farmers who adopted on-farm feed formulation. The main impact of improved feeding of the dairy cows was increased milk production (see Table).

Cumulatively, about 95, 80 63 and 58 per cent of participants realised improvement respectively as a result of training on fodder production, dairy cow feeding, feed formulation and calf rearing (see Figure above). However, more than 35 and 40 per cent of participants respectively did not realise any improvement as a result of training in feed formulation and calf rearing.

Feed resources for training on preparation of TMR.

Key lessons and policy orientation

The following conclusions can be drawn from the surveys:

- Smallholder dairy producers have the ability to apply technologies that enhance productivity of their farms if they are comprehensible, practical and within means to implement; thus training is a key component in availing new technologies to the farmers.
- The organisation of training (theory vs. practical, use of materials within easy reach of the trainees) and complexity of the content have an influence on technology adoption. More complex content such as feed formulation may require more training sessions with more practical sessions and relatively longer grace periods for adoption.
- Given the role that the smallholder dairy sector plays in the country, one has to distinguish small-scale farming households based on potential and incentive to invest in increased production in order to tailor, make new and repackage existing farm-level technologies to suit each group.
- With improvement in productivity, there is also a need to focus on enhanced efficiency of production and post-production segments of the value chain. Therefore, further trainings focusing on efficient breed (matching breeds to production resources) and feed utilisation, disease control, artificial insemination, agribusiness and value addition (milk processing) are needed.

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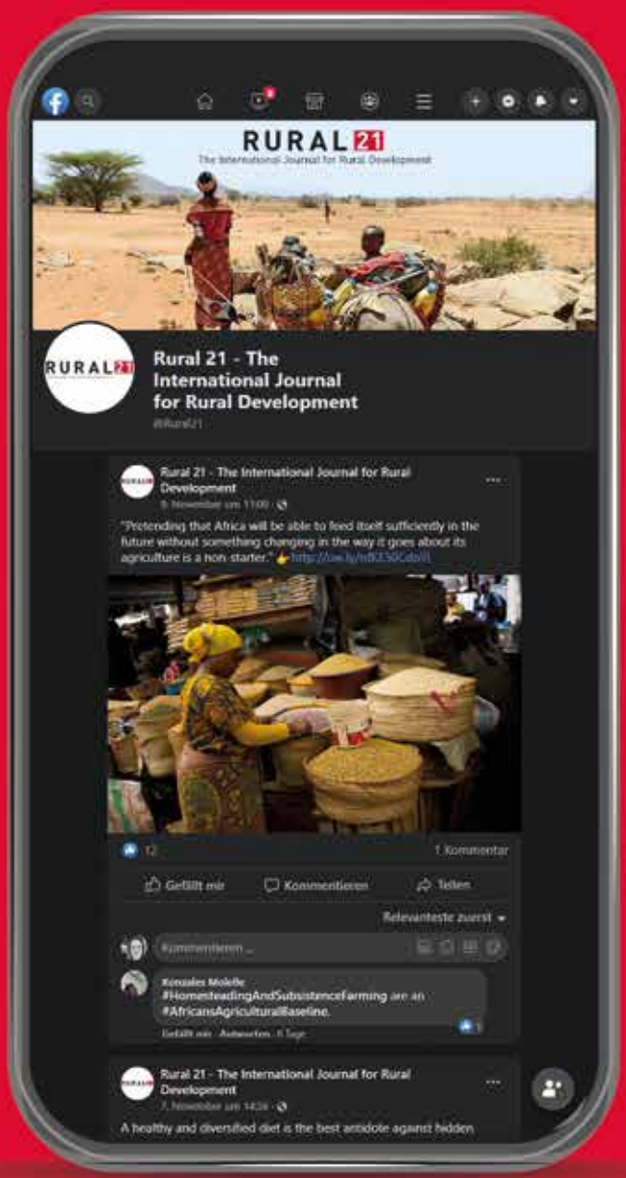

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